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Entitled

A Comparison of Developmental Mathematics
Teaching Techniques of a Community
College in the Rural Southeast

Be accepted in partial fulfillment of the requirements for the Degree of

Doctor of Education
In Educational Leadership

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A Comparison of Developmental Mathematics

Teaching Techniques of a Community

College in the Rural Southeast

A Dissertation

Submitted in Partial Fulfillment of the Requirements for the

Doctor of Education Degree

Union University

Paul Mark Doran

May 2014

DEDICATION

I dedicate this dissertation to my mother, Nancy G. Doran, who said, “You can do anything you set your mind to.”

ACKNOWLEDGMENTS

I would like to acknowledge my committee members, Dr. Melinda Clarke, Dr. Bob Agee, and Dr. Sara Hakim Rognstad, who have been so generous to give their time and input on this research. I would also like to acknowledge and thank Dr. Linn Stranak, without whom I would still be confused about statistics. Also, I would like to sincerely thank my cohort members, Kay Moore, Mitzi Roberts, and Monica Scott. We made a great team!

ABSTRACT

Many students are entering community colleges unprepared for college-level mathematics. Community colleges must attempt to prepare these students for college-level mathematics by providing quality developmental mathematics programs. The purpose of this research study was to determine if the changes in teaching method of the developmental courses made by a community college in the rural Southeast have been successful in better preparing students for their first college-level mathematics courses. The college changed from a traditional classroom consisting of lecture and problem solving to a lab environment consisting of computer drills, peer tutoring, group work, and dividing the topics to be covered into 12 discrete modules referred to as the modularized method. Data were collected for 5 years of the traditional teaching method and for 5 years of the modularized teaching method consisting of 10,665 students. Results indicated that the developmental mathematics teaching method was not associated with student success in their first college-level mathematics course, where success was defined as a grade of D or higher. Since the traditional teaching method was no longer being used, the study also looked at academic and nonacademic variables to determine if a prediction equation could be derived for students in the modularized teaching method in order for college faculty and administration to intervene when it was indicated that a student would not be successful. The 29 independent variables included (a) age group, (b) gender, (c) ethnicity, (d) mathematics ACT subscore, (e) county of residence, (f) degree type, and (g) high

school grade point average (GPA). A prediction equation was derived using 6 of the 29 variables including mathematics ACT subscore, high school GPA, gender, age group, and 2 degree types. Because the college studied had received a national award for their changes to the developmental mathematics teaching method, additional colleges have considered implementing the modularized teaching method. Further research with these additional colleges and larger groups of students is needed to determine if the teaching method changes are effective.

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CHAPTER 1

INTRODUCTION

Many students enter community colleges unprepared for college-level mathematics. Whatever the reasons for their deficiencies, community colleges must remediate students in mathematics so that they are able to be successful in their college-level mathematics courses and any other course that requires mathematical skills. However, traditional teaching methods comprised of lecturing and working problems do not seem to work for many students.

Some colleges, especially community colleges, are trying new teaching techniques in hopes of increasing developmental mathematics scores and improving retention. A community college in the rural Southeast has implemented a teaching paradigm for developmental mathematics that includes a mixture of lecture, problem solving techniques, computer exercises, one-on-one tutoring, peer tutoring, and group study with instructor intervention when needed. The mathematics topics to be covered have been divided into 12 discrete modules, ranging from integers to quadratic equations, which are to be completed in a set order by the student in a self-paced environment (Bassett & Frost, 2010). Students begin by sequentially taking the pretest for each module until they fail to pass a test. This failure will determine at which module they will begin (M. J. Bassett, personal communication, January 18, 2012). This new modularized method of teaching mathematics is referred to as "modularized mathematics" or SMART mathematics (Bassett & Frost, 2010).

Although the courses are self-paced, there are a required number of modules that must be completed in a given semester in order for a passing grade to be assigned. Students are encouraged to work slowly through material for which they need more time to comprehend, but to work quickly through material they already grasp. With the varied methods of teaching employed, students may choose both the speed at which to proceed and method or resources that help them learn best.

Statement of the Problem

The community college that implemented this new modularized approach to teaching developmental mathematics, called SMART math, had done no formal review or detailed statistical analysis to determine the effectiveness of the new teaching method. A formal study was needed to determine if student grades in the school's college-level courses were significantly higher using the SMART mathematics method than with the traditional lecture-based approach. Also, no detailed analysis had been completed to determine if the new teaching method has any impact on retention rates and graduation rates. In addition, the academic and nonacademic attributes that contribute most to success were unknown.

The researcher conducted an interview with the developmental mathematics division dean to document the parameters of both the traditional and modularized teaching methods. The interview provided the conceptual framework and purpose of this study (M. J. Bassett, personal communication, January 18, 2012).

Purpose of the Study

The purpose of this study was to determine if there were any statistical association with teaching method and student success of students who completed developmental mathematics as measured by success in their first college-level mathematics course, where success was determined by a course grade of D or higher.

Also, in order to help determine which developmental mathematics students are least likely to succeed and might need additional academic assistance, academic and nonacademic variables were analyzed to see if any could help predict those students who were statistically unlikely to succeed. The attributes that were analyzed were (a) age group, (b) gender, (c) ethnicity, (d) mathematics ACT subscore, (e) county of residence, (f) degree type, and (g) high school grade point average (GPA).

Hypotheses and Research Questions

The hypotheses and research questions listed below were addressed.

Research Question 1. Is there a statistical difference in the success rate for the traditional mathematics teaching methods and success rate of the modularized mathematics teaching methods, as measured by a course grade of D or higher, for students who progress from a developmental mathematics course to their first college-level mathematics course?

Hypothesis 1. Students who complete developmental mathematics courses using the modularized teaching method perform significantly better in their first college-level mathematics courses, as measured by their college-level mathematics course grade, as compared to students completing developmental mathematics using the traditional method.

Research Question 2. To what extent can academic and nonacademic indicators successfully predict completing the developmental mathematics program for each teaching method (the traditional mathematics teaching method and the modularized mathematics teaching method)?

Hypothesis 2. Predicting successful completion of both the traditional and modularized developmental mathematics programs is possible utilizing academic and nonacademic attributes.

Summary of Findings

This study provided both the college studied and the researcher with new insights into the effectiveness of the modularized method of teaching developmental mathematics. It will be shown that there was no statistically significant difference in the success rate of a student's first college-level mathematics course, based on developmental mathematics teaching method. Also, it was possible to generate a prediction equation for determing success of developmental mathematics students using six of the available academic and non-academic attributes. Please see chapters 3 and 4 for the methods used and the detailed findings of the study.

Definitions of Terms

For the purpose of this research study, the following definitions were utilized:

Modularized teaching method. The modularized teaching method divides mathematics topics into 12 discrete topics and utilizes various teaching techniques that include lecture, problem-solving techniques, computer exercises, one-on-one tutoring, peer tutoring, and group study with instructor intervention when needed.

New teaching method. The same as modularized teaching method (see above).

Old teaching method. The same as traditional teaching method (see below).

SMART mathematics. The same as modularized teaching method (see above).

Student success. When a student completes a course with a final grade of A, B, C, or D.

Traditional teaching method. The previous mathematics teaching method comprised of classroom lecture and problem drills.

CHAPTER 2

REVIEW OF LITERATURE

Students today are increasingly enrolling in college without the prerequisite skills, especially in the area of mathematics. This unpreparedness of students is escalating at an alarming rate, placing strains on the resources needed to prepare students for college-level mathematics. Colleges, especially community colleges, bear the burden of bringing mathematics skills up to the expected standards for college-level work by providing developmental mathematics courses.

A developmental mathematics course is simply any course that prepares a student for college-level mathematics. Courses can range from simple arithmetic and mathematics symbolism to geometry or statistics. Students graduating from high school can be underprepared for mathematics in a wide variety of ways; therefore, the level of knowledge can never be assumed. Usually, a student is tested to determine the areas of deficiency so a plan may be created and implemented to guide the student to his desired level of mathematics understanding (Bassett & Frost, 2010). This plan significantly increases the chances of success for students who must complete any college-level mathematics course.

Since most community colleges allow open enrollment, they contain the largest populations of underprepared students (P. Johnson, 2007). The research shows that the percentage of students who fall into this category can be extremely large and may seem overwhelming to colleges. However, community colleges are shown to be the appropriate environment in which to handle this situation and prepare students who cannot get into other colleges. Community colleges expect a large portion of students to have deficiencies in certain areas and have created many successful programs to correct the problem. Community colleges are on the front line of preparing students for college-level mathematics work.

All secondary schools should provide courses that are adequate to prepare students for college-level mathematics, including Algebra I and II, geometry, and usually precalculus. However, many schools require a low proficiency of the subject matter, which is not adequate to meet the challenge of college mathematics. This lack of proficiency may help account for the many reasons students need developmental work in mathematics.

Many students leave their secondary education without mastering the mathematics skills required for college. Research indicates that this failure can be the fault of both students and the secondary institutions themselves (Bahr, 2008; Hall & Ponton, 2005). Neither holds the other accountable for mastery of the material. While a large portion of students with mathematics deficiencies comes directly from secondary schools, many adults who have been out of school for many years are now entering college. Many of them are required to take developmental mathematics courses in order to refresh their mathematics skills to assist in the transition to college-level work.

This combination of students has a direct impact on the teaching methods employed by colleges. Research suggests a multitude of methods, but they generally fall into either a traditional method or a "new" method (Bassett & Frost, 2010; Mireles, 2010).

Traditional methods of teaching mathematics include lecture-based courses where the professor explains the material with examples. Students have little hands-on practice with this method. Another method is rote memorization, where students simply memorize the way to solve a problem. For some, this works well but provides little understanding of the reasons why the solution is correct. The most common method of traditional teaching is working problems repeatedly until a student can master both the understanding and the mechanics of the solution.

Newer methods of mathematics instruction have been introduced recently (Bassett & Frost, 2010). One such method is the use of mathematics labs where students work in small groups. Students work mathematics problems using a computer that targets a specific topic or skill. Many supplemental instruction methods have been introduced, which include video lecture, animation, and mathematics games. To help students understand how mathematics will be used in everyday life, real world problems have been introduced. In the health care field, specific mathematics courses have been developed that use examples directly from health care (Shore, Shore, & Boggs, 2004). This method was created to hold the interest of students and to help mask the fear of mathematics. While instructors can be very helpful in learning mathematics, some students prefer to ask their fellow students for help. In the cohort or peer-based learning method, students helping students is encouraged. Students help and support each other with skills and problem solving. This interaction reinforces the knowledge they have mastered. While there are many more traditional and newer methods, they are beyond the scope of this research.

Students today are increasingly attached to their computers. In recognition of this, many computer programs have been created to aid students with mathematics skills and drills. For many students, this method of learning is preferred while being an area of frustration for others. Research indicates that while there are benefits to computer mathematics learning, there are some inherent problems, such as mathematics symbol representation and entry by the student (Jacobson, 2006). The research suggests that despite drawbacks, this method of mathematics instruction will not be eliminated from the community college curriculum.

Literature on the effectiveness of the teaching methods and programs listed above will follow. One such area focuses not on the learning curve for students, but for instructors who must master the material and technology to teach a course effectively. Instructors must also evaluate the mastery of skills by students, as well as determine which teaching methods produce the best results. Instructors have a variety of opinions on the best way to measure outcome, but several trends and ideas have been shown to be generally accepted.

While the available research focuses primarily on developmental mathematics courses, especially at the community college level, the impact of reading on mathematics success is briefly included. There is less literature than expected on the correlation of reading skills to mathematics success. However, several obvious impacts of reading skills on mathematics and logical conclusions are presented. There are many other aspects to developmental college mathematics, but this review will limit itself to the aforementioned topics. Students unprepared in mathematics will continue to enroll in college. For this reason, the community college must meet the challenge to prepare these students using available resources so that they can succeed at the college level.

Why Developmental Mathematics?

The necessity for developmental mathematics in community colleges has been increasing at an alarming rate. Many public school systems are failing to prepare students for college-level mathematics courses by requiring only the *minimal* amount of mathematics knowledge to graduate, thereby forcing them to take remedial classes before they can begin their college studies in earnest (Beaudrie et al., 2007). This leads to several questions concerning the preparation of secondary education students. First, what is the role of secondary education in mathematics education? Second, is there a failure of mathematics at the secondary education level, and if so, what are some of the reasons? And last, what influence do adults returning to college have on the need for mathematics remediation?

Before an exploration of the need for developmental mathematics can begin, we must first understand what developmental mathematics really is. Developmental mathematics is defined as "precollegiate mathematics courses that are designed to prepare students for the study of college-level mathematics, as defined by entrance requirements of the institution" (Arendale, 2007, p. 18). By this definition, secondary education institutions should be preparing students for college-level mathematics. Since mathematics has been regarded as one of the most important disciplines, its impact in education cannot be overstated (Schornick, 2010).

Secondary education must not only prepare students in the intricacies of mathematics, but also must use it as a tool to help students develop critical-thinking skills, problem-solving skills, and analytical-thinking skills in order to succeed in the world today. However, according to Schornick (2010), teachers in elementary and secondary schools do not fully understand the complete nature of mathematics, and they fill students with rules instead of complete understanding and higher order thinking skills. Schornick and others have pointed out that students are given meaningless exercises and they cannot apply what they learn in the real world (Hammerman & Goldberg, 2003; Mireles, 2010; Schornick, 2010; Shore et al., 2004). Most students today are being trained to pass a standardized test rather than to master the concepts and application of mathematics (Hammerman & Goldberg, 2003; Hodges & Kennedy, 2004).

The "transition from high school to university is brutal" (Beaudrie et al., 2007, p. 8). One prevalent reason is that there seems to be a disconnect between what secondary education institutions are teaching and what colleges expect (P. Johnson, 2007; Fact Sheet, 2011; Kendall & Williams, 2004; Lundin, Oursland, Lundgren, & Reilly, 2005). One study found that only 43% of high school graduates possess the requisite college-level mathematics skills (Taylor, 2008). One solution proposed to this problem is for secondary and postsecondary institutions to create a well-defined and enforceable set of standards for high schools that accurately reflects the skills and knowledge that colleges require (Kendall & Williams, 2004). However, since different state and local agencies are responsible for requirements concerning mathematics, the term *college-level* seems to be ambiguously defined (Perin, 2006). As Kendall and Williams (2004) indicated, more college-level mathematics preparation would logically reduce the number of postsecondary developmental mathematics students. Some current indicators of mathematics quality in elementary and secondary institutions simply measure "seat time," not a student's ability or knowledge, leading to a natural deficiency in mathematics skills (Kendall & Williams, 2004).

A recent study by the state of New Hampshire reported that while "90% of all high school freshman expect to complete college"; however, "only 44% take the college preparatory curriculum" (Beaudrie et al., 2007, p. 19). Most literature agrees that between approximately 24% and 49% (depending on state and type of college) of students entering postsecondary education require a course in developmental mathematics (P. Johnson, 2007; Frost, Coomes, & Lindeblad, 2009; Perin, 2006; M. Johnson & Kuennen, 2004). For developmental courses overall, at least 40% of students require at least one developmental course in reading, writing, or mathematics (Beaudrie et al., 2007; Donovan & Wheland, 2008), with more students enrolled in developmental mathematics than writing or reading (Fact Sheet, 2011).

Why are so many students required to register for a developmental mathematics course? A study by Beaudrie et al. (2007) uncovered some disturbing information that concluded high school teachers are inadequately prepared. It stated that 1 in 4 teachers has a temporary or emergency license or no license at all, 1 in 3 is teaching classes outside their certification, and that 40% to 50% of teachers have left the profession after only 5 years (Beaudrie et al., 2007). According to an ACT study, "Students who took rigorous, college-oriented courses taught by qualified, flexible, personable, and supportive teachers graduated high school more prepared for college than other students" (Schornick, 2010, p. 19).

There does seem to be some consensus on the progression of high school courses that are required to minimally prepare students for beginning college-level mathematics. Rigorous courses in Trigonometry, Algebra I, Geometry, Algebra II, and possibly data analysis and statistics are required to fully prepare students for postsecondary courses (Achieve, Inc., 2011; Blank, Langesen, & Petermann, 2007). According to a recent *Washington Post* website article, “Of all the classes offered in high school, Algebra II is the leading predictor of college and work success” (Whoriskey, 2011, para. 4). While this level of mathematics skills is desired, it is not always what students receive or strive to achieve.

Schornick (2010) wrote at length about students’ views of high school mathematics, including detailed interviews with individual students. The comments by students about their experiences in their high school mathematics classes are shocking and appalling. Students readily admitted to cheating, with no effort to hide the fact, while the teacher knew about it. Students also cited teachers who did not care if students did any actual work, did not enjoy teaching, and did not assist in the learning process (Schornick, 2010). While the study clearly documented the experiences of one distinct group of students, no claim was made that it was representative of all students and all teachers.

Although most literature regarding developmental mathematics students focuses on high school students entering college or students in general, adults are returning to college in record numbers as well. Unfortunately, little information can be found particular to adults, especially concerning developmental mathematics. However, a few statistics about adult students are singled out. For example, according to one study, 17% of developmental mathematics students are ages 35 and older (Taylor, 2008). Another study stated that when enrolling for distance learning developmental mathematics courses, most students are older than the traditional aged college student (Zavarella & Ignash, 2009). Hopefully, more research and statistics will be applied to adults in the area of developmental mathematics in the future.

Most studies or literature state the reasons that students in their sample population required developmental courses in mathematics. From the literature available today, the reasons are as varied as the students themselves. Once students reach the postsecondary education level, the *reason* that they need remediation in mathematics is irrelevant. They simply need to "catch up" and colleges must do everything in their power to assist the students in becoming proficient in mathematics. Dotzler (2003, p. 124) stated, "Developmental education is the key to bringing more people into higher education." "Mathematics is not a careful march down a well-cleared highway, but a journey into a strange wilderness, where the explorers often gets lost" (Eades & Moore, 2007, p. 19).

Traditional Teaching Methods for Developmental Mathematics

"As students transition from high school to college, frequently they are asked to be more responsible for their own learning and more active in their learning environments" (Wadsworth, Husman, Duggan, & Pennington, 2007, p. 6). Developmental mathematics is a contact sport where students must wrestle with problems using their skill and mental strength until the problems are solved. Students must possess skill, will, and self-regulation in order to succeed in the various methods used by teachers (Wadsworth et al., 2007).

While there are varied ways to instruct students, the basic lecture-based course still appears to be the most common classical method of teaching (Galbraith & Jones, 2008; Zavarella & Ignash, 2009). However, many teachers forget that "the essence of learning math is doing math, rather than passively listening" (Thiel, Peterman, & Brown, 2008, p. 46). Students must actively participate in working mathematics problems, repeatedly if necessary, using drill-and-practice exercises in order to improve both their fundamental and problem-solving skills and to master the application of each new concept (Thiel et al., 2008). Students must not be allowed to sit passively and watch an instructor do mathematics; they must actively participate in the problem-solving process (Bassett & Frost, 2010). Interestingly, the lecture-based method of teaching using step-by-step procedures appears to be most widely used by part-time faculty and graduate assistants (Mireles, 2010).

There is no substitute for a knowledgeable instructor. However, the instructor must be able to clearly explain concepts and how to apply them. Requiring students just to memorize formulas does not enhance a student's critical-thinking skills. Memorization does not reinforce the underlying concepts or help develop ideas that can be expanded and applied in new ways to new problems (Hammerman & Goldberg, 2003).

For example, while researching foundational elementary mathematics knowledge, fourth-grade students were expected to memorize the multiplication tables. When one student was asked the answer to 6×7, he worked it out quickly using simple mathematics instead of just quoting a memorized answer. While his answer was absolutely correct and his logic showed a clear mastery of the concept, his teacher was upset that he had not memorized the answer (Hammerman & Goldberg, 2003). This incident clearly demonstrated that the teacher was unable to appreciate the student's mastery of the subject matter and his ability to apply concepts in a logical fashion.

Many secondary mathematics teachers rely so heavily on memorization of formulas that they "teach to the test," (Hodges & Kennedy, 2004, p. 38) and this teaching method has led to "students [who] were trained to pass standardized tests rather than to learn mathematics" (Hammerman & Goldberg, 2003, p. 83). This failure to properly apply concepts, along with the applicable formulas, has dire implications for any student's future in mathematics, especially at the college level.

Students have frequently reported being bored in class and feeling as if mathematics courses could have inspired new ways of thinking (Flick, Sadri, Morrell, Wainwright, & Schepige, 2009). Since most degree plans require at least one mathematics course beyond the developmental level, students, in order to be successful, need to acquire both fundamental and problem-solving skills before progressing further toward a degree (Mireles, 2010). These skills "can sharpen the mind and thus produce positive results in other areas of student learning" (Siadat, Musial, & Sagher, 2008, p. 342).

Problem-solving skills apply to all areas of college, not just mathematics. Developmental mathematics can be the gateway to honing these logical and problem-solving skills with the right leadership and instruction from a qualified and caring instructor. It has been suggested that this instruction is usually best done in person.

Alternative Teaching Methods for Developmental Mathematics

While traditional lecture-based courses are still the predominate method of teaching development mathematics, other methods are gaining widespread acceptance. While not every method can be explored, several are mentioned in literature more often than others. These include supplemental instruction, real-world-based problem solving, cohorts and peer-based learning, and a very new method utilizing mathematics labs.

Before exploring Supplemental Instruction (SI), a clear definition is needed. According to Arendale (2011), "Supplemental Instruction (SI) is an academic assistance program that utilizes peer-assisted study sessions. SI sessions are regularly-scheduled, informal review sessions in which students compare notes, discuss readings, develop organizational tools, and predict test items. Students learn how to integrate course content and study skills while working together. The sessions are facilitated by 'SI leaders,' students who have previously done well in the course and who attend all class lectures, take notes, and act as model students" (para. 1). This method of teaching was developed in the early 1970s by Dr. Deanna Martin at the University of Missouri-Kansas City.

Supplemental Instruction has a three-part purpose: (a) to increase retention within targeted historically difficult courses, (b) to improve student grades in targeted historically difficult courses, and (c) to increase the graduation rates of students

(Arendale, 2011). An interesting aspect of SI is that it is designed to target high-risk courses instead of high-risk students (Phelps & Evans, 2006). Since developmental mathematics courses are by their nature high risk, this method of enhancing instruction is a natural fit.

Stephen F. Austin State University in Nacogdoches, Texas, conducted a multipilot trial during the spring, summer, and fall of 2000 to determine if supplemental instruction could increase learning and retention in its developmental mathematics courses (Wright, Wright, & Lamb, 2002). Because of some missteps in the university's initial implementation, the statistical results were not indicative of the expected outcomes. However, Wright et al. (2002) did observe students who benefited from supplemental instruction.

While student attendance for supplemental instruction sessions is voluntary, the students who attend indicate that the individualized assistance is an asset to their learning. The sessions provide an environment where students from all backgrounds can meet and get to know and trust one another, not only through peer-to-peer learning, but tutor-to-peer learning as well (Phelps & Evans, 2006). Not only is this type of interactive learning strategy helpful, SI encourages students to better integrate into the college environment in a nonthreatening way.

One supplemental instruction study found that "students who participate in SI have significantly better GPAs than those who do not participate in the sessions" (Phelps & Evans, 2006, p. 24). Also, students who attended SI sessions to help with their developmental mathematics learning also had a much greater chance of completing the course (Phelps & Evans, 2006). Since "many underprepared college students do not know how to study," (Phelps & Evans, 2006, p. 25) working one-on-one and in groups with instructors, tutors and peers can help students develop better study habits and skills.

Keeping students interested in the course material is always a challenge. One reason that students lose interest is that they cannot see how they will apply the material in their everyday lives. The Fund for the Improvement of Postsecondary Education (FIPSE) funded and conducted a project to see if incorporating allied health examples into developmental mathematics course curriculum would increase student scores and retention (Shore et al., 2004). A custom textbook was created that provided specific examples and applications that linked the allied health field to developmental mathematics (Shore et al., 2004).

The hope was that if meaningful course content was provided, students could apply it to other areas of interest and be encouraged to study and participate more in the learning process. "The ultimate goal [was] to provide a student-centered learning environment where students gain an understanding of mathematical concepts by creating pertinent algorithms using problem-solving techniques that are reinforced through carefully developed problems, including these based on real-world situations" (Mireles, 2010, p. 84).

While the study focused on allied health examples, developmental mathematics course content could be tailored to a variety of other areas such as education, chemistry, physics, computer literacy, and others. One interesting result of the FIPSE study was that not all problems should be related to allied health. They compared different courses with

30%, 50%, and 70% of the assignments related to the allied health field and discovered that 70% was too high (Shore et al., 2004). It has been suggested that while specializing developmental mathematics course content to a particular area may be beneficial, it can be just as detrimental if it is too specialized as when it is too general.

Another project designed to engage students with the transition from high school to college was conducted in Eastern Washington for four years (Frost et al., 2009). This time it involved the instructors more than the students. Since college instructors tend to blame high school teachers for students' failure, and high school teachers tend not to understand what colleges expect, a cohort of teachers from both levels of academia was created to help each understand the other (Frost et al., 2009). This innovative project's philosophy was to reject placing any blame on students, social factors, or past teachers for failures (Frost et al., 2009). The project members met monthly to discuss teaching techniques and ideas to better bridge the gap between high school and college-level mathematics courses. If students can be better prepared for college-level mathematics, then fewer students would be required to enroll in developmental mathematics courses at the college level.

Teachers at both the high school level and college level were better able to understand what was taking place and help each other to plan activities, lessons, homework, and classroom lectures in order to better educate and prepare their students. High school teachers were invited to help with college-level courses and vice versa. This helped each to see the stark differences in students, especially for those who had never taught outside their level of academia. One college instructor noted that "high school students were much more difficult to engage because they had no choice about attending class [and that] high school mathematics instruction was inherently more difficult than he had imagined because of these behavioral issues" (Frost et al., 2009, p. 233). Being able to understand the frustrations and challenges the "other side" faces gave educators a better appreciation and insight into how to better educate students. It also helped to create trust and respect between secondary and postsecondary instructors, break down barriers, and create an environment better suited to helping student succeed in their mathematics courses. Schornick (2010) echoed this sentiment when she said that "high school math teachers working collaboratively with college and university math teachers would be beneficial" (p. 32).

The Eastern Washington study provided some interesting conclusions that should be mentioned. First, it is important to address the issues because complacency is unacceptable. Changes must be implemented and everyone at every level is held accountable, regardless of their role. Second, the issues are very complex and there is no sure solution for students who do not succeed at the college level. Even with planning and collaboration in teaching, there is no guarantee that it will help students progress to the desired level of mathematics knowledge. And third, changing the culture of secondary and postsecondary education is a slow and uncertain process. It is difficult to unseat deep-rooted beliefs about teaching and learning (Frost et al., 2009). The most interesting overall conclusion of the study was that no earth-shattering changes need to take place. Instructors need to work together to identify and implement "little changes" over time based on their situations and environment in order to improve the education of students (Frost et al., 2009).

A novel approach in the way developmental mathematics is taught has recently been introduced by a community college in the rural Southeast. This new approach involved abandoning the traditional methods of teaching and creating a combination of classroom, supplemental instruction, tutoring, and testing into a concept known as the "mathematics lab." Traditionally, students have been placed into developmental mathematics courses that expected a certain level of knowledge and did not provide accommodations for students whose level was lower. One of the major goals of the mathematics lab concept was actually to let students start at the appropriate level where help was needed and progress to the level required by their career choice or chosen course of study (Bassett & Frost, 2010).

The developmental mathematics curriculum was divided into 12 smaller clearly defined modules, providing students with the chance for small successes. Students were evaluated using both pre- and posttesting to determine the start point and exit point from the program (Bassett & Frost, 2010). If a student tested above 80% on any module pretest, he or she immediately progressed to the next module. Students were provided assistance by means of instructors, tutors, peer groups, step-by-step workbook guides, interactive online guides, videos, and customized computer software (Bassett & Frost, 2010). All resources for the developmental mathematics program were available in a "mathematics center," providing students with easy access.

As students completed each module and successfully passed its posttest assessment, they may continue directly into the next module. This allowed students to progress as fast or slowly as they need in order to master the material fully. The community college that implemented the mathematics lab concept has seen the pass rate for developmental mathematics students increase from 41% to 60% and student retention increase by 12% (Bassett & Frost, 2010). Allowing students to begin at the appropriate level and take only the mathematics needed for their career choice helps students experience success in small steps and encourages them to continue to complete their goal of completing their developmental mathematics course.

Computer-Aided and Online Developmental Mathematics Courses

Since the Phonographic Institute began distance learning via the United States Postal Service in 1852, students have wanted education to come to them, wherever they may be, on their own terms (Casey, 2008). The current system of education delivery using the World Wide Web (WWW) has snowballed over the past 2 decades as educators have attempted to meet students' demands for it (Kanuka & Kelland, 2008). This relatively new medium of learning has provided many students with a new freedom from the classroom.

What is online or distance learning? According to the U.S. Department of Educational Research and Improvement, distance education is "the application of telecommunications and electronic devices which enable students and learners to receive instruction from some distant location" (Bruder, 1989, p. 30). According to Casey (2008), online learning has flourished in the United States for three primary reasons. First, students and educational institutions are separated both geographically and socio-economically. Second, there is a great desire and need for education. Third, a rapid advancement of technology has made online learning possible (Zavarella & Ignash, 2009).

In addition, combining information from several sources provides general characteristics that an online education must possess. First, an online education assumes the majority of the interactions between faculty and students are noncontiguous (Jacobson, 2005). Second, there must be two-way communication among the faculty and students to support the learning process (Kinney & Robertson, 2003). And third, this technology is used to facilitate the required two-way communication (Kinney & Robertson, 2003).

Online education is often viewed as a teaching method and a means of instruction. Both can be combined into a blended definition of learning that highlights the separation of faculty and students, the material being created by an educational institution expressly for the learning process, and the use of all electronic media to provide the instruction, such as audio and video (Kinney & Robertson, 2003).

There are four stages for learner-to-learner and instructor-to-learner interactions: communication, collaboration, cooperation, and community (Brindley, Walti, & Blaschke, 2009). Communication involves talking or discussing, typically through e-mail or discussion forums (Jacobson, 2005; Brindley, Walti, & Blaschke, 2009). Collaboration is “people sharing ideas and working together in a loose environment” (Brindley, Walti, & Blaschke, 2009, p. 3). Cooperation is people doing things together by building a community and striving for a common purpose (Brindley, Walti, & Blaschke, 2009). Brindley et al. (2009) referred to this type of interaction as a "working group."

To facilitate this idea of a working group, proper communication technology must be provided to the participants. The most common tool is e-mail. As of 2008, it was reported that 99.9% of students used e-mail, 80% used some type of messaging system, and well over 90% used other technologies in their learning activities on a daily basis (Nworie & Haughton, 2008).

While this level of saturation of technology seems like a positive thing, there are a few drawbacks. Students have reported that while e-mail provides a quick way to communicate, it can be overwhelming at times (Jacobson, 2005). Other major drawbacks highlighted in the research on online learning interactions were the lack of timely and adequate feedback from faculty and ambiguity of instructions (Chapman & Henderson, 2010).

Generally, student satisfaction with online courses interaction is very high. Research by Diaz (2002) has shown that while the number of students receiving A grades in an online course was twice that of a traditional course, the drop rate was also double—13.5% versus 7.2%. This drop rate statistic is echoed repeatedly throughout the literature on developmental mathematics (Zavarella & Ignash, 2009; Kinney & Robertson, 2003). "There is a well-documented high dropout rate in courses delivered via computer instruction in general and distance learning courses and programs in particular" (Zavarella & Ignash, 2009, p. 2). Many students are unprepared for the challenges of an online course.

While the largest area of research in the arena of online learning is on the technology itself, the biggest impact of online learning is on the student (Lei & Gupta, 2010). Lei and Gupta (2010) provided a breakdown of benefits and costs for students, faculty, and institutions in an online learning environment. Listed below are some of the key benefits and costs identified by Lei and Gupta for students:

Benefits

- offers course flexibility/freedom to work at own pace
- reduces/eliminates commuting
- provides easy access to course materials via the Internet
- allows education to continue with a busy schedule
- minimizes culture shock
- develops practical skills

Costs

- costly technology and equipment required (computer)
- online technology fee required to support online courses
- basic/advanced understanding of technology
- no face-to-face interactions with students or instructors
- challenging electronic work submissions
- delayed feedback
- strong motivation and self-discipline

While the list above is not exhaustive, it does provide insight into why some students succeed and some students fail in an online environment. For students who possess self-discipline, self-motivation, less reliance on other students, and the requisite comfort level with distance learning, research shows that these students tend to excel in an online course environment (Diaz, 2002; Perez & Foshay, 2002). Likewise, students who do not possess these qualities tend to do poorly (Diaz, 2002). Unfortunately, many developmental mathematics students would fall into the latter category.

Diaz (2002) noted two surprising characteristics that research has linked to academic success in an online course: older age and more academic experience. Diaz (2002) also noted research by Dille and Mezack that suggested “older students are more successful because they are typically more mature and disciplined and may value their time and money more highly than younger students” (Diaz, 2002, p. 3).

This research highlights the need for community colleges to offer developmental mathematics courses in a variety of formats so that students can choose the delivery method with which they feel the most comfortable. When students have a choice in the way they learn, they tend to overcome their own deficiencies and perform better (Villarreal, 2003).

While most refer to the technology used to support developmental mathematics simply as “online,” this term can actually refer to a variety of teaching methods using an alphabet soup of acronyms. There is computer-aided instruction (CAI), which is a combination of classroom instruction and computer-based assignments (Villarreal, 2003). Another method is computer-directed instruction (CDI), in which computer-based instruction is the primary delivery technique (Villarreal, 2003). In this method, an instructor or tutor can be available to assist a student, if need be.

Next, there is distance education (DE), which can fall into two categories (Perez & Foshay, 2002). First, there is "pure" distance education in which all material is presented in a computer-based format. Second, there is a "mixed" or hybrid format in which most of the material is presented in a computer-based format, but may include an asynchronous mode of communication with instructors or tutors.

Interestingly, the most common method of teaching online developmental mathematics seems to be a hybrid model. Most literature that references computer-based learning of mathematics also mentions available contact with an instructor, facilitator, or tutor (Perez & Foshay, 2002; Zavarella & Ignash, 2009; Villarreal, 2003; Kinney & Robertson, 2003). Villarreal (2003) managed to summarize it best when he said that "while computer-based instruction has positive effects, it was most successful when it was used as a supplement to regular classroom activities" (p. 74).

Almost all studies into computer-based or assisted development mathematics courses mention specific software systems used. However, no two studies use the same software, spanned the same time frame, used the same textbook or teaching materials, or used the exact combination of computer systems and teaching methods in exactly the same way. Comparing available studies directly is an impossible task. However, as mentioned above, it can be gleaned that most agree that some version of a hybrid model seems to work best.

No matter which model fits a particular postsecondary institution best, one problem has surfaced that should serve as a warning to anyone attempting to use any computer-based assistance or teaching method. Students have reported having extreme difficulty in learning the specific ways and peculiarities of entering mathematical equations and notation into each software system (Jacobson, 2006). One student remarked that "sometimes the answers I would type in were right, but the computer would mark them wrong" (Jacobson, 2006, p. 4). Care must be taken to properly educate and train students in the use of any software and technology chosen in order to receive an educational benefit. Otherwise, students will become frustrated and overwhelmed, resulting in an increased withdrawal rate.

For students who possess the necessary skills to succeed in an online or hybrid program, the world of education is wide open. These students will be able to fulfill any educational need by sitting down at their computer anytime and anywhere. However, those students who do not have the skills to succeed, or attain the skills to succeed, will find the experience frustrating and unrewarding.

Effectiveness of Teaching Methods and Programs

For any developmental mathematics program to be successful, mathematics instructors need to be fully trained and prepared for the unique challenges that await them and their students. This hiring process can present a major challenge to community colleges. "Finding and hiring well-prepared teachers, is however, sometimes impossible, especially in mathematics" (Schornick, 2010, p. 35). For those colleges lucky enough to find qualified instructors, the environment of developmental mathematics presents instructors with its own individual reality.

First, instructors must be fully aware that for many years developmental students have been frustrated and anxious with mathematics (Taylor, 2008). Instructors must help to remove the students' anxiety about mathematics in order for them to become more confident in their ability to do mathematics (Taylor, 2008). Hammerman and Goldberg (2003) stated that "the sooner the students believe that the past is not a predictor of the present, the sooner the students gain confidence in themselves, and their chances of future success dramatically improve" (p. 83). It is the instructor's job to instill this confidence of mathematical ability in order for students to succeed (Hall & Ponton, 2005).

One of the major obstacles facing instructors is the fact that students may be years behind in their mathematical ability. Instructors must realize this fact and prepare students for the bombardment of material about to come their way. There may be years of material to cover, unfortunately, usually in just one semester (Hammerman & Goldberg, 2003). This concentration of material is where many students become overwhelmed and realize that their preparation for college was inadequate, causing them to consider withdrawing from college altogether.

Suddenly the art of teaching becomes important. Research suggests that not only must instructors be technically familiar with the material, but also they must be able to successfully transfer the requisite knowledge to students in an efficient manner. "Developing the mechanics of teaching is important, but the development of the art of teaching is essential. A balance of the two elements is vital for the learning and teaching process to be successful" (Galbraith & Jones, 2006, p. 24). Not only should full-time faculty be well versed in the art of teaching, but also since part-time or adjunct faculty teach a large portion of developmental mathematics, these teachers should be properly trained as well (Mireles, 2010).

Instructor training should include not only basic lecture techniques, but also should include nontraditional instructional techniques as well (Mireles, 2010). "Good community college instructors plan for learning through various philosophical and conceptual means" (Galbraith & Jones, 2006, p. 22). Instructors need to become experts at how to engage students in the classroom with whatever means of instruction and technology are available. In order to help students feel that they can continue and succeed, research has shown that the "recognition of seemingly minor accomplishments was a motivator to students to persevere" (Galbraith & Jones, 2006, p. 26). Since it has been well documented that students who were required to take developmental mathematics courses withdrew from college more often than students who were not required to take any developmental courses, instructors should use all available resources to encourage and assist students in any way possible (Lesik, 2007).

One of the key responsibilities of a developmental mathematics teacher is to help students understand how mathematics can actually be useful in everyday life (Taylor, 2008). It should be obvious that students who cannot see the "how and why" of mathematics will be reluctant to learn mathematics. Schornick (2010) observed that rigorous courses that were made to be relevant to students' lives positively affect learning outcomes greatly. She also noted that teachers should "learn how to engage students in complex, real-world problem-solving that is academically rigorous, relevant and empowering" (Schornick, 2010, p. 33).

Also, teachers need to understand that not all mathematics is for all students. Teachers should consider the actual future needs of a developmental mathematics student (P. Johnson, 2007). A student's career choice should dictate the level of mathematics needed, not some arbitrary threshold set by administrators. "Administrators ultimately hold the responsibility of ensuring that teachers teach the curriculum in a manner making it relevant to the students" (Schornick, 2010, p. 34). While this may be true, it is the teacher that students see every day, and it is the teacher that must be fully prepared to present the material in a cohesive manner.

Teachers must also be keenly aware that not only do the formulas and techniques for solving problems need to be explained, but the concepts as well. Sometimes it is more important to fully comprehend the concept behind the problem than it is to actually be able to solve the problem. "Students only need one equation and lots of understanding" (Hammerman & Goldberg, 2003, p. 90). It is the teachers' ultimate responsibility to make sure that students understand the *why* as much as the *how*. However, "the most important variable in why and what and how much something gets learned is not what professors do; it's what students do" (Eades & Moore, 2007, p. 19). Students must walk away from a developmental mathematics course with a firm understanding of the fundamentals of mathematics and how to apply them in a consistent and useful manner.

To help students learn as best as possible, teachers must provide structure for learning. Thiel et al. (2008) provided six points that can help not only developmental mathematics students, but most any student be successful. The points are:

1. Provide a structure for the course that guides students in their active learning.
2. Provide sufficient time on task and enforce deadlines.
3. Reward students for their efforts.
4. Provide regular assessment of progress.
5. Accommodate diverse styles of learning.
6. Stay in touch.

These useful recommendations can help teachers not only focus on ways to ensure that students succeed, but will also help students to know what to expect in their learning environment.

One great problem of concern for teachers is that underprepared developmental mathematics students have no idea how to study (Phelps & Evans, 2006). This lack of preparation is where instructors can assist with one-on-one instruction, recommend tutors, or encourage participation in a peer-led study group. Students tend to blame everyone but themselves for their poor performance in mathematics, but it is ultimately up to the student whether he wants to be successful or not (Hall & Ponton, 2005). Sometimes it takes encouragement from an instructor to help a student see what factors are limiting their success because rarely can students see for themselves what their stumbling blocks are (Hall & Ponton, 2005).

In one study by Taylor (2008), a surprising conclusion was reached concerning students and their ability to succeed. “Students’ confidence in their ability to learn mathematics is the only variable included that contributed to prediction of performance in a developmental mathematics course” (Taylor, 2008, p. 37). It should come as no surprise that students who doubt their ability will be less successful than those who believe in themselves and are provided encouragement by instructors. However, as Hammerman and Goldberg (2003) so insightfully pointed out, regardless of encouragement or persuasion, some students may not yet be intellectually ready for the material.

Developmental mathematics instructors must always remember that they are the ones that provide direction and structure for students. They must use whatever means and methods are at their disposal to help students learn the material. They must not “be afraid to be creative and nontraditional. By definition, the students are enrolled in the developmental classes because traditional methods have failed them before” (Hammerman & Goldberg, 2003, p. 94).

How effective are the teaching methods currently employed by instructors today? There is understandable disagreement about the effectiveness of current methods, especially in the areas of computer-based or computer-directed learning. This disagreement seems to be due to the never-ending variety of ways in which computer-directed learning is implemented and used. While there have been some limited successes with computer-based instruction for developmental mathematics, most have not lived up to expectations. Villarreal (2003) stated that computer-directed courses are clearly not meant for the majority of their students. Why is that?

Some studies suggest that most students learn and perform better with direct instruction, especially in a course like developmental mathematics. A computer-directed course may provide good structure, but students cannot ask questions of the computer (Wadsworth et al., 2007). There is no face-to-face interaction that most students are accustomed to. The social aspect of learning is important, and computer-directed courses fail to provide this facet of learning in any meaningful way (Zavarella & Ignash, 2009).

Students in a computer-directed course may have difficulties in interpreting instructions and instructor feedback effectively, thereby diminishing their chances for success (Wadsworth et al., 2007). This phenomenon may be due to "very little research conducted that examines the use of learning strategies and their effects on student learning and achievement in Web-based courses" (Wadsworth et al., 2007, p. 6). When, then, is a computer-based curriculum appropriate for a developmental mathematics course?

This is the one area in which a large portion of the literature is in agreement. A computer component was most successful with learners when integrated as part of a comprehensive program that still includes a traditional classroom lecture and fully integrates all course objectives into the online portion of the course (Perez & Foshay, 2002). Studies show that there is "little specific evidence bearing on the value of computer practice for developmental math students" (Jacobson, 2006, p. 2). Interestingly, students in one study who did do computer-based practice exercises did not perform any better than students who didn't; however, they *believed* it helped them learn (Jacobson, 2006)!

What did seem to help students learn is hybrid instruction. That is, the instructor presented the material, and then the computer software presented the material again (Kinney & Robertson, 2003). Using this in combination with supplemental instruction techniques involving peer or tutor groups, students were better able to think, communicate, and act on their learning (Phelps & Evans, 2006). Villarreal (2003) concluded that "while computer-based instruction has positive effects, it was most successful when it was used as a supplement to regular activities" (p. 74). No study directly stated what seems to be obvious, that is, the instructor is still at the heart of teaching and learning. No matter what software or computer systems are used, the instructor is still the best tool to assist students in their pursuit of mastering the mathematical concepts, critical-thinking skills, and self-efficacy required to continue toward their goal of taking college-level mathematics.

Reading Skills and Developmental Mathematics

"An ability to read, and to learn from reading, is a fundamental academic skill and its importance to scholastic success in any area of study at all levels of education is widely recognized" (Cox et al., 2003, p. 170). This assertion is especially true in mathematics, where concepts must be fully understood and mastered before more new material is covered. Unfortunately, many students enter college as underprepared to read as they are underprepared to do mathematics, and this number has increased dramatically in recent years (Cox et al., 2003).

At least one study has noted that a large percentage of students is dual-developmental, meaning students need both mathematics and reading remediation (Lesik, 2007). It has also been noted that students who have a reading deficiency are much more likely to have additional developmental academic needs than students who are underprepared in other ways, such as in mathematics or writing (Cox et al., 2003).

Several studies suggest that students who cannot read and comprehend will not be able to master the required material for any college-level course successfully, especially mathematics. It is easy to see why a deficiency in reading can present a student with a roadblock that may permanently impair his ability to succeed at the postsecondary level (Cox et al., 2003). Logically, if colleges truly want students to succeed, they should require students to remediate in reading before attempting any other courses. One problem that can plague students is the fact that completing a developmental course in reading clears a hurdle; however, they must continue to improve and keep up, which is another challenge altogether (Cox et al., 2003).

For those students who do successfully remediate in reading, especially those with A-level work, indicators suggest that they will achieve a higher GPA than those students whose work is below the A level (Cox et al., 2003). Further research into the area of reading ability and developmental programs in English have been proposed to see if there is any indication that these programs are effective in student retention (Lesik, 2007). Common sense would dictate that if a student can read well, he would be much less frustrated and able to comprehend any material in a much better way.

A unique study by Eades and Moore (2007) looked at the simple task of note taking to see if there is any improvement in both reading and writing skills in conjunction with developmental mathematics. They proposed that a method of note taking be utilized by students whereby they are required to rewrite and annotate their notes (Eades & Moore, 2007). Rewriting their notes, they surmised, would help students better retain the information, especially when working with mathematical information. They concluded that "note taking and note reviews enhance short-term and longer term recall of lectures and that students' note taking and test scores are correlated" (Eades & Moore, 2007, p. 18). Wright et al. (2002) suggested that combining supplemental instruction with traditional lecture can also help students in their study skills, critical-thinking skills, and most importantly, their reading skills.

Findings in the Literature

From the literature available, it is suggested that a majority of students who begin their college education at a 2-year institution will never earn a baccalaureate degree (Duranczyk & Higbee, 2006). Surprisingly, there is no mention of the goals of these students. It is unclear if these students ever intended to pursue a baccalaureate degree to begin with. Some may simply prefer to obtain an associate's degree to fulfill their educational needs.

However, when it comes to completing developmental mathematics courses, students who delayed taking these courses until later in their college career had the highest failure rate of any group of students (M. Johnson & Kuennen, 2004). One interesting difference between men and women when it comes to delaying developmental mathematics courses is that men were found to be significantly more likely to delay taking developmental mathematics courses than women (M. Johnson & Kuennen, 2004).

Unfortunately, there is no reason provided for this statistic or implication that any research would be conducted to find out why.

There seems to be little literature that looks at the weaknesses of developmental mathematics in general. Most of the studies either look at the students' performance or the manner in which the material is delivered. While this is of use, the primary interest of most study literature focuses on increasing posttest scores for developmental mathematics students by changing the manner in which the material is presented. No one mentions the underlying reasons or initial needs for the change or strives to understand the fundamental flaws in the current teaching methods. As mentioned by an earlier study that involved a collaboration of secondary and postsecondary teachers, more research into the effects of “little changes” might be warranted.

While the literature mostly avoids the topic of weaknesses in current developmental mathematics courses, there is ample documentation of the strengths and need for such education. It should be clear that in the United States, secondary “schools are not providing students with the mathematical background necessary to compete on an international level and become successful adults” (Schornick, 2010, p. 19). For this reason, colleges and universities are left to help students master these skills in order to compete for jobs, both domestically and abroad.

Secondary schools fail to recognize that successful completion of higher level mathematics courses greatly increases a student’s chance of completing a baccalaureate degree (Beaudrie et al., 2007). “Of all pre-college curricula, the highest level of mathematics one studies in secondary school has the strongest continuing influence on bachelor's degree completion. Finishing a course beyond the level of Algebra 2 (for example, trigonometry or pre-calculus) more than doubles the odds that a student who enters postsecondary education will complete a bachelor's degree" (Lundin, Oursland, Lundgren, & Reilly, 2005, p. 19). However, most students have a misconception that since they fulfilled all necessary requirements and graduated from high school, they are adequately prepared for college-level mathematics (Beaudrie et al., 2007). Even worse is that "students get conflicting signals from high schools and colleges about what constitutes adequate preparation" (Fact Sheet, 2011). Simply put, students "no longer know what to expect" (Lundin et al., 2005, p. 18). Since it is obvious that secondary education is, for the most part, failing to properly educate students in mathematics, the need for developmental mathematics at the postsecondary level is greater than ever.

Developmental mathematics is defined as "pre-collegiate mathematics courses that are designed to prepare students for the study of college-level mathematics" (Arendale, 2007, p. 18). While this is the formal definition, most studies strongly emphasize that additional goals for students are to not only master the concepts of mathematics, but also for students to develop the "ability to apply knowledge gained in one situation to solve problems in another, such as using mathematics skills in non-mathematics courses that have a quantitative, problem-solving, logical, or abstract component" (M. Johnson & Kuennen, 2004, p. 24). Wadsworth et al. (2007) added that these skills must be developed reliably so that they can be applied "flexibly and efficiently" to other disciplines as well.

In the literature currently available, one thing is immediately obvious. That is, "postsecondary remediation is a controversial topic" (Bahr, 2008, p. 420). "Although they have completed secondary education, a large number of college students lack the literacy and mathematics skills needed to learn at the postsecondary level" (Perin, 2006, p. 339). Many legislators and postsecondary educators argue that secondary institutions should be held to a higher standard in their preparation of students for college-level work (Bahr, 2008). It has been proposed that students who fail to remediate in mathematics (and other disciplines as well) be required either to return to high schools to master this material or that secondary institutions that fail to properly prepare students reimburse the cost of remediation at community colleges (Bahr, 2008).

One odd statistic was found concerning secondary mathematics education. National test scores on the mathematics section of the SAT and ACT exams have actually risen; however, the number of students entering college unprepared for mathematics and requiring remediation has risen as well (Beaudrie et al., 2007). Even more odd is that there is no explanation for this statistic found in the literature. This anomaly would be a fascinating area for further research.

Remediation courses at community colleges create a tension between access and standards goals (Perin, 2006). On the one hand, colleges strive to maintain their academic standards, but on the other hand they must provide access to students who would otherwise not be able to further their education. One strain on community colleges is that they provide many resources to help students succeed, but only 35% of the students who are required to take developmental mathematics courses actually graduate, compared to 60% of those who do not (Parmer & Cutler, 2007).

Community colleges do provide ample opportunity for students to correct deficiencies by way of developmental mathematics courses; however, "the majority of remedial math students do not remediate successfully" (Bahr, 2008, p. 421). A plethora of reasons are found in the literature. Some of the most recurring reasons for failure to remediate in mathematics include: (a) students lack prior knowledge required to succeed; (b) students are unmotivated to succeed; (c) students begin their remediation work at too high a level; (d) and most importantly, students do not believe that they will succeed.

To help with remediation, Hammerman and Goldberg (2003) listed three important goals that any developmental mathematics course should accomplish:

1. to reverse the negative student attitudes towards the remediation materials.
2. to present the material in a meaningful way that is geared for understanding rather than for pure memorization.
3. to incorporate relevance to the students' lives outside of the classroom in the examples presented during the lectures.

Students may feel as though they are being punished by having to take developmental mathematics courses. It is the instructors' job to make sure that students realize that this is not the case and that it is required simply to prepare them for college-level work. Also, instructors must be sure to fully explain the concepts required for complete understanding of the material. Rote memorization of formulas is not helpful unless a clear understanding of how to apply them is understood. Also, it is of utmost important that students understand how the material is relevant. Otherwise, common sense dictates that "useless" material provides no incentive to learn. Mathematics is not just something that students "just [have] to get through" (Schornick, 2010, p. 21), but a necessary component of many other disciplines as well.

Summary and Conclusion

"All students need a comfortable level of mathematical ability that does not limit life-altering choices, such as the choice of a major" (Hall & Ponton, 2005, p. 28). This statement underscores the intense need to improve the mathematics skills of college students. Unfortunately, students are leaving secondary institutions underprepared to enter college-level mathematics. A major disconnect occurs because students believe that since they have fulfilled all graduation requirements, they are fully prepared for postsecondary courses, especially mathematics. There needs to be better collaboration between secondary and postsecondary expectations by whatever means necessary, including cross-training of instructors in each other's environment.

Instructors not only need to be technically competent in mathematics, but also well versed in instructional techniques as well. They need to be able to engage students and keep their interest in the material. One way instructors can keep the interest of their students is by providing real-world examples that apply to the students' everyday life or choice of major.

Instructors should encourage the use of supplemental instruction, such as peer-led study groups, individual or group tutoring, additional problem-solving exercises, and proper note-taking techniques. All of these have been shown to have at least some improvement in a student's ability to learn and retain material better. Additional instruction may also include a computer-based component to the course.

The area of online or computer-based instruction has exploded in popularity recently. Every institution is touting its online courses and degree programs. However, the effectiveness of computer-related activities is dependent on the type of activity and how it is incorporated into the course.

Purely computer-directed courses fare the worst in educating students in mathematics. In computer-directed courses, all material and problems are presented via a computer interface. Because there is no direct interaction with an instructor, students are often unable to grasp the material in a meaningful way. Also, there is no way for a student to ask questions and receive individualized answers.

Computer-aided instruction did, however, seem to help in some studies. Computer-aided instruction is a "bolt-on" to traditional courses in which the material is originally presented and explained by the instructor, but then re-presented by means of some computer-based system. This allows the students to see the material twice, thereby increasing their chance of mastering and retaining the information. Since classroom lecture and hands-on problem solving are still involved, students get to interact personally with the instructor. In this way of learning, students can ask questions, get quality answers, and receive personalized assistance customized to their specific needs.

It seems that some institutions are substituting computer-based software systems to replace time that could be spent with a quality instructor. While this may not be all bad, students still need the guiding hand of a qualified instructor. A computer is no valid substitute. Most students would probably be quick to say that a computer program helps them to learn. However, some research has shown that a computer program has marginal or no real effect on a student's ability to learn mathematics, regardless of what students believe.

One of the major problems with computer-based learning in mathematics is that there has been little real research into how effective the learning strategies are for a developmental student when it comes to online or computer-based instruction (Wadsworth et al., 2007). From the literature currently available, it appears that many studies include a computer-based component into their developmental mathematics instruction without proper planning and forethought. It should be obvious that any computer-based component must compliment the desired content in a way that students find meaningful. Including computer-based instruction just for the sake of including computer-based instruction seems to provide no learning advantage for the student.

"Over the past 10 years, our nation's students have remained academically stagnant, especially in mathematics" (Schornick, 2010, p. 18). It is left up mostly to the community colleges to help students catch up and succeed in the area of mathematics. Since it is clear that a student's mathematical ability can be a limiting factor in other areas as well as mathematics, the need is dire for quality mathematics instruction.

Even with quality instruction, not every student will succeed. Students may be too far behind to successfully master enough knowledge in the time allowed to proceed to a college-level mathematics course. Interestingly, it is the student's own attitude toward success that is the limiting factor!

The key question remaining is "does developmental math really work?" Bahr aid it best: "Yes, remediation does work for *some* students" or perhaps, "*When* remediation works, it works extremely well" (Bahr, 2008, p. 444). The sad fact is, for most students, remediation in mathematics does not work. "There is no one straightforward, key resolution for helping college students master math" (Eades & Moore, 2007, p. 18). It requires a combination of techniques, and most importantly, time and patience. The community college is at the forefront of the battle to educate students in order to help more people attain a college-level education.

While there are detractors who suggest that higher achievement can be obtained through the attrition of weaker students, it is the weaker students who need help most and have the most to gain (Siadat et al., 2008). It is up to the community colleges to ensure that there is much to gain and that any student who wants to succeed has the opportunity.

Future Research Opportunities

In 2010, a community college in the rural Southeast received the Bellwether award for instructional programs and services (Bassett & Frost, 2010). Beginning in 2007, the college decided to see if it could reconfigure its developmental mathematics course offerings in such a way as to increase posttest scores and retention. While most of this information is available in an article entitled "SMART Math: Removing Roadblocks to College Success" (Bassett & Frost, 2010), some was provided directly by the article's authors in the form on an unpublished electronic presentation (Bassett & Frost, 2013).

The first major departure from the traditional way in which the college's developmental mathematics classes were taught was to divide the currently available three semesters of material into 12 distinct modules that could span *up to* three semesters. Instructors, tutors, pen-and-paper and computer-based exercises, and private coaching were made available in a lab setting. Formerly, students were required to take the two developmental mathematics courses in sequence, regardless of their existing knowledge. Using pretest measurements, students could begin at the level where their deficiencies started. Starting at the appropriate level would help prevent boredom and frustration on the students' part.

Also, students could complete modules as quickly as they liked. After they were confident in their mastery of the module, they could take a posttest to determine if they could continue to the next module. If they failed a posttest, additional resources were available to assist the student to fully understand the material and see where improvement was needed.

The biggest departure from traditional methods of teaching developmental mathematics was to require students to take only those mathematics modules that would prepare them for their chosen major. Since all majors do not require the same level of mathematics knowledge, this reduction helped students to feel that all mathematics they learned would be useful in their chosen field of study. Surprisingly, only seven degree programs required the full complement of 12 mathematics modules. Forty-one degree programs required eight modules or less of developmental mathematics. Since students are now required to take only the mathematics they need, it has improved the completion rate for the college's developmental mathematics program.

In the statistics gathered for the redesigned program, they looked to see if there was an increase in posttest scores and in retention. While the program did show an increase in both, no other statistics or variables were considered.

Of interest would be the impact of their reading comprehension scores, or dual enrollment in a developmental reading course. Their ACT or high school mathematics scores could also be evaluated to see if they have any predictive value for success in their mathematics education. Also, it would be interesting to see what methods of instruction used are perceived as helpful by students as compared to those statistically shown to be significant.

While the list of possibilities is by no means exhaustive, it would be interesting to see if any significant predictors could be determined. Since this program received the Bellwether Award, more statistics could be gathered beyond the basic few reviewed so far.

CHAPTER 3

METHODS

Purpose of the Study

Students are graduating high school underprepared for college-level work, especially in mathematics. In order for students to proceed to college-level mathematics, they must first correct deficiencies from their secondary education by means of developmental mathematics courses. Typically, community colleges must bear the responsibility of remediating students in order for them to be prepared for the rigors of college-level mathematics. Traditional methods of teaching college developmental mathematics courses have been moderately successful, at best, in preparing students for college-level mathematics courses.

One community college in the rural Southeast has changed the method of teaching developmental mathematics courses from the traditional lecture-based approach using problem sets to a more focused approach using modularized mathematics courses. The new method of teaching developmental mathematics, called modularized mathematics, breaks all mathematics topics into 12 discrete modules on which a student can focus, allowing students to master one area of mathematics at a time. Based on the student's pretest results, this approach allows students to take only the modules in which they are deficient and focuses on the skills they truly need to succeed in a college-level mathematics course.

This study examined the success of students under the traditional method and the modularized method of teaching developmental mathematics courses. The purpose of the research was to (a) determine if the developmental mathematics teaching method (traditional teaching method versus modularized teaching method) made a difference in the success rate for students in their first college-level mathematics, as measured by a grade of D or higher; and (b) determine whether any student attribute, or combination of attributes, indicate whether a student has the potential to succeed in the modularized developmental mathematics program. The attributes considered by the researcher were (a) age group, (b) gender, (c) ethnicity, (d) mathematics ACT subscore, (e) county of residence, (f) degree type, and (g) high school grade point average (GPA).

Description and Design of the Study

This study looked at developmental mathematics students from 5 years prior to the teaching method switch to 5 years after the switch. The modularized mathematics courses were introduced on a trial basis in the spring 2008 term, running concurrently with traditional courses for that semester only. In the summer 2008 term, all developmental courses were taught using the modularized approach. Students who took developmental mathematics courses utilizing both teaching methods were excluded from the study. Also, because of the time since the switch, only 5 years of each teaching method (10 years total) were studied to ensure a balanced analysis.

When the researcher viewed and analyzed the data for this study, there were no data that could easily identify any given student. The institution studied provided a randomly generated identifier for each student. This identifier allowed for tracking a student's progress over time without identifying the individual student. The chance of uniquely identifying any student was minimized due to the number of student records studied and the attributes analyzed. There were just over 1,000 records per academic year for developmental mathematics students. During the ten year period studied from spring 2003 to fall 2012, 10,665 students took 16,340 developmental mathematics courses and 1,559 college-level mathematics courses.

In the traditional method of teaching developmental mathematics, there were three possible courses that could be required for students. In the modularized method, students were required to complete at least four modules per semester in order to advance to the next set of modules in the sequence. If a student is required to complete all 12 modules, the student should complete the sequence in a maximum of three semesters, which is comparable to the traditional method. This study reviewed students who were required to take one, two, or all three traditional courses to determine if there were a successful progression from one course to the next, based on a grade of D or higher. For the modularized mathematics courses, this study reviewed students who completed the required sequence of modules, which indicated the progression from one set of modules to the next was successful and the student possibly advanced to a college-level mathematics course.

Data Collection

The data were collected from one community college in the rural Southeast United States by utilizing data already assimilated and maintained in its computer system. The quantitative analysis determined the rate at which students successfully completed their developmental and college-level mathematics courses, and determined if any student attribute or combination of attributes were a predictor for success. Predictors included (a) age group, (b) gender, (c) ethnicity, (d) mathematics ACT subscore, (e) county of residence, (f) degree type, and (g) high school grade point average (GPA).

A member of the Office of Information Technology (OIT) at the institution studied retrieved the data and acted as an assistant to the researcher to ensure anonymity and integrity of the data. Research data were pulled from the existing computer system and provided in a format that can easily be loaded into a database system. This database system interface provided basic analysis and had an export feature for use by the Statistical Package for the Social Sciences (SPSS).

Hypotheses and Research Questions

Research Question 1. Is there a statistical difference in the success rate for the traditional mathematics teaching method and success rate of the modularized mathematics teaching methods, as measured by a course grade of D or higher, for students who progress from a developmental mathematics course to their first college-level mathematics course?

Hypothesis 1. Students who complete developmental mathematics courses using the modularized teaching method perform significantly better in their first college-level mathematics courses as measured by their college-level mathematics course grade, as compared to students completing developmental mathematics using the traditional method.

Research Question 2. To what extent can academic and nonacademic indicators successfully predict completing the developmental mathematics program for each teaching method (the traditional mathematics teaching method and the modularized mathematics teaching method)?

Hypothesis 2. Predicting successful completion of both the traditional and modularized developmental mathematics programs is possible utilizing academic and nonacademic attributes.

Statistical Methods and Data Analysis

The primary method of analysis for this study was quantitative statistical analysis. The Statistical Package for the Social Sciences (SPSS), Version 21, was used to analyze the data in order to answer the research questions outlined above and to determine if the hypotheses were to be rejected. Both descriptive and inferential statistics were used in the analysis of the population. Measures of central tendency (i.e., means, medians, modes, and standard deviations) were used to determine the typical value of each variable. These descriptive statistic values cannot be used for generalizations or predictions.

Students who did not have an ACT mathematics subscore were required to take the COMPASS exam. The COMPASS exam was used to help place students into the correct beginning developmental course. A standard mapping was used to convert the COMPASS mathematics score to an equivalent ACT mathematics subscore for analysis.

For determining if success could be predicted for each teaching method, a binary logistical regression analysis was performed and a prediction equation was derived for the new teaching method using the academic and nonacademic attributes. No formula was created for the traditional teaching method since it is no longer in use. Because many records had missing data, 4,186 records were included in the binary logistic regression analysis. The analysis produced an equation using the 29 independent variables. However, since only six variables were significant at the .05 level, the equation did not work when the non-significant variables were removed. A second binary logistic regression was performed using only the six significant variables to generate the correct coefficients and constant.

A chi-square analysis was performed to determine if there were a statistically significant difference in the success rate for students first college-level mathematics courses, based on teaching method. The cross-tabulation feature of SPSS was used to determine the expected values for each teaching method (see Chapter 4, Table 2). There were 1,559 students who took college-level mathematics courses during the 10-year time period analyzed.

Limitations of the Study

One limitation of the study was the requirement for students to have an ACT mathematics subscore or a mapped score based on the COMPASS test using a standardized score mapping. Any student missing both a COMPASS and ACT mathematics subscore was excluded from the study.

Another limitation was analyzing those students whose developmental mathematics courses were a combination of the traditional and modularized mathematics course teaching methods. These students were a small percentage of the total number studied. In order to keep the study pure, these students were excluded from the study.

Students were allowed to continue a course across semesters if they did not complete the required number of modules. The course that was continued received a grade of PR. Any course record with a grade of PR was removed from the study. Also, any course record with a grade of W (withdrawal) was removed. Only course records with traditional grades of A, B, C, D, and F were included in this study.

Also, data for developmental mathematics students were available from the college being studied for many prior years. However, in order to keep the study balanced, only 5 years of data were analyzed for each teaching method, giving 10 total years of data.

CHAPTER 4

FINDINGS

This chapter describes the demographic data for the participants in this study. Next, the findings pertaining to the two research questions listed below are addressed.

1. Is there a statistical difference in the success rate for the traditional mathematics teaching method and success rate of the modularized mathematics teaching methods, as measured by a course grade of D or higher, for students who progress from a developmental mathematics course to their first college-level mathematics course?
2. To what extent can academic and non-academic indicators successfully predict completing the developmental mathematics program for each teaching method (the traditional mathematics teaching method and the modularized mathematics teaching method)?

Data for this study were obtained from a small community college in the rural Southeast. The informational services staff provided data to the researcher for a ten-year period spanning from spring 2003 to fall 2012. The staff provided five years of data for the traditional teaching method (spring 2003 through fall 2007) and five years of data for the modularized teaching method (spring 2008 through fall 2012). The five years of data for each teaching method allowed for a balanced study and provided a more consistent set of data to analyze.

The data were delivered in three files. The first data file contained information about each student during the research time frame, such as age, gender, ethnicity, ACT mathematics sub-score, county of residence, degree type, and high school grade point average (GPA). The second data file contained a record for each developmental mathematics course taken by each student. The file contained the term and year each course was taken and the grade earned. The third data file contained a record for each college-level mathematics course taken and provided the same information as the second file for each student. All three files contained a unique identification number for each student that allowed the researcher to tie the information together using a relational database management system (RDBMS). The RDBMS allowed the researcher to calculate descriptive statistics and combine data in a very quick and efficient manner.

Upon examination of the data, it was determined by the researcher that certain records must be excluded from the study. First, any student who took developmental mathematics courses under both teaching methods was excluded from the study. Second, any student under age 18 was excluded in order to exclude minors from the study. Third, any mathematics course record with a recorded grade of W was excluded from the study, where W represents that a student withdrew from the course. Last, any developmental mathematics course record with a recorded grade of PR was excluded. A grade of PR was used exclusively in developmental mathematics courses and indicates that a student performed satisfactorily, but did not complete the required number of modules within the semester. The student was required to register for the same course the following semester in order to complete the required number of modules. As is implied in this section, only mathematics course records with a traditional grade of A, B, C, D, or F were included in this study.

In analyzing the data provided, the researcher discovered that several students had taken multiple college-level mathematics courses in the same semester. In this circumstance, the highest grade earned was used in the analysis. Also, for each course record, a new piece of data was added which indicated whether the student was successful in the course. The success indicator was assigned the value of 0 for failure (a grade of F) or 1 for success (a grade of A, B, C, or D). This success indicator was necessary in preparation for both the chi-square analysis and the binary logistic regression analysis.

Participant Demographics

During the ten year period studied, 10,665 students took 16,340 developmental mathematics courses and 1,559 college-level mathematics courses. The researcher was surprised at the small percentage of students who progressed from developmental mathematics courses on to take a college-level mathematics course. Table 1 details the demographics of participants in this study.

Table 1

Participant Demographics

Variable	Frequency	Percent
Age Group		
18 – 24	7,038	65.99
25 +	3,568	33.46
Not Reported	59	0.55
Gender		
Female	7,019	65.81
Male	3,570	33.47
Not Reported	76	0.71
Ethnicity		
White	6,250	58.60
Black	3,035	28.46
Other	1,121	10.51
Not Reported	259	2.43
ACT Mathematics Sub-Score or Equivalent		
< 18	7,646	71.69
18 +	652	6.11
Not Reported	2,367	22.19

Table 1 (continued)

Participant Demographics

Variable	Frequency	Percent
Teaching Method		
Traditional	4,952	46.43
Modularized	5,713	53.57
Degree		
Associate of Applied Science	4,746	44.50
Associate of Arts	403	3.78
Associate of Science	4,030	37.79
Associate of Science in Teaching	253	2.37
Certificate	326	3.06
Non-Degree	461	4.32
University Transfer Program	446	4.18

Table 1 (continued)

Participant Demographics

Variable	Frequency	Percent
County of Residence		
County 1[a]	3,654	34.26
County 2	1,043	9.78
County 3	972	9.11
County 4	700	6.56
County 5	637	5.97
County 6	498	4.67
County 7	482	4.52
County 8	465	4.36
County 9 – 14[b]	1,619	15.19
Other	513	4.81
Not Reported	82	0.77

Note. N = 10,665.
[a]County of college location. [b]Counties 9 through 14 each have less than 400 students.

Statistical Results

The Statistical Package for the Social Sciences (SPSS) version 21 was used to analyze data obtained for this study to provide insight into the research questions posed by the researcher. In order to ensure anonymity of the students in the study, the raw data was seen only by the two assistants who gathered the data from the computer systems at the community college studied and the researcher. As required, each assistant signed a statement of confidentiality to protect the identity of the participants.

Question 1

Is there a statistical difference in the success rate for the traditional mathematics teaching methods and success rate of the modularized mathematics teaching methods, as measured by a course grade of D or higher, for students who progress from a developmental mathematics course to their first college-level mathematics course?

Because of the nature of the data, a chi-square analysis was performed on the data using two variables, method and success. Method was coded as 1 for the traditional teaching method and 2 for the modularized teaching method. Student success was coded as 0 for not successful (grade of F), or 1 for successful (grade of A, B, C, or D). All 1,559 students who completed a college-level mathematics course were included in the analysis. The expected counts were calculated using the SPSS crosstab feature. Table 2 shows the observed and expected cross tabulation of method and success.

Table 2

Observed and Expected Cross Tabulation of Method and Success

	Method 1		Method 2	
Variable	Observed	Expected	Observed	Expected
Success = 0[a]	32	32.7	299	298.3
Success = 1[b]	122	121.3	1106	1106.7

Note. N = 1,559.
[a]Grade of F. [b]Grade of A, B, C, or D.

The chi-square analysis of method and success produced a Pearson chi-square statistic of $\chi^2 = .021$ and $p = .885$. The analysis showed that success is *not* associated with method at the .05 level.

Question 2

To what extent can academic and non-academic indicators successfully predict completing the developmental mathematics program for each teaching method (the traditional mathematics teaching method and the modularized mathematics teaching method)?

SPSS was used to compute a binary logistic regression analysis using the twenty-nine academic and non-academic variables and whether a student was successful in completing their developmental mathematics courses successfully. Table 3 lists all twenty-nine academic and non-academic binary logistic regression variables and their meaning.

Table 3

Academic and Non-Academic Binary Logistic Regression Variables

Variable	Description[a]
ACTscore	ACT math sub-score (1 – 36)
HSgpa	High School GPA (0.000 – 4.000)
Gender	Student's gender (1 = Male, 2 = Female)
AgeGroup	Student's age group (1 = age 18 – 24, 2 = age 25+)
County1	County of residence 1
County2	County of residence 2
County3	County of residence 3
County4	County of residence 4
County5	County of residence 5
County6	County of residence 6
County7	County of residence 7
County8	County of residence 8
County9	County of residence 9

Table 3 (continued)

Academic and Non-Academic Binary Logistic Regression Variables

Variable	Description[a]
County10	County of residence 10
County11	County of residence 11
County12	County of residence 12
County13	County of residence 13
County14	County of residence 14
CountyOther	Other county of residence
RaceWhite	White ethnicity
RaceBlack	Black ethnicity
RaceOther	Other ethnicity
DegreeAAS	Associate of Applied Science degree
DegreeAA	Associate of Arts degree
DegreeAS	Associate of Science degree
DegreeAST	Associate of Science in Teaching degree
DegreeCert	Certificate

Table 3 (continued)

Academic and Non-Academic Binary Logistic Regression Variables

Variable	Description[a]
DegreeNonDegree	Non-Degree seeking student
DegreeUnivTrans	University Transfer program

Note. N = 4,186.
[a]For categorical variables, a value of 1 is used to indicate a member of this group; otherwise, a value of 0 is used.

For each student in the study who completed all required developmental mathematics courses and progressed to their first college-level mathematics course, a variable called Success was added with 1 indicating that a student successfully passed their first college-level mathematics course, and 0 indicating they did not.

A binary logistic regression was performed and six variables were found to be significant at $p \leq .05$. The six significant variables were ACT mathematics sub-score (ACTscore), high school GPA (HSgpa), gender (Gender), age group (AgeGroup), Associate of Arts degree (DegreeAA), and Associate of Science degree (DegreeAS).

Because all variables were included in the prediction equation, the coefficients and constant for the significant variables could not be taken out of context of the larger equation and used by themselves in a new prediction equation. An additional binary logistic regression using only the six significant variables was performed, which yielded adjusted coefficients and a constant, providing a proper prediction equation. The equation produced was:

$$Z = (\text{ACTscore} \times .100) + (\text{HSgpa} \times 1.263) + (\text{Gender} \times .196) + (\text{AgeGroup} \times -1.639) + (\text{DegreeAA} \times .438) + (\text{DegreeAS} \times .268) - 3.412$$

Summary

The purpose of this study was to: (a) determine if the teaching method for developmental mathematics courses was associated with success of the student's first college-level mathematics course; and (b) determine the extent that a prediction equation could be derived for students requiring developmental mathematics courses.

In order to answer the first research question, a chi-square analysis was performed to determine if there were any statistically significant association between teaching method and success of a student's first college-level mathematics course, where success was defined as a grade of A, B, C, or D. The findings show no statically significant relationship between the teaching method and student success at the .05 level.

To answer the second research question, a binary logistic regression analysis was performed to determine if any of the 29 academic and non-academic variables were statistically significant to student success in the developmental mathematics program. The grade of the last developmental mathematics course taken by each student was used in the analysis. Only students who took developmental mathematics courses using the modularized teaching method were included since the traditional method was no longer in use. The prediction equation produced by this analysis will benefit current students.

The binary logistic regression analysis showed that six variables were statistically significant at $p \leq .05$. The six variables (ACT mathematics sub-score, high school GPA, gender, age group, AA degree, and AS degree) were then analyzed using a new binary logistic regression to determine their exact prediction equation coefficients and constant. The analysis produced a reasonable equation which was 87.6% accurate at predicting success, and 70.3% accurate overall at predicting student success in the developmental mathematics program using the modularized teaching method.

CHAPTER 5

CONCLUSIONS AND DISCUSSION

This chapter provides an interpretation of the findings and discussion from this research study. The purpose of this study was to determine if there were any statistical association with teaching method and student success of students who completed developmental mathematics as measured by success in their first college-level mathematics course, where success was determined by a course grade of D or higher.

Also, in order to help determine which developmental mathematics students are least likely to succeed and might need additional academic assistance, academic and nonacademic variables were analyzed to see if any could help predict those students who were statistically unlikely to succeed. The attributes that were analyzed were (a) age group, (b) gender, (c) ethnicity, (d) mathematics ACT subscore, (e) county of residence, (f) degree type, and (g) high school grade point average (GPA). The research questions for the study were:

1. Is there a statistical difference in the success rate for the traditional mathematics teaching methods and success rate of the modularized mathematics teaching methods, as measured by a course grade of D or higher, for students who progress from a developmental mathematics course to their first college-level mathematics course?

2. To what extent can academic and non-academic indicators successfully predict completing the developmental mathematics program for each teaching method (the traditional mathematics teaching method and the modularized mathematics teaching method)?

Research Question 1

Teaching method. The first research question required the researcher to determine the teaching method used for each developmental mathematics course. Any developmental mathematics course taught in the 5 year period from spring 2003 and fall 2007 used the traditional teaching method. Any course taught in the 5 year period from spring 2008 and fall 2012 used the modularized teaching method. Any student who took courses under both teaching methods was eliminated from the study. There were 4,952 students who took developmental mathematics courses utilizing the traditional teaching method and 5,713 students who took developmental mathematics courses utilizing the modularized teaching method.

Student success. For the purpose of this research, student success was defined as a grade of A, B, C, or D. A grade of F was not considered successful. Since the college studied considered any grade of D or higher as passing, this research reflected the same. Overall, the success rate for students in developmental mathematics courses was just above 67%, with the failure rate at just below 33%. This means that at the college studied, 1 in 3 students will fail their developmental mathematics course.

For the 10,665 students who took developmental mathematics courses, the success rate for females was almost 70%, while the success rate for males was just above

62%. The success rate for whites was slightly above 72%, while the success rate for blacks was almost 58%. The success rate for students over age 24 was higher at slightly over 74% and the success rate for students age 18 to 24 was just below 64%.

For the 1,559 students who progress to a college-level mathematics course, the success rate was much higher at almost 79% overall, which indicated that students who do continue on to college-level mathematics succeed at a much higher rate. However, the reasons for the higher success rate in college-level mathematics courses remain unknown.

Analysis. Since only the letter grade for each of the 1,559 students who progressed from the developmental mathematics program to a college-level mathematics course was available, a chi-square analysis was the only available statistical method to determine if there was an association between the teaching method and student success. A chi-square analysis was performed using SPSS that produced a Pearson chi-square statistic of $\chi^2 = .021$ and $p = .885$. Since $p \geq .05$, the researcher accepted the null hypothesis that success is not associated with method. This suggested that the teaching method utilized in the developmental mathematics courses had no impact on the student's success in their first college-level mathematics course, so the researcher rejected the research hypothesis that success could be associated with teaching method.

Research Question 2

The college studied maintains an electronic database containing many academic and nonacademic variables which needed to be included to determine if any could be used to predict whether a student would be successful in the developmental mathematics program. This would help the administration and faculty intervene as necessary to help those students who were predicted to be unsuccessful in their coursework.

During the initial investigation phase of this study, many variables were identified that might prove significant. Many variables, like major for example, were too numerous to include. The majors were classified into seven different degree types which were included in the analysis. One faculty suggested that the high school a student attended might be a predictor, but again proved to be too numerous to include in the analysis. Instead, the county of residence was included even though there might be several high schools of varying quality in one county. Other more obvious variables were included, such as ACT mathematics subscore (or equivalent based on a mapping conversion from COMPASS score), high school GPA, gender, age group, and ethnicity.

Because the traditional method of teaching was no longer used, no analysis of these students was performed to see if a prediction equation could be produced. Only students who took courses using the modularized teaching method were included. Of the 10,665 total students included in the study, 5,713 were students who took 8,614 developmental mathematics course offerings using the modularized teaching method. However, since many students took more than one course, only the grade from the last course was used to determine if the student was successful in the program. Success was defined consistently with the chi-square analysis where a grade of A, B, C, or D represented a successful outcome.

A binary logistic regression was performed with success defined as the predictor variable. All variables except ACT mathematics subscore and high school GPA were defined as categorical covariates. Because of missing data, only 4,186 of the 5,713 records were included by SPSS in the analysis. Six variables were significant at the $p \leq .05$ level. The six variables were ACT mathematics subscore, high school GPA, gender, age group, Associate of Arts degree, and Associate of Science degree.

Since the prediction equation produced by this analysis contained coefficients for each of the twenty-nine variables, the equation was unusable. A second binary logistic regression was performed using only the six significant variables which produced a valid equation. During this analysis, all variables were significant at the $p \leq .01$ level. According to SPSS, the equation produced for this student data was correct at predicting success over 87% of the time, correct at predicting students who would be unsuccessful almost 39% of the time, and correct overall just above 70%. The prediction equation produced was:

$$Z = (\text{ACTscore} \times .100) + (\text{HSgpa} \times 1.263) + (\text{Gender} \times .196) + (\text{AgeGroup} \times -1.639) + (\text{DegreeAA} \times .438) + (\text{DegreeAS} \times .268) - 3.412$$

Limitations

This study was conducted at one small community college in the rural Southeast. This study and the resulting statistics cannot be generalized to other colleges, teaching methods, or student populations. While there were 10 years of data, 5 years for each teaching method, the data was sequential and not consecutive. The two teaching methods could not be compared side-by-side during the same time period.

Another limitation of the study was the quality of the data provided by the college. During the time frame studied, much data was incorrectly entered into their computer system or missing entirely. Any data which fell outside normally accepted values was excluded from the study. For example, high school grade point averages greater than 4.0 were excluded.

Conclusions

Research outcomes from this study suggest that the success of students in their first college-level mathematics course had no association with the method in which the developmental mathematics courses were taught. These findings are consistent with other studies, such as Frost et al.(2009) who concluded that there was no one solution for helping students succeed in a developmental mathematics program. The college studied had implemented computer labs to help with the pace of learning for students as they progress through the 12 defined modules. Johnson (2007) suggests that while students may *think* computer-based learning helps, there is little evidence of this. This study reinforces this conclusion based on the results of students' first college-level mathematics courses. While much effort was put forth by the college studied to improve student's ability to succeed in college-level mathematics, the changes implemented have so far not provided any statistical improvement in student success.

While the teaching method used in the developmental mathematics program has not yielded the results hoped for by the researcher, the analysis of academic and nonacademic variables might prove useful in helping students be successful in developmental mathematics courses. This could lead to more students progressing into college-level mathematics.

Implications for the Educational Community

Finding from this study indicate that there was no difference in the student success rate for their first college-level mathematics course based on the teaching method employed by the developmental mathematics courses. However, this should *not* be a deterrent for change. A bold and radical change was implemented by the college studied in hopes that it would have a profound impact on student success. While the impact may not have been as dramatic as expected, the college did implement an exciting program. The program has drawn interest from other colleges and received a national award (Bassett & Frost, 2010). The faculty and administration of the college studied have now devoted many years to the modularized teaching method and will hopefully continue to do so.

Recommendations for Future Research

The first recommendation is to follow up with the college studied to see how well the prediction equation developed from this research analysis has performed. As more students progress through the developmental mathematics program, the more data that will be available for use in refining the equation. The more accurately student success can be predicted, the better the college can be in helping those students whose variables indicate they might not succeed.

Another recommendation is to determine if any other colleges have implemented the modularized teaching method and to perform statistical analysis on their data to see if their results differ from this research. If the modularized teaching method has been implemented by other colleges, it should be determined if any changes were made that would affect student success.

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