SUBSEQUENT COURSE PASS RATES IN MODULARIZED DEVELOPMENTAL MATHEMATICS COURSES IN SELECT COMMUNITY COLLEGES IN NORTH CAROLINA: THE DIFFERENCES BETWEEN TEACHER-CENTERED, STUDENT-CENTERED, AND COMPUTER-CENTERED DELIVERY

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Tammy J. Bishop

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DEDICATION

This dissertation is dedicated to my parents, Joseph and Virginia Roberts, who instilled in me from an early age that education was important. Higher education was never an option, but rather an expectation. Because of this emphasis on education and its importance I have been able to continue my pursuit of education throughout my life and encourage many other students to do the same. Each of them had their own unique way of supporting me and living an example of perseverance. I am truly grateful for all that they have done for me.

ABSTRACT

Bishop, Tammy J., *Subsequent course pass rates in modularized developmental mathematics courses in select community colleges in North Carolina: The differences between teacher-centered, student-centered, and computer-centered delivery*. Doctor of Education (Developmental Education Administration), December, 2016, Sam Houston State University, Huntsville, Texas.

Throughout the past decade the structure of developmental education courses and teaching methods has been changing in order to try and improve success rates of students in developmental education courses and beyond. Course redesigns have taken place throughout the country. The modularized, mastery redesign for developmental mathematics of the North Carolina Community College System was examined in this study. The purpose of this study was to compare the subsequent gateway course success rates of the pre- and post-redesign courses, as well as compare rates of the post-redesign courses based on the delivery method used. Delivery methods compared were teacher-centered, student-centered, and computer-centered. Data showed that there was no statistically significant difference in the subsequent gateway course success rates based on the design of the course. However, data did show that the student-centered and computer-centered delivery methods, which both use indirect instruction, have a statistically significant difference in subsequent gateway course success rates when compared to teacher-centered instruction.

KEY WORDS: Developmental mathematics, Course redesign, Direct instruction, Indirect instruction, Subsequent course success rates

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CHAPTER I

Introduction

In 2011, the North Carolina Community College System (NCCCS) redesigned the developmental mathematics (DMA) curriculum. The three semester sequence was condensed into eight, 4-week, mastery-based units of study (NCCCS, 2013). These new courses were implemented in a phased roll-out beginning spring 2012 and ended with a system wide implementation, fall 2013. The new courses were implemented based on published course learning outcomes, curriculum guidelines, and instructional design outlines included in the NCCCS Common Course Library, posted on the SuccessNC website (NCCCS, 2011c), and approved by the NCCCS Curriculum Committee. The DMA courses were designed, and guidelines written, by an 18 member Developmental Math Task Force (NCCCS, 2011a). Open to many different interpretations and implementation styles at the 58 different community colleges in the system, research is needed to determine to what extent the redesign improved the subsequent gateway course success rates and investigate the impact that a particular delivery method may have on those success rates. Teacher-centered (Kirschner, 2009), student-centered (Tobias & Duffy, 2009), and computer-centered (NCAT, 2013) instruction are the predominant forms of instruction used in the redesigned courses (Kalamkarian, Raufman, & Edgecombe, 2015). All three methods will be examined in this study.

Background of the Study

In 2009, the Community College Research Center conducted a study on North Carolina Community College System developmental mathematics courses (NCCCS, 2011a). The findings of the study were that only 8% of students referred three levels or more below the mathematics gateway course actually passed the gateway course. Most students failed to complete the sequence by not enrolling in the next course. Using this information, the state Developmental Education Initiative (DEI) committee led the charge for a state redesign by writing new design principles. The principals changed the existing sequence of courses into a system of modules, accelerating the curriculum in order to shorten the time required in developmental education (NCCCS, 2010). The pedagogy of the new courses focused on conceptual, contextual, discovery, and mastery learning (NCCCS, 2011b).

The three semester long sequence of developmental mathematics courses was reduced to eight 4-week modules that can be completed in one year, based upon the Developmental Mathematics Guidelines distributed by the North Carolina Community College System (NCCCS, 2011c). Austin and Gustafson (2006) evaluated different time-frames for accelerated courses and determined that the 4-week timeframe works best. Overlap of material was eliminated and multiple points of successfully exiting developmental education were established, based upon the curriculum level course that was needed for a program of study. Students take the North Carolina Diagnostic and Placement Test (NC-DAP) and are assigned only to the modules that they need (NCCCS, 2013). The course is graded on a mastery system of 80%. Each college decided how they determine the 80% grade, but at least 90% of the grades are from proctored exams (NCCCS, 2011c). Students that do not meet the 80% mastery requirement are immediately re-enrolled in the same module for the next four weeks. Hence, students are not getting bogged down in repeating long courses, but instead immediately repeating the 4-week course they did not master. The shortened class lengths allow students to repeat courses in the same semester, rather than waiting 16-weeks to repeat a course. Students needing three 4-week math modules can repeat one module and still finish in a semester. Consequently, students are able to move on to curriculum courses faster. The local colleges were given the responsibility to determine the delivery method and instructional design of the course that was conducive to the local college structure. The results of this study gives colleges information about the level of success at teacher-centered, student-centered, and computer-centered institutions.

Statement of the Problem

Underprepared students are testing into developmental education at an extremely high rate, but few successfully complete the gateway course (Bailey, 2008; Bailey, Jeong, & Cho, 2009). Using Achieving the Dream (AtD) data, Bailey (2008) stated that only 31% of students referred to developmental mathematics completed the courses in their sequence in three years. In a similar study, Bailey et al. (2009) reported that 33% of those referred to math completed the courses in their sequence. Bailey et al. indicated that only 20% of students referred to developmental mathematics completed their gateway course within three years after they first enrolled in a developmental course. In 2009, the Community College Research Center conducted a study for NCCCS on their Developmental Mathematics Courses (NCCCS, 2013). The findings of this study were that only 8% of students referred three levels or more below the gateway course actually passed the gateway course (NCCCS, 2011b, 2013). Many of the students passed their courses along the path, but failed to enroll in the next course. The multiple levels in the sequence created exit points for students and an opportunity for them not to re-enroll.

From these studies (Bailey, 2008; Bailey et al., 2009) and a listening tour of the NC system community colleges, NCCCS formed the DEI Committee (NCCCS, 2013). As a result of work by the DEI committee, the decision was made to redesign developmental mathematics coursework into individual units of study (NCCCS, 2013). In 2011, the math redesign, led by a group of 18 faculty members from system community colleges (NCCCS, 2011a), developed eight developmental math modules that could be completed in one year (NCCCS, 2013) and produced a guide containing the outline, competencies, and examples of questions for each module (AtD, 2011; NCCCS, 2011c). These modules were initially implemented during spring 2012 at select colleges, and system-wide during the next three semesters with full implementation in fall 2013 (NCCCS, 2013).

Low completion and subsequent course success rates in gateway mathematics coursework reinforced the notion that the status quo sequence system was not working well, and that a redesign of developmental mathematics was needed (Ginsberg & Wlodkowski, 2009; Jaggars & Stacey, 2014). Yet little is known about the long-term success of students taking gateway courses (Saxon, Martirosyan, Wentworth, & Boylan, 2015), particularly subsequent gateway course success rates for students who took the NC redesigned developmental courses. Subsequent gateway mathematics course success rates from prior to the developmental mathematics redesign need to be compared with the success rates of students who participated in the redesign (Edgecombe, 2011). In addition, the redesign was completed with a committee of 18 faculty members representing only 18 community colleges. Forty statewide community colleges implemented the redesign based upon a written document, implementation workshops, webinars, and discussions with task force members. Also, each community college decided the instructional design and delivery method best for their college for the new developmental mathematics classes. Delivery methods include teacher-centered, student -centered, and computer-centered instruction. Evaluation of subsequent gateway course success rates compared to the delivery method used at each college will provide information on the effectiveness of each delivery method and identify any emerging best practices.

Purpose of the Study

The purpose of this study was to evaluate the effectiveness of the NC redesign in improving subsequent gateway course success rates among students who took the redesigned 4-week developmental mathematics courses versus the prior 16-week courses. Twelve community colleges from the North Carolina system were chosen to participate in this study. One purpose of the NCCCS redesign of developmental coursework was to increase the subsequent course pass rate for developmental education students completing the curriculum gateway course. Evaluating the success of students in subsequent courses is essential in determining the effectiveness of the new structure and success of the implementation.

Gateway course success rates were also compared by delivery method (i.e., student-centered, teacher-centered, or computer-centered) used at each college to ensure course effectiveness. The curriculum guidelines written by the math task force assumed that subsequent course rates for each delivery method would be similar. In addition, data was analyzed to see if any best practices emerged. Findings of this study provided information on the efficacy and emerging best practices for modularized developmental mathematics courses requested by practitioners. This analysis was important because colleges were given the flexibility to design the courses, using the instructional design that was conducive for the local college. This allowed for many different interpretations of the implementation guidelines and multiple delivery methods. Comparison of individual delivery designs, in conjunction with an evaluation of subsequent college course success rates, was necessary in order to evaluate the effectiveness of the redesigned courses and compare whether a particular delivery style showed larger increases than another.

Significance of the Study

Redesigned developmental mathematics courses in North Carolina are fairly new. The first implementation for DMA math courses occurred in fall 2012, with system-wide implementation in fall 2013 (NCCCS, 2013). This study reports on the success achieved through North Carolina's redesign efforts in relation to subsequent course success rates and delivery methods. Because redesign nationwide is relatively new, many states across the nation are waiting to review research on the effectiveness of early redesigns before making any changes. This study provides data regarding the success of the redesign in the North Carolina Community College System, one of the early adopters of this approach. This study reports the subsequent course success rates for students who participated in developmental courses within one year of taking their gateway course. Subsequent course success rates are reported collectively for each delivery method. The collective data was used to compare the overall success of each delivery method.

Information regarding effective teaching practices will be available to state and national leaders. Evaluation of subsequent course success rates for different delivery methods will help determine the effectiveness of each individual course design. Identifying delivery methods that show promise can help struggling colleges make changes in their design and delivery of the new courses, or validate approaches used. Colleges with a similar delivery method could work together to improve outcomes and/or tweak the design.

State and local policy may be impacted based on the results of the comparison. If some identified delivery method is overwhelmingly effective in increasing success rates, then guidelines could be rewritten. Locally, the identification of promising delivery methods could lead individual colleges to modify their redesign or adopt additional or different practices into their redesign. The findings from this study will be useful to the North Carolina Community College system and the 58 individual colleges within it.

Theoretical Framework

The NCCCS redesign involved more than just developing new courses; rather it required completely changing how information is learned in the developmental mathematics classroom. The new structure and pedagogy relies on a deep conceptual understanding of mathematics by the student, rather than just skill and drill demonstration. Constructivist theory takes this type of classroom design into account, by designing activities that simulates learning through prior experience (Karagiogi & Symeou, 2005; Pang 2010). Therefore, the constructivist theory was chosen as a framework for this study.

Constructivism is a “theory of comprehension and learning” (Kintsch, 2009, p. 234), and is rooted in both philosophy and psychology, having ties to behaviorism theory (Fletcher, 2009). Prominent researchers took into account “internal, constructivist, cognitive processes" that are involved in learning (Fletcher, 2009, p. 245). John Dewey supported the idea of student involvement in their learning, and the creation of such learning environments (Fletcher, 2009). Behaviorism and constructivism should be seen as "complementary approaches in the pragmatic business of designing, developing, and delivering instruction" (Fletcher, 2009, p. 257).

Constructivist theory takes comprehension and learning one-step further adding the additional element that students control how and where learning takes place. "Constructivist theory is based on the view that learners are active processors of content, in control of their own learning and are active agents assuming responsibility and management for in their own learning process" (Pang, 2010, p. 30). In the construction of knowledge, students also learn basic strategies and study skills that they can transfer to other, more complex situations. An example of a strategy is time management, where a student learns the time that it takes to present a quality product and how to budget that time into their schedule.

The instructional design of constructivist type courses are student-centered, focused on student engagement, collaborative, and present multiple perspectives of a problem (Karagiogi & Symeou, 2005; Kintsch, 2009). Such activities may include group work, peer teaching (Ginsberg & Wlodkowski, 2009), and even properly constructed drill and practice activities (Fletcher, 2009). These types of activities allow students the opportunity to understand how they learn, because each person constructs knowledge differently (Ertmer & Newby, 1993; Ginsberg & Wlodkowski, 2009; Karagiorgi & Symeou, 2005). Working together on common problems or having a problem explained by a peer helps everyone involved in the process to learn (Ertmer & Newby, 1993).

Research Questions

The following research questions were addressed in this study:

1. What is the difference in subsequent course pass rates (students making a C or better) in gateway math courses for former developmental math students based on the type of developmental mathematics course completed (4-week versus 16-week)?

2. What is the difference in subsequent mathematics course pass rates in gateway math courses among students in teacher-centered, student-centered, or computer-centered 4-week developmental mathematics courses?

Null Hypotheses

H_{01}: There is no statistically significant difference between the subsequent course pass rates (students making a C or better) in gateway math courses for former developmental math students based on the developmental mathematics course completed (4-week versus 16-week).

H_{02}: There is no statistically significant difference in the subsequent mathematics course pass rates in gateway math courses among students in teacher-centered, student-centered, or computer-centered 4-week developmental mathematics courses.

Definition of Terms

Acceleration. Acceleration is an instructional design technique that is described "as the reorganization of instruction and curricula in ways that facilitate the completion of educational requirements in an expedited manner" (Edgecombe, 2011, p. 4).

Achieving the Dream (AtD). Achieving the Dream is a "comprehensive non-governmental reform movement for student success" that is working to improve institutional policy and practice by helping institutions make informed decisions based on evidence (AtD, 2016).

Active learning. Active learning is an instructional technique that requires students to engage in the exchange of ideas with other students and the instructor to resolve a problem (Karagiorgi & Symeou, 2005; Osterholt & Barratt, 2010). Active learning is also referred to as student-based learning, inquiry-based learning, self-directed learning, cooperative learning, collaborative learning, and group work (Bandura, 1993; Boylan, 2011; Kirk, n.d.; Wilkins, 2008).

Collective efficacy. Collective efficacy is the collaboration between instructors in a department that helps to establish a belief that what the department is doing is making a difference in the lives of students and promoting student success (Protheroe, 2008).

Collaboration. Collaboration is in instructional strategy used predominately in student-centered classrooms. This strategy requires instruction to focus on constructing meaning from interactions with others and/or personal inquiry into the subject (Edwards & Beattie, 2016), and focuses on student-to-student discussion, rather than instructor lectures (Osterholt & Barrett, 2010).

Computer-assisted instruction. Computer-assisted instruction is an active learning strategy that includes emporium, online courses, or instruction supplemented with computer software (Zavarella & Ignash, 2009). Computer software is used outside of class in supplemental designs, and as part of class in integrated courses, as a complement to instruction (Epper & Baker, 2009).

Computer-centered instruction. Computer-centered instruction is where the focus of learning and attainment of knowledge is done via the computer and the student learns from the computer. The Emporium design (defined later in this section) is considered computer-centered instruction in this study.

Conceptual learning. Conceptual learning is the instruction that promotes the development of a deep understanding of a concept and is described as a "relationship with mathematics characterized by considering the act of making meaning as the goal for accurate mathematical work" (Gresalfi & Lester, 2009, p. 270).

Constructivist learning. Constructivist learning is based on the constructivist theory that designs activities to simulate learning based on prior experiences, and relies on the premise that students are in control of their own learning (Karagiogi & Symeou, 2005; Pang 2010).

Contextual learning. Contextual learning is an instructional technique used in order to develop "a type of knowledge that includes knowledge of the content and/or situations in which it is or will be useful" (Kirschner, 2009, p. 148).

Delivery method. Delivery method is the instructional design used for teaching and learning at a particular institution in this study. Classroom instruction uses either a teacher-centered, student-centered, or computer-centered delivery method.

Developmental Mathematics (DMA). Developmental Mathematics courses are the remedial mathematics courses that are offered as a refresher for students not yet ready for curriculum level mathematics courses.

Direct Instruction. Direct instruction is the instructional technique that is used when the instructor tells the student all the information that is needed in order to perform a task, before allowing the student to try the task on their own (Sweller, 2009).

Emporium. Emporium is a term to describe computer-centered courses where students view lessons and complete work individually on the computer throughout the class period (NCAT, 2013).

Indirect instruction. Indirect instruction is when students are given the appropriate background information to learn a concept and then given the opportunity to figure out and master that concept on their own, using the information they are given and any prior knowledge (Wise & O'Neill, 2009).

Instructional design. Instructional design is the process of developing an instructional plan from the principles of learning and the techniques that will be used for instruction. This includes resources, activities, materials, and the evaluation process that will be used in the implementation of the design (Smith & Ragan, 2005).

Instructor Efficacy. Instructor efficacy is an instructor's belief system where instructors believe that all students can learn and they have the ability to help all students learn (Goddard, Hoy, & Hoy, 2000).

Mastery learning. Mastery learning is an instructional technique that requires students to obtain a certain level of learning before moving on to the next topic. Topics are divided into individual units of study and students learn, assess, remediate, and assess again until the required level is obtained (Guskey, 2001).

Modularization. Modularization is an instructional design technique that breaks up learning objectives into smaller discrete units of study that concentrates on a single concept (Nodine, Dadgers, Venezia, & Bracco, 2013).

Motivation. Motivation is a student behavior exhibited when a student has a reason to participate in a particular experience (Middleton & Spanias, 1999).

Redesign. Redesign is the instructional change in course structure, curriculum, student learning outcomes, and pedagogy in developmental education. This change in structure is referred to as redesign in North Carolina, as well as other projects nationwide (Hayward & Willett, 2014; Kalamkarian et al., 2015; NCCCS, 2013).

Remediation. Remediation is an instructional technique that is used in mastery learning. Once students are assessed, specific instructional plans are developed in order to correct deficiencies in student learning, so mastery can be obtained (Guskey, 2001).

Scaffolding. Scaffolding is an instructional strategy that is the process of giving students the help they need, as they need it, and removing that help when they are ready to do as much of the work as they can on their own (Clark, 2009; Rosenshine, 2009; Tobias & Duffy, 2009; Wlodkowski & Ginsberg, 2010).

Self-efficacy. Self-efficacy is a belief system, wherein the student believes that their actions will have an impact on the outcome of an event (Bandura, 1999).

Self-regulated learning. Self-regulated learning is the internal process of a student that allows them to change their own learning behaviors in order to be academically successful (Zimmerman, 2008).

Student-centered instruction. Student-centered instruction is where the focus of learning and attainment of knowledge is via interactions that the student has in class with both the instructor and other students.

Subsequent gateway course. The subsequent gateway course is the first curriculum level course that a student is required to take for their course of study.

Teacher-centered instruction. Teacher-centered instruction is where the focus of learning and attainment of knowledge is via the instructor and information that the instructor gives to the student.

Volition. Volition is a student behavior and is the "persistent striving and navigation of obstacles" in order to accomplish a goal (Corno, 2008, p. 199). This process involves a series of decisions made after an evaluation of the learning situation (Zimmerman & Schunk, 2008).

Limitations

Factors that are out of the control of the researcher include the fact that colleges are self-reporting their delivery method, the time frame to gather data is short, and only the North Carolina redesigned developmental mathematics courses are being evaluated in this study. Colleges that were chosen to be part of this study self-reported on the type of delivery method that they implemented in the year that is being compared. Even though care was taken to clarify any misunderstandings in the questionnaire, assumptions by the individual college, as to what delivery method is used, could lead to categorizing a college with the wrong method. Also, the fact that only one year is being compared could affect the results of the study. This study evaluates the first full year of implementation. It is possible that a study done with only the first year of data will be different than a study using four or five years of data, because of variables and changes that naturally occur during the first year of implementing a new curriculum. This limited time frame is due to the fact that the North Carolina developmental mathematics courses have only been offered since 2012. North Carolina also implemented a new Multiple Measures policy (NCCCS, 2013) in 2013 which changed the population of students taking developmental mathematics. Not all colleges implemented this policy, but some did. Lastly, because only North Carolina redesigned developmental mathematics courses are being used in this study, and the purpose is to determine if a particular delivery method is better than another in the redesign, the results may not be generalizable to other instructional designs in other states or systems. Also, this study is not evaluating external factors such as motivation, self-efficacy, and instructor efficacy as possible factors influencing student success in developmental mathematics courses.

Delimitations

This study focused on a limited number (12) of NCCCS colleges, and included only those who are using either a teacher-centered, student-centered, or computer-centered approach. For this study the researcher chose to use the definition of Emporium style for the characteristics of a computer-centered classroom. Designs that incorporate computer work as a supplement to the class or integrate it into instruction time were classified as the delivery method used when not working on the computer. Also, the research questions were chosen to only evaluate students who had completed their developmental mathematics courses during the same or previous academic year and at the same college where they enrolled in the subsequent gateway mathematics course to match the North Carolina Performance Measures during that time (NCCCS, 2013).

Hence, archived data from the NCCCS was used, along with a questionnaire that representatives from participant colleges used to self-report on the delivery method used in their redesigned mathematics courses.

Assumptions

The redesigned North Carolina Developmental Mathematics (DMA) courses were dispersed to the North Carolina community colleges through a printed document written by the Math Task Force that included the student learning outcomes. Implementation workshops provided information and training of the new courses. It was the assumption of the researcher that all colleges that participated in this study were following the student learning outcomes and curriculum design of the DMA courses. Additionally, it was assumed that the contact person from each college was knowledgeable about the delivery method at the college and honest about their comments on the questionnaire.

Organization of the Study

This dissertation is organized into five chapters. The first chapter includes the introduction to the study and research questions, explains the purpose of the study and theoretical framework, defines terms used throughout the proposal, and discusses limitations and delimitations of the study. Chapter II reviews the literature that is associated with the study and summarizes how each of the different instructional techniques, methods, and external factors affect the amount of learning that takes place in the classroom. Chapter III describes the method of the study, including participants, data source, and procedure. Chapter IV shares the results of the study. Chapter V discusses the implications of the study and recommendations for further research.

CHAPTER II

Literature Review

As the movement for instructional redesigns of developmental mathematics is surging forward, this chapter reviews the North Carolina Community College System's (NCCCS) redesign of developmental mathematics. Included in this review is a background on the rationale for the redesign, information on the NC redesign, an explanation of the types of instruction and delivery methods, external factors that could influence learning, including motivation, self-efficacy, and instructor efficacy, and the review of existing studies related to these factors. This review is meant to provide information about what is happening in NC and the three dominant delivery methods used, not to advocate for a particular method.

Background

In 2004 the Lumina Foundation began the Achieving the Dream (AtD) initiative, and during 2004, 2005, and 2006 awarded 57 colleges $450,000 each. An AtD college was required to collect data, identify areas of weakness at their college, and develop and implement reforms in their developmental education programs (Zachry, 2008). The data collected by these institutions was placed into one national database, and studies measuring the effectiveness of developmental education were conducted using these data. Some of the studies focused on the success of developmental education students as they progressed through developmental education course sequences to graduation (Bailey, 2008; Bailey et al., 2009; Jaggars & Stacey, 2014; Zachry, 2008). Bailey (2008) concluded that only 31% of students referred to a developmental mathematics completed the courses in their sequence. Bailey et al. (2009) found that only 20% of students referred to developmental mathematics actually completed their gateway course. Jaggars and Stacey (2014) reviewed data from 57 colleges and found long sequences to be "leaky" (p. 4), and concluded "the traditional system of developmental education is not achieving its intended purpose" (p. 6). Results after the initial AtD rounds also showed that local redesign efforts did not increase success rates on a large scale (Clancy, 2013). Edgecombe, Cormier, Bickerstaff, and Barragan (2013) wrote that small scale redesigns only affected a few students, and teaching and learning were much the same in many of the redesigned courses. Reform on a larger scale, involving a change in pedagogy, was needed to show increases in success and completion.

These data showing minimal changes in developmental education on the local level prompted the Lumina Foundation and the Bill and Melinda Gates Foundation to combine efforts into a Developmental Education Initiative (DEI, MDC, n.d.). Of the round one and two AtD states, five states were chosen to "move more deliberately to support institutional and state efforts to improve outcomes for the large number of students who enter community college in need of developmental courses" (MDC, n.d., p. 6). NCCCS was one of the five state systems chosen and decided to redesign their state developmental courses (NCCCS, 2011b).

North Carolina Redesign

Modularization was used in the NC math redesign and broke the concepts into individual units of study (NCCCS, 2011b), requiring mastery to be obtained for all concepts needed to succeed in the subsequent gateway course (McTieran, Palmer, & Fulton, 2013). The focus on mastering the material before moving on to the next concept ensures that students fully understand all the concepts needed to succeed in the subsequent gateway course. Each of the eight, 4-week courses focuses on one topic of study with specific student learning outcomes. This shortened course length allows students to study and master one topic at a time, with a shorter time frame for forgetting mathematics concepts in between courses (Edgecombe, 2011). If a student needs to repeat a course, he/she can repeat right away, not waiting until a new semester starts. Only the material not mastered would be repeated, rather than a full 16-week course. Promotion to the gateway course is no longer contingent on an average understanding of the background material, but rather mastery of everything (NCCCS, 2011c). Students enter the gateway course with a stronger foundation.

The course redesign was more than a structural change, based on data showing attrition in long sequences, but also a pedagogical change, incorporating elements that had been shown to increase success. These changes challenged students to learn through inquiry, increased rigor in the coursework, and engaged students in the learning process (Barragan & Cormier, 2013; Carnegie Foundation, 2008; Kirschner, 2009; McTieran et al., 2013; Mesa, 2012). Jaggars, Hodara, Cho, and Xu (2014) stated that “curricula and instruction that lack rigor and relevance may create an insufficient foundation of key concepts and skills necessary for success in subsequent coursework” (p. 3). The redesigned courses included several different teaching and learning techniques: modularization, acceleration, mastery learning, conceptual learning, contextual learning, and active learning strategies which included collaboration and computer-based instruction (Bailey et al., 2009; Bonham & Boylan, 2011; Fletcher, 2009; Gresalfi & Lester, 2009). Guidelines and policies for the implementation were designed, written, and distributed to all NCCCS colleges prior to implementation by the NC DEI math task force who redesigned the courses (Edgecombe et al., 2013; NCCCS, 2011c).

Modularization. Modularization has many advantages for students when the material is broken into individual units of study (NCCCS, 2010; Nodine et al., 2013), and requires mastery to be attained in order to proceed to the next module (McTieran et al., 2013). Modularization allows students to move more quickly and intentionally to credit-bearing coursework (McTiernan et al., 2013), only taking the units that they need for their program of study. Students may exit the sequence once they master the topics required, rather than when the semester ends.

Because the material is broken up into discrete units, students earn credit for the material they have mastered, rather than having to master multiple topics in order to receive any credit (NCCCS, 2011a). Since students earn credit for each topic they master and are only repeating topics not mastered right away, they accumulate credits and qualify for the gateway course faster. In the 16-week course design students may have mastered the first two topics, but received no credit because they did not master the last two. This would result in the student receiving no credit and having to repeat all 4 topics even though they mastered two. If they passed the course the next semester they would have four credits at the end of two semesters. In the 4-week course structure the student would receive credit for the two they mastered. The student would be forced to repeat the first topic they did not master right away. In this system they could potentially pass the third topic in the last 4-weeks and end the semester with three credits instead of no credits. They would pick up where they left off in the next semester.

The frustration of being unprepared for new material or waiting for a new semester to begin is eliminated. When a student does not master a topic they repeat the material right away, rather than progressing into material that requires pre-requisite knowledge they have not attained. In this new system topics can be repeated right away, so there is no time delay in waiting for classes to start (NCCCS, 2011c). This combination of earning credits as topics are mastered and repeating topics right away keeps the student progressing through the sequence and moving toward the requirements to take their gateway course. At no point during the sequence will a student repeat topics they have mastered, be exposed to topics they are not prepared to take, or experience wait time in their progress.

In addition, individual units make it possible to customize pre-requisites to only the topics needed for a particular gateway course (Edgecombe, 2011). Students can exit the sequence when they are finished with the pre-requisite requirements for the gateway math course for their program of study as prescribed in the NCCCS (n.d.) Common Course Library. In most cases students take fewer than eight courses, resulting in less time to the gateway course.

Mastery. Mastery learning is an integral part of the student assessment in the redesigned courses. A mastery level of 80% is required in all NC developmental courses in order to progress (NCCCS, 2011c). Mastery learning was introduced by Benjamin Bloom in 1968 as instructional units taught in about one to two weeks, followed by an initial assessment, a review of the weak topics, and a final assessment (Guskey, 2001). To prepare for the initial assessment, instructors help students identify areas of weakness during the normal course of instruction. Identification of areas of concern throughout the course gives students the ability to understand what areas need additional attention and to take more responsibility for their learning (Sturgis & Patrick, 2010). Providing an opportunity for students to identify their areas of weakness helps increase student motivation, engagement levels, attendance, and attitudes (Guskey, 2001; Reddy et al., 2013; Sturgis & Patrick, 2010).

In accordance with Bloom's process (Guskey, 2001), students are given the opportunity to take a second assessment and must remediate in-between. Students take the initial assessment, followed by remediation if needed, and then a second assessment. Similar to identifying difficult topics during the course of instruction, the first assessment shows what they have yet to master. Remediation reviews these topics specifically and then students retest on all of the topics.

Requiring mastery facilitates the possibility that the student understands the material required and will remember it in the subsequent course once they move on (Guskey, 2001). Requiring mastery of a knowledge base is essential in setting up a student for success in the future. As information builds from one module to the next, motivation and self-efficacy increase in math students (Siegle & McCoach, 2007). Mastery promotes a deeper level of understanding of the material and provides a deeper foundation for future courses as they progress through the math sequence (Ariovich & Walker, 2014). Math is a subject that builds upon knowledge gained, so subsequent math success is almost impossible without initial success and mastery (Boylan, 2011). Posamentier (2013) describes mastery as a motivation strategy in math classes and describes it as "sequential achievement" (p. 2).

Acceleration. Edgecombe (2011) defines acceleration "as the reorganization of instruction and curricula in ways that facilitate the completion of educational requirements in an expedited manner" (p. 4). North Carolina's design incorporated principles of curricular redesign that were used in the California Acceleration Project (CAP, Haywood & Willett, 2014). In addition to shortening the amount of time to complete developmental mathematics courses, this curricular redesign also refined the curriculum to include only material needed to be successful in the gateway course (Edgecombe, 2011). Accelerated courses are intentionally more demanding than the traditional semester course, not only from the increased workload, but because the expectations of the course are more in line with the outcomes of the gateway course (Baragan & Cormier, 2013; CCRC, 2012; Edgecombe, 2011; Haywood & Willett, 2014; Jaggars et al., 2014; Nodine et al., 2013). Due to this increased demand in the new curriculum, deeper understanding of a concept is possible in an accelerated course, because students are expected to think through solutions and situations (Stigler, Givvin, & Thompson, 2010).

Fears that accelerated courses will result in a lower completion rate did not hold up in a study of four accelerated models by the Community College Research Center (Jaggars, Edgecombe et al., 2014). Results of studies presented in Edgecombe (2011) show that the change of structure alone resulted in increased student success "even when teaching practice remains unchanged" (p. 25). However, Edgecombe (2011) does suggest that most structural changes are accompanied by a pedagogical change, but more research on the outcomes using different instructional designs is needed.

Conceptual learning. Conceptual learning is the process of developing a deep understanding of a concept. Gresalfi and Lester (2009) describe conceptual learning as a "relationship with mathematics characterized by considering the act of making meaning as the goal for accurate mathematical work" (p. 270). True mastery of a problem occurs when a student understands the why behind the procedure to solve a problem, can solve the problem and ascertain whether the solution is viable or not, and find any mistakes in the work of a problem (Stylianides & Stylianides, 2007). This connection allows the solution to become more than just a procedure, but rather a way to solve a problem. Learning both the conceptual and the procedural knowledge involved in a problem helps "students become competent and confident in their ability to tackle difficult problems and willing to persevere when tasks are challenging" (National Council of Teachers of Mathematics [NCTM], n.d., p. 2), and provides the ability to transfer the learning and skills to other situations (Richland, Stigler, & Holyoak, 2012; Stylianides & Stylianides, 2007).

The instructor has a vital role in making these connections possible. Conceptual understanding of the material occurs through active engagement in the material (Bain, 2004; Karagiorgi & Symeou, 2005; Styliandes & Styliandes, 2007). In order to create activities that teach the concepts behind a problem, an instructor must understand these connections first (Gresalfi & Lester, 2009; NCTM, n.d.). Karagiorgi and Symeou (2005) emphasize that classes with such activities are student-centered, focused on active and collaborative learning, present multiple perspectives of a problem, and tend to follow a constructivist theory approach. A well-planned approach to instruction can incorporate questions, reflection, and a high level of guidance that will lead to deeper meaning (Herman & Gomez, 2009).

It is important for a student to develop their own framework of meaning and build connections that are more than just learning a rote procedure (Styliandes & Styliandes, 2007). Too many times students are given a problem along with the steps to solve it, rather than reflecting on a problem to determine what approach is needed and making connections to similar problems in order to develop a plan to solve the problem. Instruction focused on making connections and the underlying concepts that are involved in solving a particular problem builds both conceptual understanding and procedural skill (Edwards & Beattie, 2016). Deliberate practice is “highly structured and designed to improve performance and strengthen understanding” (Edwards & Beattie, 2016, p. 31).

Contextual learning. Contextual learning, sometimes called situated learning (Fletcher, 2009), is “a type of knowledge that includes knowledge of the content and/or situations in which it is or will be useful” (Kirschner, 2009, p. 148). This type of learning takes place in a context and requires well thought out lessons and activities (Bain, 2004; Ginsberg & Wlodkowski, 2009; Perin, 2011). These lesson plans and activities can promote the effective transfer of learning by engaging both the affective and cognitive domain (Perin, 2011). Lessons created are usually relevant to a particular major that a student is studying to show how math is used in that context (EDC, 2012). Ginsberg and Wlodkowski (2009) explain that relevance of the material encourages a positive attitude, making the information or activity have a personal meaning. This produces curiosity which provides challenge and interest for the student, leading to a positive attitude and motivation (Perin, 2011).

Properly constructed contextualized learning provides the needed support to enable students to develop a deeper thinking and understanding of the situation and the mathematical concept. Effective instructional design includes “generalizable features of situations” (Kintsch, 2009, p. 231) to allow students to connect the material with their own experiences. Struggles encountered while learning the material are considered “contextual clues that may later aid transfer” (Wise & O’Neill, 2009, p. 85) of the material to future situations. These clues allow students to construct their own meaning to the concept and develop ways to test them out (Fletcher, 2009).

Active-learning. Active learning requires students to engage in the exchange of ideas with other students and the instructor to resolve a problem (Karagiorgi & Symeou, 2005; Osterholt & Barratt, 2010). This type of engagement is designed to help students discover concepts, learn how to learn, become independent learners, take more responsibility for their learning, and develop deeper conceptual understanding of a topic (Birmingham & Haunty, 2013; Pang, 2010; Smittle, 2003; Stigler et al., 2010; Sturgis & Patrick, 2010). Active learning situations are designed by the instructor to help students take the knowledge they already possess, gain knowledge from others, and build new connections (Karagiorgi & Symeou, 2005).

Active learning experiences can be incorporated throughout the design of a course and have an important part in how students learn. These experiences are also referred to as student-based learning, inquiry-based learning, self-directed learning, cooperative learning, collaborative learning, or group work (Bandura, 1993; Boylan, 2011; Kirk, n.d.; Wilkins, 2008). These learning environments provide an opportunity for students to engage in motivating activities. Wilkins (2008) writes that inquiry-based learning allows math to become a social activity and open to analysis. Kirk (n.d.) agrees that collaborative learning strategies improve self-efficacy, which has been shown to increase academic achievement. An inquiry-based instructional design presents challenge, involves students in justifying mathematical curiosities, helps students discover a pattern, and helps students identify the voids that may exist in their knowledge structure (Posamentier, 2013). Student participation in the learning process allows the brain to begin organizing what information is known or unknown and work through the learning process towards a solution.

Collaboration. Collaborative learning is considered an active learning strategy that is used in a student-centered classroom. This pedagogical approach requires instruction to focus on constructing meaning from interactions with others and/or personal inquiry into the subject (Edwards & Beattie, 2016). Collaborative learning focuses on student-to-student discussion, rather than instructor lectures (Osterholt & Barrett, 2010). Proper instructional design using collaborative learning can add rigor to coursework, allow students to struggle, and help students construct meaning (Barragan & Cormier, 2013; Edwards & Beattie, 2016; Wlodkowski & Ginsberg, 2010).

The goal of the group experience is not for the student to solve the problem, but rather to get the student thinking about the math and procedure that is needed to complete the problem. With collaborative learning students are able to think about a problem, formulate a hypothesis, develop questions to help them fill in knowledge gaps, and potentially solve problems either on their own or with some guided instruction (Ginsberg & Wlodkowski, 2009). Solving a math problem becomes more than following a set of procedures, but rather a mental strategy to identify the problem and work through to a solution (Stigler et al., 2010).

Group exchanges facilitate the process of changing behaviors, attitudes, and engaging higher order thinking skills through the struggle of completing an assignment together (Ginsberg & Wlodkowski, 2009; Richland et al., 2012). This process promotes an understanding that helps students relate to the material, encourages a positive attitude, and stimulates a personal meaning needed to conceptually and contextually understand the problem (Ginsburg & Wlodkowski, 2009). Students benefit from collaborative situations, because the challenge and struggle reveal to students their own abilities, strengths, motivation, self-efficacy, and confidence (Barringer & Cormier, 2013; Ginsberg & Wlodkowski, 2009; Mesa, 2012; Wise & O'Neill, 2009). Zientek, Ozel, Fong, and Griffin (2013) note that engagement with other students in a problem solving activity provides necessary feedback for students to assess self-regulatory strategies that work for them. Peer teaching helps both the "teacher" and the "listener" acquire a deeper understanding of the material, and will allow students to struggle while providing challenge and motivation with the support of peers and an instructor to complete the problem (Ginsberg & Wlodkowski, 2009). The development of multiple representations of the same problem and cognitive pathways for future reference are possible when students work together and everyone contributes to the conversation through the process of questioning and giving answers (Ertmer & Newby, 1993). The level of learning is unpredictable when students are given the opportunity to take charge of their learning.

Computer-assisted. Computer-assisted instruction, another active learning strategy, includes emporium, online courses, or instruction with computer software

(MDC & AtD, 2014; Zavarella & Ignash, 2009). The redesign allowed the option and flexibility to use computer software for either instruction, as a supplement or integrated into the course. Courses with instruction on the computer are known as emporium courses where students view lessons and complete work on the computer throughout the class period (NCAT, 2013). Supplemental and integrated designs use the computer work as a complement to instruction (Epper & Baker, 2009). When used as a supplement, computer work is completed outside of class time. Integrated computer courses dedicate some class time to working on the computer. For this study, Emporium courses will be classified as computer-centered instruction.

Advantages to using computer software include fostering immediate feedback to students and providing additional instruction via videos and examples. Students can get help at the time they are working on the computer, or can prepare for class by watching videos and come to class already familiar with a topic. Computer-assisted instruction can reinforce topics through skill and drill computer practice (Spradlin & Ackerman, 2010; Sturgis & Patrick, 2010). Best practice institutions tend to use computer-assisted instruction as a supplement to or integrated into instruction (Bonham & Boylan, 2011; Boylan, 2002; Spradlin & Ackerman, 2010; Zavarella & Ignash, 2009).

Related research. North Carolina redesign is in its infancy. Statewide full implementation of redesign did not occur until fall 2013, and limited implementation occurred fall 2012. With only a few years of implementation, research on the North Carolina redesign is virtually non-existent. The research in this section is from various redesigns around the country using similar strategies that were incorporated in the North Carolina redesign. These studies are important to the North Carolina redesign, because the strategies were added to the design based on the review of research. It is also important to note that the strategies discussed above work together and are not mutually exclusive. Some of the studies (Jaggars, Hodura et al., 2014; Stigler et al., 2010) show that implementation of one strategy helped facilitate the use of other strategies.

One study featured The Community College of Denver where the FastStart program was implemented, which was designed for lower-scoring students, by accelerating the sequence using compression (Jaggars, Hodura et al., 2014). In the spring of 2006, the Community College of Denver compressed its three semester math sequence (three 16-week courses) into two semesters (Jaggars, Hodura et al., 2014). Students had the choice of taking the two lowest levels in an 8-week format and the highest level the next semester in 16-weeks or vice versa. Seat time was not reduced, just longer blocks of time, which provided the opportunity for instructors to “implement a wider variety of instructional activities” (Jaggars, Hodura et al., 2014, p. 6). The study investigated the likelihood of accelerated students completing the college level gateway course and their success. The sample was taken from courses between spring 2006 and spring 2008 and resulted in a sample size of 133 in the program group and 1,222 in the comparison group. The results of propensity score matching showed that FastStart students were 11% more likely to complete gateway courses than those in the traditional sequence, and once enrolled in the gateway course, those students performed just as well (Jaggers, Hodura et al., 2014). Researchers concluded that accelerated courses provide “students with a strong positive boost in terms of their probability of enrolling in and completing college-level math” (Jaggers, Hodura et al., 2014, p. 18).

In fall 2009, Queensborough Community College (QCC) in Bayside, NY, tried an accelerated Developmental Arithmetic class, but unlike The Community College of Denver, they used curricular redesign, which reduced the seat time required (Guy, Cornick, Holt, & Russell, 2015). The college also left all the other courses in the developmental math sequence the same. The original course was not eliminated, so students had a choice between the new accelerated 4-week, 20-hour student-centered Arithmetic course, or the original 16-week teacher-centered course. Students who took the accelerated course had to wait until the beginning of the next semester to take the next course in the sequence, so the acceleration did not shorten the amount of time to completion (Guy et al., 2015), which is opposite the modularized model used in the NC design. Similar to the NC design, the traditional lecture format was replaced with active engagement in problem solving activities to encourage cooperative learning (Guy et al., 2015). Guy et al. limited their participants based on four pre-determined criteria (i.e., COMPASS taken before taking a math course, COMPASS score greater than or equal to 25 and less than 30, arithmetic course was the first math course taken, and first attempt at course was Fall 2009-Fall 2012), resulting in a sample size of 1,001 students. Using Fisher's exact (an association's test), statistically significant results in favor of the accelerated courses were obtained in the categories of passing the course the first time, passing the course any time during the semester, enrolling in the subsequent course, and completing the sequence (Guy et al., 2015).

The results of this study (Guy et al., 2015) were both positive and negative. Out of the 1,001 students taking arithmetic through fall 2012, 233 chose the traditional 16-week format and 768 chose the accelerated 4-week format. Of those students, 618 (80%)

passed the accelerated course sometime between fall 2009 and 2012, while only 159 (68%) passed the traditional course in the same amount of time. A total of 676 (68%) students enrolled in the next course, Elementary Algebra; 144 (62%) were from the traditional course and 532 (69%) were from the accelerated course. Results for completing the next course in the sequence the next semester, however, were weak. In fall 2011, 959 students enrolled in the accelerated arithmetic course, but only 107 (11%) successfully completed the Elementary Algebra course spring 2012. Guy et al. (2015) noted that there were several flaws in the study (e.g., did not begin as a research study, students self-selected courses, significant differences in sample size), and that "generalizability of these results may be limited" (p. 8), so it is difficult to determine what part of the redesign made the most difference. They did state that "the entire sequence should be viewed as the redesign target" (p. 9), and the accelerated format gave "students a lower cost, less time-consuming option to persist" (p. 9).

One strategy that can help facilitate the success of acceleration is teaching mathematics conceptually, so that students can use reason to solve problems, rather than trying to memorize multiple procedures (Stigler et al., 2010). Stigler et al. evaluated placement test scores and analyzed the worked solutions of math questions that were solved by 748 community college developmental math students, in order to evaluate the reasoning skills used by students when solving problems. After administering the math questions to students, Stigler et al. identified the most difficult questions. In review of the errors, Stigler et al. began to draw the conclusion "that rather than using number sense, students rely on memorized procedure, only to carry out the procedure incorrectly or inappropriately" (p. 9), and the errors "may provide evidence that students have a disposition to treat the goal of mathematical problems as getting answers quickly rather than correctly and with understanding" (p. 9). The focus of solving a problem was on a procedure rather than on numerical logic and reasoning, and with any reasoning, many of the errors could have been avoided. Stigler et al. also suggested that the difference in the level of conceptual understanding between students who tested into Basic Arithmetic or Elementary Algebra may not be that different. Opportunities need to exist that give students the skills to conceptually understand mathematics and the time to practice it (Stigler et al., 2010). Without reasoning, students rely on multiple procedures that they have memorized and confuse when using the procedures together.

As changes in course structure occur, feedback from stakeholders is helpful in determining what is working. Ariovich and Walker (2014) conducted a mixed methods research study that analyzed instructor and student views of mastery and computer-centered instruction in a modularized, Emporium setting, at a large community college in Virginia, and the success rates of students in these courses. After interviewing both instructors and students, researchers reported that instructors were pleased that mastery increased the rigor of the course and set a higher standard for learning, but students felt that mastery required more work and learning to pass the course. Some students did express how they were able to develop strategies to deal with increased workload and higher demand. The computer instruction, however, was met with mixed emotions from both instructors and students. Both agreed that computer instruction was more individualized and allowed students to move at their own pace. In addition, instructors felt that "computer-aided instruction encouraged a more active student role" (Ariovich & Walker, 2014, p. 51), and students felt empowered when they figured out a problem on their own. On the other hand, both had concerns about how the material was presented to the student. Instructors did not feel that the computer alone provided all the information that was needed for math proficiency, and felt that "complementing the software with critical thinking activities, group work, and real world applications" (Ariovich & Walker, 2014, p. 52) was needed to enhance learning. Similarly, students felt the computer skipped some important steps that they needed to understand a skill and missed "being directly observed by the teacher when working on a problem" (Ariovich & Walker, 2014, p. 53). In the comparative quantitative analysis, data revealed that even though students struggled in the more demanding redesigned course, they had a higher rate of success in the subsequent course.

The strategies incorporated into the NC design, modularization, mastery, acceleration, conceptual learning, and active learning are supported by current research. Acceleration and active learning strategies (Guy et al., 2015; Jaggars, Hodura et al., 2014) are compatible. Ariovich and Walker (2014) reported favorable findings for mastery and modularization strategies. Stigler et al. (2010) suggested that conceptual learning is a strategy that will increase learning in an accelerated course. The research on contextual learning, however, is limited (EDC, 2012; Perin, 2011). These studies indicated that the strategies chosen to be incorporated into the NC redesign had a positive effect on learning.

Types of Delivery

The North Carolina redesign completely changed the curriculum of developmental mathematics and also how deeply students learned the material. Students are expected to understand multiple representation of the material in the new courses

(NCCCS, 2011a). Mastery of the curriculum included the understanding of the why and how behind a problem. The curriculum and learning outcomes were chosen with these objectives in mind, and to create an interest and application of mathematical concepts.

Although the new structure and mastery component of the course relied on a deep conceptual understanding of the material and promoted an environment that fosters self-regulated learning (Brothen & Wambach, 2000; Zientek et al., 2013), it did not dictate how the curriculum was to be taught. The guidelines did provide information about techniques and examples to use when teaching the course in order to demonstrate the type of curriculum that was needed in the course (NCCCS, 2011c), but left the choice of instructional delivery to the colleges. Each college was to use these guidelines to design and implement the new DMA courses, but they got to choose the delivery method (i.e., teacher-centered, student-centered, or computer-centered).

Teacher-centered. Teacher-centered instruction is direct instruction where the teacher imparts knowledge to the student (Herman & Gomez, 2009; Kirschner, 2009). The teacher is the focal point of the class and holds the ultimate authority for learning (Gresalfi & Lester, 2009). This type of instruction is often referred to as a lecture-based approach or direct instruction (Herman & Gomez, 2009). Instructors break down a complex task into smaller pieces and then show students how to complete the entire problem using these smaller steps (Kirschner, Sweller, & Clark, 2006; Wise & O'Neill, 2009). They instruct the student on how to do the whole problem before they allow the student to try the problem on their own.

Teacher-centered instruction tends to decontextualize the information and teach it in a vacuum (Kintsch, 2009). The instructor communicates the framework of how to do the problem to the student, so the student can complete the problem in a similar manner (Kirschner, 2009). The steps that are taught are usually done void of a situation and lack a context. Once the instructor shows students the procedure, drill and practice is used to help students master the steps required to complete the problem (Fletcher, 2009).

In teacher-centered instruction it is important that the framework and procedure taught is correct, because it is assumed that students have no prior knowledge of this topic and how it is used (Kirschner, 2009). This assumption requires the instructor to tell the student everything they need to know in order to solve a problem. Once students develop the ability to solve the problem, then students are able to learn more about the topic and develop a context (Clark, 2009). It has been suggested that this may be a better option for less able students, because it provides the correct background knowledge and the procedure of how to do the problem without the distraction of a context (Kirschner et al., 2006; Tobias, 2009).

Student-centered. Instructional designs promoting student-centered instruction (i.e., group work, collaboration, guided instruction, and problem-based learning) puts the responsibility of learning on everyone in the classroom, not just the instructor (Gresalfi & Lester, 2009; Kintsch, 2009; Kirschner et al., 2006; Wlodkowski & Ginsberg, 2010). In these classrooms students are actively engaged with each other in the material in order to expand their own learning (Kintsch, 2009). Instructors give students information for one part of a problem at a time, allowing them to work, and guiding them through the process. Students receive a subsequent step as they demonstrate readiness for additional information (Wise & O'Neill, 2009). Throughout the process the instructor is also determining what level of guidance is needed for each student in order for them to be able to complete the assigned task (Wise & O'Neill, 2009). The instructor and students are a partnership that work together throughout the activity to master each part of the problem.

Student-centered learning tends to enhance student motivation by helping students learn from each other and develop their own learning schema (Herman & Gomez, 2009; Hill, 2004). Active engagement in the lesson through conversation, inquiry, and critical-thinking can provide the motivation needed to learn, be successful, and build self-efficacy (Bain, 2004; Bandura, 1993; Kirk, n.d.). This environment provides the opportunities for students to understand how they individually learn material, what effort is required to truly understand a concept, and practice self-regulatory behaviors (Ertmer & Newby, 1993; Fletcher, 2009; Ginsberg & Wlodkowski, 2009; Karagiorgi & Symeou, 2005; Pang, 2010; Zientek et al., 2013). Given the opportunity to learn how much they already know and learn how they learn, students are able to develop their own plan for learning (Bain, 2004). Allowing students to struggle some can also "result in better long-term retention and transfer" (Wise & O'Neill, 2009, p. 93), fostering better retrieval of knowledge for future problems. Students should then retain much of the information learned in developmental mathematics courses into their future gateway course (Barragan & Cormier, 2013; Stylianades & Stylianades, 2007). Students who are learning how they learn, learning material at a deeper level of understanding, and expected to master the material become active participants in their learning and understanding of the material and are no longer passive learners in the classroom (Kintsch, 2009; Pang, 2010; Wlodkowsi & Ginsberg, 2010).

Exposure to student-centered instructional designs can show increases in student success in a short period of time (Siegle & McCoach, 2007). According to Gresalfi and

Lester (2009) characteristics of a well-functioning student-centered classroom are students discussing, debating, conjecturing, inventing, and the teacher rarely in the front of the room. Instructional designs that incorporate opportunities for discussion are critical to fostering an environment of investigation and experimentation (Gresalfi & Lester, 2009). In math courses, student discussions of concepts and solutions can increase the development of mental structures for math procedures in the brain (Smilkstein, 1991). This formation of neural pathways can increase comprehension and learning of critical math procedures. This engagement of higher order thinking, beyond the basic rote memorization of facts, helps students develop a deeper conceptual understanding of the information (Fletcher, 2009).

Computer-centered. There are multiple types of computer-assisted delivery methods, but computer-centered delivery will be defined as the Emporium model where teaching is done by the computer with available assistance (NCAT, 2013; Zhu & Polianskaia, 2007). According to NCAT (2013) the underlying principle for the Emporium model is that "students learn math by doing math, not by listening to someone talk about doing math" (p. 1). Students take pre-tests to determine what they already know, so they can focus on the material they need to learn, and master the required material in order to move on to the next concept (MDC & AtD, 2014; NCAT, 2013). Faculty monitor the progress of students, but ultimately each student determines the pace and time that it will take to complete the material (NCAT, 2013).

The majority of the work that a student does in class is completed individually, at a self-prescribed pace (Epper & Baker, 2009; Parcell, 2014; Spradlin & Ackerman, 2010; Zhu & Polianskaia, 2007). Students sit in large computer labs and work on their math in isolation. Every student has a different lesson plan. Professional tutors and/or instructors are available to answer individual questions while the other students work. The curriculum in most cases is provided by publishers who have created material and programs for this classroom structure (Epper & Baker, 2009).

Related research. A number of researchers (e.g., Clark, 2015; Kahl & Venette, 2010) examined the relationship between various instructional delivery methods (i.e., teacher-centered, student-centered, computer-centered) and academic performance of students in higher education. Clark (2015) conducted a mixed methods research study that compared the performance of students in a teacher-centered versus a student-centered classroom. The researcher specifically used the flipped classroom model, where instruction is taught via technology outside of class time and class time is used for student engagement in homework and/or cooperative learning activities, for a student-centered classroom. Forty-two students from two Algebra I classes at a rural high school were the participants of the study. Students completed a survey prior to the implementation of the flipped classroom to obtain their opinion of a teacher-centered class, and then took a post-survey to obtain their opinion of a student-centered class. Focus groups were conducted with a random sample of the participants, and a unit test was administered to the participating Algebra I classes, as well as a teacher-centered Algebra I course. Using a t-test, quantitative results indicated that there was not a statistically significant difference ($p = 0.44$) between the test scores of students receiving teacher-centered versus student-centered instruction (Clark, 2015). However, the qualitative results indicated that students were more engaged and active in the student-centered classroom. They were more satisfied with the experience and felt that they received more one-on-on instruction that helped clarify their understanding. The limitations in this study included that the researcher taught all three classes (the two student-centered classes and the one teacher-centered class that was used as the comparison) involved in the study, and due to the timing of the study, students had to learn a new instructional approach and challenging material at the same time. The final results indicated comparable learning in the student-centered classroom, but with more engaged and motivated learners (Clark, 2015).

Similarly, Kahl and Venette (2010) conducted a research study comparing teacher-centered and student-centered classrooms using the content and structure of speech outlines. One hundred and fifteen speech outlines were collected from three Midwestern universities that were teaching the same course, using the same textbook. One university's speech instructors were taught Kolb's cycle of learning and how to develop lesson plans that continued on to stage two of the cycle to design a student-centered course. The other two universities used the traditional lecture approach of a teacher-centered course. An independent samples *t*-test of the composite score was used to answer the research question, and Levine's test was used to determine population similarity. The difference in the mean scores for the content, structure, and composite score were all found to be statistically significant at the $p < .001$ level (Kahl & Venette, 2010). They concluded that students in a student-centered classroom "perform more successfully" (p. 184) than those in a teacher-centered classroom. Even though speech students were compared rather than developmental mathematics students, Kahl and Venette make the point that, "fostering students' ability to apply course content successfully … may be better achieved in a learner-centered environment" (p. 185), and "instruction could be adapted by incorporating group discussion and relevant activities" (p. 184). These observations create a need for similar comparisons of developmental mathematics courses.

Studies (e.g., Zavarella & Ignash, 2009; Zhu & Polianskaia, 2007) on comparisons between computer-centered and teacher-centered classrooms focused primarily on examining completion and success rates. Zavarella and Ignash (2009) compared completion rates between online, computer-centered (hybrid), and lecture-based courses. The sample size consisted of 192 students from a large, urban community college in Florida. Sixty-nine of the students were enrolled in the lecture-based version, 67 in the hybrid version, and 56 in the online version of a Beginning Algebra course. The rate of withdrawal for each delivery method was 20% for the lecture-based courses, 42% for the hybrid, and 39% for the online (Zavarella & Ignash, 2009). The results of a logistic regression analysis showed that learning styles and placement test scores did not appear to affect withdrawal from a course, however, the reason a student chose to take a particular delivery method did predict completion in the course at a statistically significant level. Students who registered for a particular delivery method for personal reasons were more likely to complete the course, but students who registered for a particular delivery method based on how they perceived the class were more likely to withdraw from the course. Based on these results Zavarella and Ignash recommended that students taking computer-centered courses need to be better educated on the expectations of the course before the course begins.

Zhu and Polianskaia (2007) compared student completion and success rates between a traditional lecture-based course and a computer-centered course. The computer-centered course used interactive multimedia software and was set up to be a self-paced, mastery course. This study took place at Victoria College in Houston, Texas, and compared all students who were enrolled in developmental mathematics between 1996 and 2005. The analysis showed that completion rates were generally higher for students in lecture courses than computer-centered courses. One interesting finding was that lecture students passed the course with a C or better at a higher rate, but the computer-centered students passed the placement test (a requirement to move on the next course) at a higher rate (Zhu & Polianskaia, 2007). From these results Zhu and Polianskaia recommended that "assist[ing] students in selecting the instructional format that will be best suited for them" (p. 70) may raise completion and success rates in both formats. Interestingly, both Zavarella and Ignash (2009) and Zhu and Polianskaia suggested that better advising about the structure and expectations of a computer-centered course could raise the completion rates of students in computer-centered courses.

Instructional Techniques

Different instructional techniques are used throughout each delivery method. The technique that is debated the most is the use of direct and indirect instruction or minimal guidance (Kirschner et. al, 2006; Tobias & Duffy, 2009). Teacher-centered instructors tend to believe that direct instruction is the best, because indirect instruction overloads working memory and students are unable to learn (Kirschner et. al, 2006). Student-centered instructors believe that there is a place for both direct and indirect instruction in the classroom (Fletcher, 2009; Kuhn, 2007; Schmidt, Loyens, van Gog, & Paas, 2007; Wise & O'Neill, 2009). He (2013) states that "They [direct and indirect instruction] can be very well-aligned to each other, so as to complement one another and maximize the advantages of each" (p. 7). Kuhn (2007) agrees that there is a place for both types of instruction, but emphasizes that "activities centered on inquiry and argument enable students to appreciate the power and utility of these skills as they practice them" (p. 111). It has been suggested to "produce a clear taxonomy of instructional support" that outlines when to use each strategy (Clark, 2009. p. 175). Scaffolding, the use of questions to promote critical thinking and deeper understanding, is used in both direct and indirect instruction as a support system. However, the use of scaffolding varies depending on the type of instruction used (Clark, 2009; Rosenshine, 2009; Tobias & Duffy, 2009; Wise & O'Neill, 2009).

Direct instruction. Direct instruction occurs when the instructor tells the student all the information that is needed in order to perform a task and leaves nothing for the learner to discover on their own (Sweller, 2009). Kirschner et al. (2006) note that direct instruction avoids cognitive overload in students, because they receive all the information that they need to do a problem. Students are not required to learn any of the information or procedure on their own. Clark (2009) points out that direct instruction is a three step approach. First, the student receives all the information they need to perform a procedure. Second, guidance provides the information and practice that allows a student to transfer the knowledge to a different situation. Third, independent practice of the procedure is required with immediate feedback to quickly correct any mistakes.

Direct instruction is most associated with teacher-centered instruction (Herman & Gomez, 2009). Much of the information is disseminated to them from the instructor in a step-by step process. Even in active learning situations students are guided step-by-step through the procedures so that their memory is not overloaded (Mayer, 2009). Scaffolding, defined later in this section, is used in lessons, but with the instructor modeling the questions and thought processes that students should use to arrive at a solution (Rosenshine, 2009). Rather than the student asking questions to fill in their knowledge gaps, the instructor decides the information and techniques that are needed to reach a successful outcome.

Indirect instruction. Indirect instruction is usually associated with student-centered and computer-centered classrooms. Students are given the appropriate background information to learn a concept and then given the opportunity to figure out and master that concept with that information and any prior knowledge (Wise & O'Neill, 2009). This is typically done by breaking up a lesson into small increments and allowing a student to master one part at a time (MacSuga-Gage, Simonsen, & Briere, 2012). This does not mean that students receive no guidance, but rather a different form of guidance (Gresalfi & Lester, 2009). This different form of guidance is typically misunderstood by instructors who hold firm to the direct instruction approach and call the practice minimal guidance or Problem Based Learning (PBL; Kirschner et al., 2006).

The purpose behind indirect instruction is to offer students the chance to discover learning on their own, rather than be told what they need to know, and construct new knowledge. In order to construct new knowledge, the brain must encounter an experience where existing knowledge does not work, pause, evaluate the situation, and cope with the frustration associated with learning new beliefs (Bain, 2004). This does not happen when a student is told everything they need to know and/or avoid in order to solve a problem. Also, older students bring with them a wealth of experience to every learning experience in the classroom that can help them work through this process. Indirect instruction is the delicate balance of learning when assistance is needed and when to allow a student to struggle. Offering assistance when it is not needed could led “to student boredom and ineffective learning” (Tobias, 2009, p. 344).

Scaffolding. Scaffolding is a strategy used by both direct and indirect instruction supporters, but in different ways. Scaffolding is the process of giving students the help they need, as they need it, and removing that help when they are ready to do as much of the work as they can on their own (Clark, 2009; Rosenshine, 2009; Tobias & Duffy, 2009; Wlodkowski & Ginsberg, 2010). Scaffolding and questioning helps students discover their misconceptions (Bain, 2004). The difference between scaffolding in direct and indirect instruction is in the way that help is delivered (Clark, 2009; Rosenshine, 2009; Tobias & Duffy, 2009; Wise & O’Neill, 2009).

In direct instruction scaffolding is seen as the modeling of questions and procedures for the student, so they can develop the skills to ask the same types of questions and procedures in the future on different problems (Clark, 2009; Rosenshine, 2009). Students should not have to construct their own questions, but should be provided with all the information needed to complete a lesson at the beginning, so that there are no stumbling blocks to learning (Clark, 2009). Focused instruction will help guide students in the “appropriate cognitive processing” (Mayer, 2009, p. 185), and allow students to optimize what they learn and prevent cognitive overload of information (Kirschner et al., 2006; Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2010).

Scaffolding in indirect instruction is where guidance is offered only as the student requires it, and the amount of help needed is determined by the questions students ask

(Tobias & Duffy, 2009; Wise & O'Neill, 2009). Questions are encouraged and expected, and are seen as a way to facilitate the construction of knowledge (Bain, 2004). Allowing students to contemplate what they are learning and struggle can aid in retention and transfer (Wise & O'Neill, 2009). Guidance is provided after students are unable to proceed, and is gradually withdrawn again as the learner is able to do the work on their own (Tobias & Duffy, 2009). Indirect instruction supporters do not accept that indirect instruction is minimal guidance, but rather a different form of guidance that requires careful and detailed "preparation, and guidance, and modeling" (Gresalfi & Lester, 2009, p. 269).

Related research. How content is delivered has been an ongoing debate between those who firmly believe direct instruction is the only way and those who espouse to the use of indirect instruction or a combination of both methods (Tobias & Duffy, 2009). Kirschner et al. (2006) presented the argument that direct instruction is better than indirect instruction and wrote that there was no evidence to back up the claims of the effectiveness of minimal guidance. Basing their argument on human cognitive structure and cognitive load theory, indirect instruction places too much stress on the working memory of the brain and students are unable to process the information into long term memory. They back their argument using the conclusions of several research studies (e.g., Campione; Carlson, Lundy, & Schneider; Clark; Moreno; Schauble; Sweller & Cooper, as cited in Kirschner et al., 2006) which concluded that direct instruction was confusing, lead to misconceptions, and inefficient. Students would learn better by studying problems, rather than trying to solve them on their own, and less abled learners needed more support and guidance to retain more information. Kirschner et al. also reported that the findings on the transferability of knowledge using the various forms of instruction was inconclusive. Even without evidence that direct instruction aided transfer, their final conclusion was that “not only is unguided instruction normally less effective; there is also evidence that it may have negative results when students acquire misconceptions or incomplete or disorganized knowledge” (Kirschner et al., 2006, p. 84).

Defending indirect instruction, Schmidt et al. (2007) argued that indirect instruction (specifically PBL) is not minimal instruction, but rather “a flexible adaptation of guidance” (p. 1) that is compatible with cognitive load theory. PBL activates the prior knowledge that students have and allows them to use this knowledge to learn. An earlier study by Schmidt, De Grave, De Volder, Moust, and Patel (1989) tested this argument. They divided 88 Dutch high school students into four groups (novice/treatment, novice/control, expert/treatment, and expert/control). The treatment group was given a scenario about a blood cell and the control group was given a scenario about cargo airplanes. They were asked to discuss the scenario, then given a text about osmosis to read. Upon conclusion of the reading they were asked to write down everything they could remember about osmosis. Students who discussed blood cells prior to reading the text remembered 40% more of the text than the other group (Schmidt et al., 1989). Schmidt et al. (2007) argue from this study that indirect instruction breaks a complex problem into a series of smaller problems that “is compatible with the manner in which our cognitive structures are organized” (p. 95), and PBL strategies focus on learning on how to approach problems, so that knowledge can be transferred and future learning can occur. Schmidt et al. (2007) did agree with Kirschner et al. (2006) that there is overwhelming support that direct instruction is most effective for novice learners “in the initial phases of skill acquisition” (Schmidt, 2007, p. 93). In conclusion, Schmidt et al. (2007) encouraged collaborative research between the direct and indirect instruction advocates to further investigate the role direct and indirect instruction has on learning.

In order to study the use of direct and indirect instruction on novice learners, Vogel-Walcutt et al. (2010) conducted a study for the military. The study targeted 292 volunteers from a psychology course, but after eliminating those with prior knowledge and those that did not complete all the requirements, only 78 were included in the final sample. The study did not state how many were left in each group (direct instruction and indirect instruction). Results of ANOVA showed that the type of instruction was comparable for the procedural, declarative, and conceptual knowledge, or decision-making skills obtained during the instruction. Integrated knowledge had a slightly elevated retention rate for students who received worked examples and had additional time to review. Also, the results supported the hypothesis that “efficiency was improved” (Vogel-Walcutt et al., 2010, p. 142) when using direct instruction. Limitations to this study included the final sample size and the time between test 1 and test 2 used for demonstrating recall was only 7 – 11 days. Vogel-Walcutt et al. recommended that in order to expand this research between the effect of direct and indirect instruction, further investigation was needed focusing on non-novice participants and evaluating participants as they move from novices to experts.

Another study, in accordance with the recommendation from Schmidt et al. (2006) to conduct collaborative research, was completed fall 2009, Goldstein, Burke, Getz, and Kennedy (2011) studied a redesigned Intermediate Algebra course at a four-year public institution that was a hybrid of direct and indirect instruction, as well as scaffolding techniques. This model consisted of writing and collaborative activities, as well as lecture and computer work (Goldstein et al., 2011). Researchers were interested in finding out how well these variations in instruction prepared students for their subsequent gateway course. The study compared three redesigned courses with one original, traditional lecture course that included some problem applications. There were no statistically significant differences between student characteristics in the redesigned and original courses. However, students in the redesigned course were performing at statistically significant higher rate (using Cohen's *d*) than those in the traditional lecture course (Goldstein et al., 2011). From this observation Goldstein et al. concluded that course redesigns could be enhanced by "emphasiz[ing] more problem-based, collaborative, and student-centered forms of teaching and learning, rather than traditional classroom lecture" (p. 34).

External Factors on Student Learning

The mindset of a student and instructor is a very powerful force that affects learning. Motivation (Wlodkowski, 2008), self-efficacy (Bandura, 1993), self-regulation (Zimmerman & Schunk, 2008), and instructor efficacy (Goodard et al., 2000) all affect how students learn, persist, and achieve their goals. Motivation increases learning, learning increases success, and success increases motivation, resulting in a cycle where the affective and cognitive domain work together to increase long-term student performance (Bandura, 1993; Olatunji, 2013). This affective and cognitive connection of learning is considered a learned skill that helps students develop self-efficacy (Bandura, 1993), and can be learned by any student regardless of prior knowledge (Murayama, Pekrun, Lichtenfield, & vom Hofe, 2013). Self-regulatory behaviors help students to persist when things get tough (Zimmerman & Schunk, 2008). Instructor efficacy is the belief level of the instructor that all students can learn, and that they are able to instill that belief in their students (Goddard et al., 2000). All of these external factors have an impact on learning, because it is only when students demonstrate a high level of motivation, self-efficacy, persistence, and follow through of difficult tasks, along with instructors believing their students can learn, that learning takes place.

Motivation. Motivation is sometimes used as a general term or separated into extrinsic and intrinsic motivation. Extrinsic motivation focuses on external rewards, where students work to earn some sort of recognition, and intrinsic motivation is an internal passion or desire to meet a goal (Reeve, Ryan, Deci, & Jang, 2008). Students with high motivation tend to equate their past failures with a lack of effort and motivation (Hill, 2004; Siegle & McCoach, 2007), while students with low motivation equate their failures with a belief that they are not smart enough (Pajaras, 2008). Intrinsically motivated students seek out learning and mastery (Reeve et al., 2008), however motivation will decline for students who do not experience success (Wlodkowski, 2008). Thus making the argument that "learning and motivation … are inseparable" (Ginsberg & Wlodkowsi, 2009, p. 27).

Motivation provides the conditions necessary to produce an internal desire to seek after knowledge. Murayama et al. (2013) wrote that motivation is more significant to the learning process than prior knowledge and is the catalyst behind the ability to learn. Wlodkowski (2008) stated that "adults will learn more about something they care about" (p. 109). Challenging and engaging adults in relevant activities will increase intrinsic motivation, because it engages the cognitive and emotional functions of the brain (Wlodkowski, 2008).

The type of motivation a student exhibits also affects how well they learn and retain information (Ginsberg & Wlodkowski, 2009; Murayama et al., 2013). Classrooms that stimulate intrinsic motivation tend to be student-centered, while extrinsically motivated classrooms tend to rely on rewards, which can sometimes be observed by the student as controlling (Ginsberg & Wlodkowski, 2009). It should be noted that extrinsic motivation can weaken and sometimes even destroy intrinsic motivation (Bain, 2004; Ginsberg & Wlodkowski, 2009; Reeve et al., 2008; Vansteenkiste, Lens, & Desi, 2006; Wlodkowski, 2008; Wlodkowski & Ginsberg, 2010). The degree to which this takes place is dependent on whether the extrinsic motivation is seen as controlling or meeting one's basic need as expressed in Self-Determination Theory (Vansteenkiste et al., 2006). Students acquire deeper learning, better performance, and greater persistence when pursuing intrinsic goals (Reeve et al., 2008).

Self-efficacy. Self-efficacy is the belief in one's ability to complete a task and affects the way a person thinks, feels, and acts (Bandura, 1993; Pajares 2008). Students with high self-efficacy seek out learning opportunities, work through challenges, persist longer, visualize success, exert greater effort to complete a task, and ultimately change the direction of their life, where those with a low self-efficacy tend to give up easily or avoid learning tasks altogether (Bandura, 1993; Edwards & Beautie, 2016; Kirk, n.d.; Pajares, 1997; Zimmerman & Schunk, 2008). Self-efficacy in mathematics courses, sometimes referred to as math-efficacy, has been shown to be more important than mathematical ability (Pajares, 1997; Zimmerman & Schunk, 2008).

A student develops self-efficacy by analyzing their experiences and results of those situations (Pajares, 2008). When a student is performing a task they will analyze their experience with the task, the results of the task, the abilities of others who are completing the task with them, and any comments that are made to them or about them while doing the task. All this information is processed in order to determine the level of belief they have in their own ability to complete the task. Mastery experiences, that are challenging and focus on skill development, have the greatest impact on the development of self-efficacy (Pajares, 2008).

Anxiety is a by-product of low self-efficacy (Bandura, 1999), and potentially caused by surface learning of material. When students are not confident about what they have learned they get anxious. The brain responds by not being able to process new information (Bandura, 1993), store, or retrieve any information in the long term memory portion of the brain (Boylan, 2011). When this anxiety is exhibited in the math class, typically called math anxiety, the student is unable to participate in class or complete a test in a timely manner (Boylan, 2011). Teaching students motivating learning strategies and how to incorporate them into their daily lives can reduce anxiety and neutralize the effects for many students (Corno, 2008; Hill, 2004).

Self-regulation. Motivation and self-efficacy are managed through self-regulation (Pajares, 2008; Winne & Hadwin, 2008). Self-regulation is a cyclical process of forethought, performance, and self-evaluation (Laburn, Zimmerman, & Hassellhorn, 2010), in order to manage thoughts, actions, and emotions (Lens & Vansteenkiste, 2008), where students take responsibility for their own learning (Ramdass & Zimmerman, 2011). During self-evaluation, students internally decide what course of action is needed to proceed successfully and develop strategies to fulfill that plan (Pajares, 2008). Zimmerman and Schunk (2008) wrote:

> … good [self-regulated learners] set better learning goals, implement more effective learning strategies, monitor and assess their goal progress better, establish a more productive environment for learning, seek assistance more often when it is needed, expend effort and persist better, adjust strategies better, and set more effective new goals when present ones are completed. (p. 1)

This skill development is a by-product of the interest that was expressed in an activity (motivation) and the belief that one could perform the task (self-efficacy) when a student began the learning process.

The process of developing strategies from evaluation is called volition (Corno, 2008; Wlodkowski, 2008). Volition is the "persistent striving and navigation of obstacles" in order to accomplish a goal (Corno, 2008, p. 199). The conscious decision making of what is required to be done to be successful, begins the process of developing the skills that are needed to complete a task. The decisions are made once the task is underway and gives direction of how to complete the task (Corno, 2008). Sometimes the teacher must help to facilitate this process by teaching a particular skill or providing the time necessary for a student to reflect on what has been accomplished, what still needs to be done, and how to complete it (Corno, 2008; Wlodkowski, 2008). Volition depends on the reflection phase to develop the plan, because without a plan it is very difficult to complete a task.

Self-regulated activities can be introduced, modeled, and used as part of instruction. Shifting the delivery method from teacher-centered to student-centered helps facilitate the routine use of self-regulated learning in the classroom (Corno, 2008). Corno notes that cooperative learning environments can help develop self-regulation skills when assignments challenge a student's abilities. Homework is also an effective tool in developing self-regulating traits in students (Ramdass & Zimmerman, 2011).

Instructor efficacy. Instructor efficacy is just as important as student self-efficacy in increasing student motivation, classroom success, and successful implementation of different learning strategies in the classroom. Instructors must not only believe that all students can learn, but also believe that they have the ability to help all students learn (Goddard et al., 2000; Holzberger, Philipp, & Kunter, 2013). These beliefs affect the way instructors teach and their instructional impact in the classroom. Instructors with high efficacy focus on the development of students, instill intrinsic motivation, and tend to use student-based learning strategies (Bandura, 1993; Protheroe, 2008). Whereas, low efficacy instructors tend to be negative, controlling, and critical of students; focusing on extrinsic motivation strategies (Bandura, 1993; Kirk, n.d.); and tend to use instructor-based learning (Wilkins, 2008). Instructors who believe that all students can learn praise students for their effort and not their abilities, developing a mindset that it is the process that leads to success (Edwards & Beautie, 2016; Pajares, 2008; Zimmerman & Schunk, 2008).

Instructor efficacy has a greater impact on student learning than the amount of courses that an instructor has taken while earning their degree (Wilkins, 2008). Instructors with the most content knowledge are not necessarily the best teachers to instill motivation and promote self-efficacy in students (Goddard et al., 2000). In addition to evaluating a transcript, teacher efficacy should be evaluated when hiring new teachers.

Questions posed to an applicant need to include an inquiry into their efficacy and the instructional strategies they prefer to use. An individual instructor's efficacy will have a direct impact on student motivation, learning strategies used, and successful completion of students.

Not only does the instructor's efficacy affect student success, but it also has a direct effect on the cohesive and collaborative nature of a department. This department cohesiveness is also referred to as collective efficacy, and is the belief that what the department is doing is making a difference in the lives of students and promoting student success (Protheroe, 2008). Hoy, Sweetland, and Smith (2002) wrote that collective efficacy of a department is a better predictor of student achievement than socioeconomic status of the student body, because instructors from departments with high collective efficacy face challenges head-on, persist through adversity, and focus on the needs of students (Protheroe, 2008).

Instructors who collaborate with each other on a regular basis build connections that facilitate an increase in both collective and individual teacher efficacy. This is developed by talking together, sharing ideas, developing new teaching strategies, and making collaboration together as important as instructional strategies used in the classroom (Bickerstaff, Lontz, Cormier, & Xu, 2014; Dees, Moore, & Hoggan, 2016; McTiernan et al., 2013). Instructor collaboration is necessary to talk about challenges instructors encounter, behaviors and reactions of students to instructional practices, how well strategies are working, share ideas, review data, and receive professional development (Bickerstaff & Edgecombe, 2012; Edgecombe et al., 2013). An example of a discussion topic may be from an instructor who is accustomed to lecture-based instruction and is having difficulty adjusting to conceptual, collaborative learning. Reassurance is needed from peers to feel comfortable with students working together and talking overtly, rather than quietly listening in the classroom (Bonham & Boylan, 2011). Motivating developmental education students requires creative, and sometimes risky, strategies that are different from common curriculum practices, and require the constant support of colleagues to implement successfully or make modifications (Birmingham, Haunty, & O'Daniels, 2013; Smittle 2003).

Instructors in the classroom are the direct connection to promoting, modeling, and teaching motivation to students. Instructors can be trained specific learning strategies to motivate students, but it is high teacher efficacy that is a predictor of whether an instructor can execute the skills necessary to promote self-efficacy in students (Holzberger et al., 2013). The support of colleagues leads to a collective efficacy in the department, which strengthens the individual efficacy of all instructors. Instructors with high efficacy can then provide the support and belief needed to promote motivation and self-efficacy in students.

Related research. Motivation, self-efficacy, and instructor efficacy have an important role in successful learning and completion. To capture how these student and instructor traits impact learning, several studies (e.g., Labuhn et al. 2010; Zientek et al., 2014) were conducted to gather information. Zientek et al. (2014) conducted a study "to investigate beliefs of community college developmental mathematics students and the relationships between students' grades, view of intelligence, class attendance, teacher status, and Marat's subscales of self-efficacy" (p. 995). Participants (N = 382) were from three Texas community colleges taking an algebra or intermediate algebra course. Using multiple regression, beliefs in resource management strategies, beliefs in motivational strategies, and beliefs in self-regulated learning were among the top five predictors of student grades. These results support the need to instruct students on the power of self-efficacy and provide academic interventions for students who are struggling (Zientek et al., 2014).

An earlier study conducted by Murayama et al. (2013) compared intelligence and motivational strategies as a predictor of growth in future mathematics courses. The participants were 3,530 German fifth through tenth grade students. These students were assessed by the Project for the Analysis of Learning and Achievement in Mathematics Assessment (PALMA) for one or more years. This test measured the students' "modeling competencies and algorithmic competencies in arithmetics, algebra, and geometry" (Murayama et al., 2013, p. 1479). Self-report scales developed for the PALMA were used to measure motivation and learning strategies. Structural equation modeling growth curve models were used to determine growth at grade five and grade seven of the study. In regards to the growth of math achievement over time, at grade five intelligence was not a predictor, but perceived control ($p < .05$) was a statistically significant positive predictor and surface learning strategies ($p < .01$) were a statistically significant negative predictor (Murayama et al., 2013). In grade seven intrinsic motivation and deep learning strategies both had a statistically significant ($p < .05$) positive prediction of growth. Overall, motivation and learning strategies predicted long term growth from grades five through ten more so than intelligence. "Growth was positively predicted by perceived control, intrinsic motivation, and deep learning strategies, and it was negatively predicted by surface learning strategies" (Murayama et al., 2013, p. 1485). Murayama et al. concluded that a student's level of motivation and how they studied was critical to their mathematics achievement.

To understand if instructors could impact how students study, Labuhn et al. (2010) conducted a study to compare the use of student self-regulatory skills with the amount and type of feedback they receive about their work. Ninety fifth grade German students were divided into three research groups. The first group received individual feedback, the second group received feedback on how well everyone was doing, and the third group received no feedback. The first group was told that everyone could get the right answer, the second group was told that some would get the right answer and some would not, and the third group was told nothing. Students were asked to evaluate themselves on pre and posttests, explaining how they used the feedback and their assessment of their performance. Based on the results of ANOVA, Kruskal-Wallis and Chi-square tests, Labuhn et al. (2010) concluded that "students who received feedback were more accurate in their self-evaluative judgements," (p. 187) and "more able to give a reasonable verbal explanation for their rating of their perceived quality of their performance" (p. 188). Social comparative feedback had a greater effect than individual feedback, and both were better than no feedback. Because of the feedback that students received they were able to positively use self-regulatory behaviors to assess and explain their performance (Labuhn et al., 2010).

Research results show that self-regulation is a powerful force in relation to success (Murayama et al., 2013), and that teachers can affect self-regulation with their feedback (Labuhn et al., 2010). These two results lead to an important question about the instructor traits necessary for quality instruction. This question was addressed by

Holzberger et al. (2013), who conducted a longitudinal study to determine how instructor efficacy affects instructional quality and performance. The study was conducted with 155 German secondary teachers that took part in a previous study on mathematical literacy in 2002-2003. Teachers rated their self-efficacy on the Teacher Self-efficacy Scale by Schwarzer, Schmitz, and Daytner (Holzberger et al., 2013). Instructional quality was rated by both the instructor and instructor's students in each class. Using longitudinal structural equation modeling, cross-sectional correlations, and a two-level cross lagged structural equation analysis, Holzberger et al. arrived at the conclusion that "teachers with higher self-efficacy beliefs showed higher instructional quality, … whether instruction was rated by the teachers themselves or by their students" (p. 782). They also concluded that instructor-efficacy could also be affected positively by success in the classroom (Holzberger et al., 2013).

Finally, what is the impact of a department of instructors who collectively believe that all students are capable of learning and they strive for quality in the classroom? Hoy et al. (2002) conducted a study to determine what affect collective efficacy of the staff, the quest for academic excellence, and the socio-economic status of the high school had on mathematics achievement at the school. Using the Ohio Department of Education Socio-economic index, three subsets of the Organizational Health Inventory, a short version of the collective efficacy scale, and the Ohio twelfth grade proficiency test in mathematics, Hoy et al. collected data from each of the schools. The aggregate data showed the stronger the quest for academic excellence, the higher school achievement in mathematics ($p < .01$). Collective efficacy also had a statistically significant ($p < .01$), positive effect on school achievement in mathematics, and the presence of collective efficacy made the quest for academic excellence even stronger. Collective efficacy had a stronger effect on school achievement in mathematics than socio-economic status (Hoy et al., 2002), and was the single variable that had the greatest effect on school mathematics achievement.

Conclusion

There are many variables that are at play in the implementation of the NCCCS developmental mathematics redesign. It is likely that implementation at each of the 58 NCCCS colleges was unique to each college's situation. Based upon private conversations and presentations at state conferences, the prominent delivery methods chosen have either been teacher-centered, student-centered, or computer-centered, and some colleges even have some sort of combination of two or more delivery methods. The designers of the NC courses considered and implemented many strategies into the design of the new curriculum and coursework to allow flexibility at the college level, and the plan was to develop a realistic, yet rigorous pathway from developmental mathematics courses to the subsequent gateway course. The desire was no matter what methods or techniques were used at the different colleges, the design would enable students to have success in those courses and the outcomes would be universal throughout the system.

It is important to study the subsequent course success rates of each delivery method to see if the results are consistent throughout the system. If they are then the desired outcome has been met, but if not then understanding the characteristics of the different delivery methods is important to understanding how to change outcomes. This review of delivery methods and instructional techniques showed that each one has its own distinctions and claims about which technique is better, yet they have a common characteristic of challenge and rigor as instrumental to successful implementation. This leads back to the question asking if the delivery method makes a difference in the subsequent course success rate for students.

Even though this research does not directly look at the external factors that affect learning, understanding that these variables exist in the classroom will also be helpful to practitioners who are making decisions about instructor professional development and curriculum design. The attitudes and beliefs of students and instructors are part of the data that will be collected. As the results are revealed, it is expected that information on what is working or needs more research will emerge.

CHAPTER III

Method

The purpose of this study was to compare the success rates (passing with a C or better) of subsequent gateway courses for students from 16-week developmental mathematics courses with students from 4-week courses. In addition, delivery methods (i.e., teacher-centered, student-centered, or computer-centered) were compared using the subsequent gateway course success rates. Comparison of individual delivery designs, in conjunction with an evaluation of subsequent college course success rates, is necessary in order to evaluate the effectiveness of the redesigned courses and compare whether a particular delivery style shows larger increases than others. This chapter outlines what was studied, how the study was conducted, and how the data were analyzed.

Research Questions

The following research questions were addressed in this study:

1. What is the difference in subsequent course pass rates (students making a C or better) in gateway math courses for former developmental math students based on the type of developmental mathematics course completed (4-week versus 16-week)?

2. What is the difference in subsequent mathematics course pass rates in gateway math courses among students in teacher-centered, student-centered, or computer-centered 4-week developmental mathematics courses?

Null Hypothesis

H_{01}: There is no statistically significant difference between the subsequent course pass rates (students making a C or better) in gateway math courses for former developmental math students based on the developmental mathematics course completed (4-week versus 16-week).

H_{02}: There is no statistically significant difference in the subsequent mathematics course pass rates in gateway math courses among students in teacher-centered, student-centered, or computer-centered 4-week developmental mathematics courses.

Research Design

One of the reasons for the redesign of the DMA courses was to improve success rates in the gateway math course, however the implementation and delivery method varied across colleges in the NCCCS. The NCCCS guidelines allowed for flexible delivery methods during implementation (i.e., teacher-centered, student-centered, and computer-centered, NCCCS, 2011c). Practitioners across the state are interested to know how well the DMA courses at their institution performed. Have subsequent course pass rates improved? Is there a noticeable difference in the subsequent course success rates at other institutions as a result of the flexibility provided in delivery methods? Responses to these questions would be helpful to practitioners as they evaluate their programs.

This research describes the subsequent course success rates of the present developmental mathematics courses, compared to the subsequent course success rates of the past courses. Data were gathered from a year prior to the redesign (2010-11) and a year immediately after the implementation of the redesign (2013-14). The dependent variable for both research questions was success rates in the subsequent gateway mathematics course (i.e., pass with a C or better or fail). The first independent variable was the type of developmental course completed (i.e., 16-weeks or 4-weeks). The second independent variable was the delivery method (i.e., teacher-centered, student-centered, or computer-centered). Because the time frames have already occurred, the independent variables are categorical, and the dependent variable is dichotomous, this study was a descriptive, non-experimental quantitative research design (Johnson & Christenson, 2012). The findings are a description of what has taken place in the past as compared to the present, so the study is also a retrospective, descriptive study (Johnson & Christenson, 2012).

A non-experimental descriptive study was chosen to provide practitioners with information about the success rates of these redesigned courses in a timely fashion. There are limitations to non-experimental studies, such as the lack of a control group (Epper & Baker, 2009), but analyzing trends for the beginning year of the redesign will provide information on the progress of the redesign in relation to improving subsequent gateway course success rates. Epper and Baker (2009) agree that data available regarding redesign efforts are limited and not longitudinal, but provide “evidence of effective practice” (p. 20). In addition, without a control group, “holistic classroom studies offer the benefit of students learning in classrooms under less constrained conditions” (Epper & Baker, 2009, p. 19), and may provide more accurate information. This study provides information about redesign efforts that will be of interest to both individuals involved in redesign, as well as those waiting to gather more information before attempting a redesign.

Participants

This study compared the success rates of 16-week (prior to the redesign) versus 4-week (redesigned) developmental mathematics courses and three different delivery methods used for the DMA modules in the NCCCS. Prior to the 2012-13 school year the only available developmental mathematics courses were the 16-week version. Four-week DMA courses were added to the CCL for the 2012-13 school year, and 16-week courses were archived fall 2013. Developmental mathematics courses in the CCL were only available as 4-week DMA courses from fall 2013 to the present. One college in the study piloted the DMA courses in spring 2012. For consistency, data from 2010-11 were used to determine the subsequent course success rate for 16-week courses from the participating colleges, and data from 2013-14 were used to determine the subsequent course success rates for 4-week courses.

The colleges included in this study were determined by the delivery method that they used in the 4-week DMA courses during the 2013-2014 school year and whether a member of their college participated on the math redesign task force. A purposive sample (Johnson & Christensen, 2012) was chosen to ensure inclusion of each delivery method, as well as taskforce and non-taskforce participation. Through this sampling technique, twelve community colleges (approximately 20% of the NCCCS) were chosen to participate in this study. Four colleges represented each of the delivery methods (i.e., teacher-centered, student-centered, and computer-centered). However, the student-centered group had three task force member colleges and only one non-task force member college, where the teacher-centered and computer-centered groups had one task force member college and three non-task force member colleges.

College participation in this study was voluntary. College administration was contacted first to inquire if the college was willing to participate in the study. Once the college expressed that they were willing to participate in writing, then consent to participate in the study was obtained, and the person with the most direct knowledge of

DMA courses was asked to complete a short survey (see Appendix A) that was used to verify the college's delivery method. Participating colleges were assigned to a delivery method group. The goal was to acquire a sample that was representative of NCCCS colleges (small, large, rural, eastern, western, task force, and non-task force colleges).

Subsequent gateway course success rates were then computed for all developmental mathematics students (at each institution) who completed a developmental mathematics course and then enrolled in a gateway curriculum course within the same or next academic year at the same institution. Success was considered a C or higher in the gateway course. Subsequent course data were analyzed for students who took developmental mathematics for the year 2010-11 and 2013-14. These data were retrieved from archival data stored in the North Carolina Community College data warehouse.

Data Source

Archival data from the NCCCS data warehouse and a questionnaire with closed-ended questions (Johnson & Christensen, 2012) were used for this study. The NCCCS requires specific data from all 58 colleges to be sent to the system data warehouse. The review of subsequent course success for students of former developmental courses is one of those required data pieces (NCCCS, 2013). These data were used to compute the subsequent course success rates for students prior to and after the redesign. Rates were computed collectively for colleges using each delivery method.

In order to properly categorize the delivery method for each college that participated in the study, a brief questionnaire (see Appendix A) was used to gather information about how DMA courses were taught at that college. This questionnaire consisted of five close-ended items and was developed by the researcher in order to make sure the correct delivery method is attached to each institution's data. None of the information that was collected on the questionnaire was used in the data analysis phase of the study. The questions were developed to provide additional clarification of delivery method based on the vocabulary that was used in the literature review. Contact information was also collected for each institution, so follow-up information, if needed, could be obtained.

The questionnaire was piloted using multiple faculty and administrators from a single institution to check whether there was consistency in the answers, and if the answers were aligned with the delivery method used at the college. After administering the original survey, it was found that two of the questions (e.g., is there a second delivery method incorporated into the course and if so what and if you use computer instruction is it done as part of the class or outside of class) were confusing and did not offer any new information that affected the categorization of the college. These questions were eliminated from the original questionnaire. An additional question about implementation of multiple measures was added at a later date, based on a conversation with the data person at the system office and an administrator at a participating college. A Multiple Measures policy (NCCCS, 2013) was implemented during 2013-14 that affected the enrollment in developmental math classes. The college was allowed to implement the policy anytime between fall 2013 and fall 2016 semesters. Data for when the college implemented this policy was collected to see if this had any bearing on the results of the study.

Procedure

Permission for this study was granted from the researcher's doctoral committee, and approved by the Sam Houston State University IRB. Additional permission was granted from all 12 of the participating colleges, as well as the NCCCS office, where the data were retrieved. In coordination with the research department at the NCCCS office and upon approval of the IRB, data were retrieved from the NCCCS data warehouse for school years 2009-10, 2010-11, 2011-12, 2012-13, and 2013-14. Data from 2010-11 were used to establish the subsequent course success rate for former developmental mathematics students in the 16-week course format who attempted their gateway course during the same or next academic year at the same college. Data from 2013-14 were used to establish the subsequent course success rate for former developmental mathematics students in the 4-week DMA course format who attempted their gateway course during the same or next academic year at the same college. Subsequent course success rates were established collectively for colleges using the same delivery method.

Once a college was selected and consented to participate in the study, the administrator with the most direct knowledge of DMA courses and course delivery method was asked to complete a questionnaire (see Appendix A) with closed-ended questions (Johnson & Christensen, 2012). This person was either a lead instructor, director, department chair, or division chair depending on the size of the college. The purpose of this questionnaire was to provide more detailed information about the way instruction is delivered at each college and determine the delivery method classification for each college. This information was used to properly categorize the delivery method for each college to make sure that the participating college and the researcher were in sync with the delivery method used at the institution. Conclusions for the study were made based on the data that was generated by analyzing the research questions.

Data Analysis

Data in this study were analyzed using a weighted Chi-square test with contingency tables (Field, 2013; Johnson & Christensen, 2012). Data were received from the system office in an excel format containing the total number of A, B, C, D, F, OW, and W grades. OW meant an official withdraw and W meant withdraw. Each college has different guidelines for the use of each of those withdraws. The total of A, B, and C grades were used as the total passing grades, and the total of D, F, OW, and W grades were used as the fail grades. These totals, the weighted cases (Field, 2013), were then placed in SPSS (2016) version 24 for further analysis.

Descriptive statistics were computed for each of the research questions. A 2 X 2 contingency table was used to answer research question one. The rows were the number of students in 16-week and 4-week developmental mathematics courses, and the columns were the number of students who passed or failed the subsequent gateway mathematics course. The second research question was answered using a 3 X 2 contingency table. The rows were the delivery method (i.e., teacher-centered, student-centered, and computer-centered) in the 4-week developmental math course, and the columns were the number of students who passed or failed the subsequent gateway mathematics course. The Chi-Square Associations test was used to determine statistically significant relationships in all comparisons, and Cramer's *V* was used to determine effect size (Johnson & Christensen, 2012). The level of significance for the test was set at $p < 0.05$.

Summary

This study was a descriptive, non-experimental research design with the purpose of providing information regarding differences in the pass rates of redesigned North Carolina developmental mathematics courses. Because the courses are relatively new, data are limited on how the redesign is affecting subsequent course success rates and what delivery method may be showing more promise. Twelve colleges were chosen to participate in the study and separated into three groups of course delivery method (teacher-centered, student-centered, or computer-centered instruction). In addition to subsequent course pass rates, Chi-Square Association tests were conducted to determine if differences existed in the subsequent course pass rates based on the redesign and/or teaching method used by each college.

CHAPTER IV

Results

The purpose of this study was to compare the subsequent course success rates for the former (pre-redesign) developmental mathematics courses with the redesigned (post-redesign) courses. In addition, delivery methods for the new redesign were compared to see if there existed differences in the course success rates across delivery methods. Included in this chapter are the results of the data analysis.

Data from 12 NCCCS community colleges were used in this study. The data were from the 2010-11 school year as the pre-redesign data, and the 2013-14 school year for the post-redesign data. The data for 2011-12 and 2012-13 were skipped because colleges were in the midst of transition during this time frame. It was guaranteed that all the colleges in the study were using the pre-design and post-redesign curriculum at the designated times.

The sample of the study included students who took at least one developmental mathematics course during the designated year and then took the gateway course during the same or subsequent school year. This means that a student who took a developmental math course during the 2010-11 school year and then took the curriculum math in the 2010-11 or 2011-12 school years was counted in the 2010-11 data. Only one year of data for both the former and post-redesign was used, because the 2015-16 data had not been collected at the time of this study, so it was not possible to calculate the data for the 2014-15 school year to obtain two years of post-redesign data. The student data was divided into pass or fail categories. Students who received an A, B, or C were classified as passing, and students with a D, F, OW (Official Withdraw), or W were considered a failure.

Results for Research Question One

Research question one examined the difference in subsequent course pass rates (students making a C or better) in gateway math courses for former developmental math students based on the type of developmental mathematics course completed (4-week versus 16-week). A total of 4,616 developmental mathematics students from the pre-design courses in 2010-11 took a gateway course during the designated parameters of the study at the 12 participating colleges. Of those, 2,905 students passed the gateway course, resulting in a 62.93% course success rate. During the redesign year of 2013-14, a total of 3,486 students took the developmental and gateway course in the designated timeframe. Of those, 2,192 students passed the gateway course, resulting in a 62.88% success rate (see Table 1). The comparison of these two course sequence structures did not result in a statistically significant relationship ($X^2(1) = 0.002$, $p = 0.961$). The null hypothesis for research question one stating that there was no difference in success rates between the type of course taken (4-week versus 16-week) was accepted.

Table 1

Pre- and Post-redesign Comparison

		pass		
		no	yes	Total
course	Post-redesign	1294_a (37.12%)	2192_a (62.88%)	3486
	Pre-redesign	1711_a (37.07%)	2905_a (62.93%)	4616
Total		3005 (37.09%)	5097 (62.91%)	8102

Each subscript letter denotes a subset of pass categories whose column proportions do not differ significantly from each other at the .05 level.

Results for Research Question Two

Research question two examined the difference in subsequent mathematics course pass rates in gateway math courses among students in teacher-centered, student-centered, or computer-centered 4-week developmental mathematics courses. The 12 colleges that were studied for research question one were the same for research question two, but they were divided into three different delivery methods. Each delivery method was represented by four colleges, who only used a single delivery method at their college. By limiting the participants to colleges that used only one delivery method, there was little to no opportunity for contamination of data.

During the 2013-14 there were a total of 3,486 students that took a developmental mathematics course and then took the gateway mathematics course in the same or next school year. Of those, 896 students were taught using computer-centered delivery, 1,343 were taught using student-centered delivery, and 1,247 were taught using teacher-centered delivery. The number of students passing the subsequent gateway course taking computer-centered instruction totaled 566 (63.17%), for students receiving student-centered instruction was 900 (67.01%), and for teacher-centered instruction 726 (58.22%; see Table 2). The results of the analysis did show a statistically significant relationship between the delivery methods and the subsequent course success rate ($X^2(2) = 21.469$, $p < 0.001$, $\varphi = 0.078$). Therefore, the null hypothesis that the course pass rates were the same across delivery methods was rejected.

Table 2

Delivery Method Comparison

			pass		
			no	yes	Total
Method	Computer	Count	330_a (36.83%)	566_a (63.17%)	896
	Student	Count	443_a (32.99%)	900_b (67.01%)	1343
	Teacher	Count	521_a (41.78%)	726_b (58.22%)	1247
Total		Count	1294 (37.12%)	2192 (62.88%)	3486

Each subscript letter denotes a subset of pass categories whose column proportions do not differ significantly from each other at the .05 level.

To examine the relationship further, analysis of only two delivery methods at a time was completed, because the initial comparison was with three different methods. These additional comparisons were done to determine which delivery method(s) had a statistically significant difference. When comparing teacher-centered with student-centered (see Table 3) and teacher-centered with computer-centered (see Table 4) there was a statistically significant relationship between these delivery methods, $X^2(1) = 21.402$, $p < 0.001$, $\varphi = 0.091$ and $X^2(1) = 5.336$, $p = 0.021$, $\varphi = 0.050$, respectively. However, when comparing student-centered and computer-centered delivery methods (see Table 5) there was no statistically significant relationship ($X^2(1) = 3.514$, $p = 0.061$). This analysis is consistent with the fact that the teacher-centered delivery method has the lowest subsequent course success rate. Student-centered delivery has the highest subsequent course success rates for this analysis.

Table 3

Student- and Teacher-centered Delivery Comparisons

			pass		
			no	yes	Total
Method	Student	Count	443_a (32.99%)	900_b (67.01%)	1343
	Teacher	Count	521_a (41.78%)	726_b (58.22%)	1247
Total		Count	964 (37.22%)	1626 (62.78%)	2590

Each subscript letter denotes a subset of pass categories whose column proportions do not differ significantly from each other at the .05 level.

Table 4

Computer- and Teacher-centered Comparisons

			pass		
			no	yes	Total
Method	Computer	Count	330_a (36.83%)	566_b (63.17%)	896
	Teacher	Count	521_a (41.78%)	726_b (58.22%)	1247
Total		Count	851 (39.71%)	1292 (60.29%)	2143

Each subscript letter denotes a subset of pass categories whose column proportions do not differ significantly from each other at the .05 level.

Table 5

Computer- and Student-centered Delivery Comparisons

			pass		
			no	yes	Total
Method	Computer	Count	330_a (36.83%)	566_a (63.17%)	896
	Student	Count	443_a (32.99%)	900_a (67.01%)	1343
Total		Count	773 (34.52%)	1466 (65.48%)	2239

Each subscript letter denotes a subset of pass categories whose column proportions do not differ significantly from each other at the .05 level.

Odds ratios for these comparisons were calculated to help with interpretation of data (Field, 2013). Results showed that students had a better chance of being successful in the subsequent gateway course with student-centered instruction. However, the ratios are weak. A student was 1.46 times more likely to pass the gateway course when receiving instruction in the developmental course from the student-centered prospective, rather than teacher- centered. Similarly, a student was 1.24 times more likely to pass the gateway course when they received their developmental instruction in the computer-centered model over the teacher-centered model. Both the student-centered and computer-centered delivery method were found as statistically significant over teacher-centered delivery, however, the odds ratios were not convincing enough to recommend one method over another.

Summary

Data analysis did not show a statistically significant relationship between the structure of the developmental course and subsequent gateway course success rates, but did show a statistically significant relationship between the delivery method and the subsequent gateway course success rates. Student-centered and computer-centered delivery had higher success rates in subsequent courses compared to the teacher-centered delivery method. Initial conclusions could be drawn that delivery method has a greater effect on subsequent course success rates than the structure of the sequence, but more in depth research needs to be conducted to fully understand why.

Additional analysis of the data could yield more information about the effect of delivery method in relation to subsequent gateway course success rates. One question to consider is what delivery method did each of the participating colleges use prior to redesign? Aggregating all the colleges together in the analysis of the pre- and post-redesign subsequent gateway course success rates could have masked a potential relationship that existed at an individual institution. Also, as the data for more years of the post-redesign becomes available the relationship between the delivery methods and the subsequent course success rates may be quite different. Repeating this study with more data could produce different results. This study is just the beginning of an inquiry into, “Does delivery method matter?”

CHAPTER V

Discussion, Recommendations, and Conclusion

The purpose of this study was to compare the subsequent course success rates between the pre-redesign 16-week structure and the post-redesign 4-week structure, as well as compare the subsequent course success rates based on the delivery method in the 4-week courses. The analysis of the data supported that there was no statistically significant difference between the subsequent course success rates of the two designs, but there was a statistically significant difference between the student-centered and teacher-centered delivery methods, as well as the computer-centered and teacher-centered delivery methods in the redesigned courses. These findings answer some questions, but also raise new and different questions that need to be researched.

Summary and Discussion of Research Question One

Research question one dealt with a topic of concern about redesign. This concern was also posed by Jaggars and Hodura (2011), who questioned whether acceleration of developmental mathematics courses hinders student progression and learning. Edgecombe (2011) discussed the benefits to accelerating the sequence, which includes less time, greater persistence, increased retention of knowledge, and creates an environment of rigor that is needed in the subsequent courses. Research question number one for this study addressed the issue of acceleration affecting the subsequent course rates. Data from the 12 colleges in this study did not show a statistically significant difference in subsequent course pass rates when students completed the 16-week course sequence or the 4-week course sequence.

The results from this study are in agreement that accelerating the curriculum does not affect the subsequent course success rates, but rather just shortens the amount of time for many students to complete the developmental mathematics sequence.

Further confirmation of the reliability that acceleration does not negatively affect subsequent course success is the FastStart Program at the Community College of Denver (CCD, Edgecombe, Jaggars, Baker, & Bailey, 2013; Jaggars, Hodura, et al., 2014). The FastStart program accelerated the developmental mathematics sequence for students, allowing them to finish sooner. Those students who participated in the accelerated developmental mathematics courses had a subsequent course pass rate that was higher than those students who were in the traditional format.

Summary and Discussion of Research Question Two

The results of the second comparison supported the use and success of indirect instruction, because the two delivery methods with statistically significant differences were student-centered and computer-centered, which are associated with indirect instruction. When comparing the delivery methods there was a statistically significant relationship between student-centered and teacher-centered delivery, as well as computer-centered and teacher-centered delivery. Student-centered and computer-centered delivery had no statistically significant difference, with the subsequent course success rates being fairly equivalent. Students who received teacher-centered instruction had a lower success rate in the subsequent gateway course than both student-centered and computer-centered instruction. Strategies that are incorporated into these two delivery methods support retention of knowledge and future transfer (Barragan & Cormier, 2013; Stigler et al., 2010; Stylianades & Styliandes, 2007; Wise & O’Neill, 2009).

The similarities of both student-centered and computer-centered delivery are related to indirect instruction techniques. Both delivery methods focus on active engagement, while the focus in teacher-centered classrooms, using a direct instruction approach, is on lectures. Students receiving indirect instruction are working on activities that are related to the topics of the course, rather than just listening. In student-centered instruction students are working on problem solving activities as a group, and in computer-centered instruction students are watching instruction on the computer and engaging with math problems at their own pace. The instructor in both delivery methods is a facilitator of the learning, helping students and/or groups that are struggling with the concept to complete the task on their own (Guy et al., 2015; Kintsch, 2009; NCAT, 2013). The indirect instruction provides students with the background material needed in order to understand a concept, the tools necessary to learn that concept, and the opportunity to figure out how to apply the concept while solving problems (Wise & O’Neill, 2009). This process usually involves struggle, which has been shown to increase a student’s ability to transfer learning and increase subsequent course success rates (Ariovich & Walker, 2014; Barragan & Cormier, 2013; Goldstein et al., 2011; Stylianades & Stylianades, 2007; Wise & O’Neill, 2009).

Direct instruction on the other hand, assumes that students have no prior knowledge and instructors give the solution to a problem directly to the student, rather than requiring the student to engage prior knowledge to develop a solution (Kirschner, 2009). Students are passive receivers of the knowledge and procedure (Herman & Gomez, 2009), and are not encouraged to discover or ask probing questions that will lead to more knowledge. All the information that a student needs to solve a problem is given to them (Mayer, 2009; Rosenshine, 2009). After the information is received the student is then asked to replicate the solution through additional practice (Clark, 2009).

Even though student-centered and computer-centered delivery were shown to have a statistically significant outcome as compared to teacher-centered, there are factors that must be considered. The student population, college resources, and recent research must be considered when making a decision about the delivery method to use. Student-centered instruction takes place in a classroom with teacher-led and group instruction and generally a single level of student. Computer-centered instruction takes place in a computer lab, with multiple levels of students at the same time, and instruction is administered by lessons on the computer. These features must be taken into account when considering which method would be best for the student population. Modifying current teacher-centered classrooms to incorporate some of the indirect instruction strategies could be one option and further research in this area would be helpful.

Reviewing recent research could help with decisions about if and how to redesign developmental courses. Research does verify that computer-centered instruction provides the most optimal way of a true self-paced environment, but it tends to take students longer to finish the developmental mathematics sequence (Bickerstaff, Fay, & Trimble, 2016). The self-paced nature of the delivery, and the fact that some students do not have the ability to develop their own timeline, provides an atmosphere where it is easy for students to procrastinate (Bickerstaff et al., 2016). Another obstacle, cited by both students and instructors, was both groups felt that the computer instruction was missing some key concepts that were needed to fully understand the mathematics, and that these missing concepts were best communicated in teacher-led or group settings, rather than through computer instruction (Ariovich & Walker, 2014).

Student-centered delivery provides a more structured approach, but has its own limitations, especially with time. Instructors liked the more structured approach, because they felt that they could tailor the activities in such a way to make the class time more meaningful, but on the other hand they felt that a set amount of time to complete a class put constraints on the amount of time students had to master a concept (Bickerstaff et al., 2016). The instructors found that the fixed instructional days made the instruction seem very fast. Bickerstaff et al. (2016) went on to note that the structure of individual courses provided more exit points from the sequence.

Implications for Future Practice

The way material is delivered can have more of an impact on subsequent course success rates than the structure of the course sequence. In this study, the way the material is taught had an effect on future learning and retention, but the comparison of 16-week courses versus 4-week courses yielded no statistically significant difference. However, student-centered and computer-centered delivery had statistically significant differences from teacher-centered delivery. These results imply that the way a student is taught material is more important than the amount of time spent in class on that material.

A review of instructional design and curriculum could have a greater impact on the subsequent course success rates than a review of the structure of the sequence. Students who received some form of indirect instruction, whether through a student-centered or computer-centered approach, performed better in the next course. It appeared that developmental students had a greater ability to apply what they had learned in the developmental classroom to the subsequent gateway course when they were taught with one of these two methods. These findings suggest that instructional technique, rather than delivery method, may have more of an impact on future learning. A review of the content, concepts, delivery method, and instructional technique should be a vital part of any redesign effort.

The fact there was no statistically significant difference between the subsequent gateway course success rates in relation to the length of the course implies that length does not make a difference. Therefore, instructors should not fear acceleration of content into smaller units of time. Students were able to learn and remember the material at about the same rate whether they were in class for 16-weeks, learning multiple concepts during the semester, or 4-weeks, learning one concept at a time. There was no definitive answer to the common argument of whether more time is better or less time is better in this study. Based on the findings of this study, if acceleration will help students complete faster, than it should be considered when redesigning developmental mathematics sequences.

Recommendations for Further Research

The infancy of the NC redesign provides opportunities for additional research involving the subsequent gateway course success rates of students in the redesigned developmental mathematics sequence. Repeating this study with a few more years of data would provide a more accurate picture of the subsequent course success rate. As colleges perfect how they offer the new courses and curriculum, the subsequent gateway course success rates could drastically change. This could also affect the comparisons of the delivery methods and the statistically significant results.

An analysis of the delivery method prior to the redesign could be useful in further verifying that delivery method makes a difference. In an initial review of the data, the subsequent gateway course success rates based on grouping the colleges by delivery method post-redesign, provided similar success rates pre-redesign. This similarity raises the question of whether the culture of the college determines the delivery method and/or the success rate (Goodard et al., 2000). Instructor efficacy may be a reason why the subsequent course success rates for the delivery method groups were so close pre- and post-redesign.

Other areas of the redesign should be researched in order to provide a broad analysis of the redesign success. The debate on redesign initially came about with a review of how long it took to complete a developmental mathematics sequence and how few students completed it (Bailey, 2008; Bailey et al., 2009). However, Bickerstaff et al. (2016) in their research on computer-centered instruction stated that it tended to prolong the length of time that it took a developmental student to complete their sequence. Comparing delivery method by how long it takes from start to finish to complete the developmental mathematics sequence would give more information about whether the computer-centered delivery is equally ranked with the student-centered courses, and identify any potential roadblocks in the redesign. Similarly, the goal of getting more students through the sequence was the part of the debate and a second reason for redesign. Since there is no difference in subsequent gateway course success rates between pre- and post-redesign, did the redesign help get more students through the sequence?

This research focused on the subsequent gateway success rates, but a study on the developmental mathematics success rates may also be helpful to establish their effect on transfer. Clark (2015) found that there was no difference in developmental mathematics course success rates between teacher-centered and student-centered. However, Kahl and Venette (2010) found that there was a difference in performance with communications students. Examining if there is a difference in course success rates and subsequent course rates may support a theory that indirect instruction supports retention of material and transfer to gateway courses.

Another recommendation for research is a phenomenon unique to NC. During the 2013-14 school year Multiple Measures (NCCCS, 2013) was implemented. This policy eliminated students who had a 2.6 or higher HS GPA within the last five years from developmental mathematics. This implementation had an impact on the enrollment in developmental mathematics by about 13% (Grovenstein, 2015). Colleges had three years to implement the policy, so at the time of this study six of the 12 colleges had implemented this policy. This resulted in a different population of students post-redesign than their population pre-redesign. The colleges not implementing the policy assigned students to developmental mathematics the same way pre- and post-redesign. Once full implementation occurs there could be an effect on the results of research question one, so repeating the study later with more years and more colleges implementing Multiple Measures would be beneficial. A study highlighting the differences between the two population groups would also give information about the effect of multiple measures on the subsequent gateway course success rates. The same success rate pre- and post-redesign could be viewed as a success, because of the varying student population in between the conversion to the new structure or during the implementation of the redesign.

Conclusion

Indirect instruction, predominately used in student-centered and computer-centered delivery, shows promise in positively affecting subsequent course success rates in NC developmental courses. Students from courses using one of these delivery methods had a greater chance of passing their subsequent gateway mathematics course. Actively engaging with the content, whether through group work or on a computer, was more beneficial to students in future courses. According to the results, passive learning was not retained for the future at the same rate. Due to the early stages and limited data of the redesign, this research is just the beginning of evaluating the best delivery method to use when teaching the NC developmental mathematics courses. More research needs to be done in order to definitively determine the best delivery method and/or strategies to use.

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APPENDIX A

DMA Questionnaire for participating North Carolina Community Colleges

Name of College:

Person filling out questionnaire:

Title:

Relationship with DMA courses:

Phone number:

Email:

Please answer the following questions with the response that most matches the practices at your college during the 2012-2014 academic years.

1. When was the first semester that you fully implemented DMA courses at your institution?
   a. _____ Fall 2012
   b. _____ Spring 2013
   c. _____ Fall 2013
2. Are all of your DMA classrooms equipped with computers?
   a. _____ Yes
   b. _____ No
3. Are classes taught: (check only one response)
   a. _____ with only one module in a room
   b. _____ with multiple modules in the same room
      i. If so, how many? _______
   c. _____ both single and multiple module courses

4. Please check the response that primarily describes the way instruction is delivered in DMA courses: (check only one response)

    a. _____ Teacher-centered (Traditional Lecture and/or teacher shows students how to complete work.)

    b. _____ Student-centered (Collaborative learning where students are encouraged to engage both students and the instructor in discussion about the curriculum.)

    c. _____ Computer-Centered (Instruction is taught on the computer with an instructor and/or tutor answering questions as they arise.)

5. In what academic year did you implement Multiple Measures?

    a. _____ 2013 – 2014

    b. _____ 2014 – 2015

    c. _____ 2015 - 2016

APPENDIX B

Institutional Review Board
Office of Research and Sponsored Programs
903 Bowers Blvd, Huntsville, TX 77341-2448
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DATE:	August 30, 2016
TO:	Tammy Bishop [Faculty Sponsor: Nara Martirosyan]
FROM:	Sam Houston State University (SHSU) IRB
PROJECT TITLE:	*Subsequent course pass rates in modularized developmental mathematics courses in select community colleges in North Carolina: The difference between teacher-centered, student-centered, and computer-centered delivery [T/D]*
PROTOCOL #:	2016-02-28484
SUBMISSION TYPE:	INITIAL REVIEW—RESPONSE TO MODIFICATIONS
ACTION:	APPROVED
APPROVAL DATE: **EXPIRATION DATE:**	August 30, 2016 **August 30, 2017**
REVIEW TYPE:	EXPEDITED
REVIEW CATEGORIES:	7

Thank you for your submission of your **Response to Modifications** for this project. The Sam Houston State University (SHSU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received **Expedited** Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure which are found on the Application Page to the SHSU IRB website.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Sam Houston State University IRB's records

Institutional Review Board
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irb@shsu.edu
www.shsu.edu/~rgs_www/irb/

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All Department of Health and Human Services and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. **Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of August 30, 2017. When you have completed the project, a Final Report must be submitted to ORSP in order to close the project file.**

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the IRB Office at 936-294-4875 or irb@shsu.edu. Please include your project title and protocol number in all correspondence with this committee.

Sincerely,

Donna Desforges
IRB Chair, PHSC
PHSC-IRB

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Sam Houston State University IRB's records

APPENDIX C

I
R
B

Sam Houston State University

Consent for Participation in Research

Subsequent Course Pass Rates in Modularized Developmental Mathematics Courses in Select Community Colleges in North Carolina: The Differences between Teacher-centered, Student-centered, and Computer-centered Delivery

Why am I being asked?

Your college was identified as a potential participant in this research study based upon the recent implementation of Developmental Mathematics (DMA/DMS) courses in North Carolina and the delivery method chosen at your college. This study will be conducted by Tammy Bishop, a graduate student in the Developmental Education Administration Program at Sam Houston State University and Department Chair of the Pre-Curriculum Department at Wayne Community College in Goldsboro, NC, who is completing research for her dissertation under the direction of dissertation chair, Dr. Nara Martirosyan. This study has been reviewed and approved by [NC CC Name]. The researcher asks that you read this form and ask any questions you may have before filling out the study survey.

Participation in this research is voluntary. The decision whether or not to participate will not affect your current or future relations with Sam Houston State University or Wayne Community College. If you do decide to participate, you are free to withdraw at any time without affecting that relationship.

Why is this research being done?

This research is being done to obtain information regarding the implementation of the new DMA/DMS courses and their effect on subsequent gateway course pass rates. In addition, delivery methods used in DMA/DMS courses will be compared. The college will not be referenced by name during any part of the research.

What is the purpose of this research?

The purpose of this study is to evaluate the effectiveness of the NC redesign in improving subsequent gateway course success rates among students who took the redesigned 4-week developmental mathematics courses versus the prior 16-week courses. Gateway course success rates will also be compared by delivery method (i.e., student-centered, teacher-centered, or computer-centered) used at each college to ensure course effectiveness. The expectation is that subsequent course rates for each delivery method will be similar. In addition, data will be analyzed to see if any best practices emerge.

What procedures are involved?

If you agree for your college to be in this research, the researcher will ask you to do the following:

- Complete a short questionnaire with closed-ended questions about the type of delivery method that is used for DMA/DMS courses at your college.

All data regarding subsequent courses success rates will be retrieved from the NC Community College System Office.
Approximately 12 community colleges from the NC Community College System will be involved in this study.

What are the potential risks and discomforts?
Risk is minimal. Data and questionnaire information will be disguised throughout the study and your name will be coded based on the delivery method used at the college. Only the researcher will have knowledge of the specific college that the data and/or questionnaire originated from. Data provided by the system office will be void of any student data.

Are there benefits to taking part in the research?
Benefits of your participation are related to the information that is gained regarding best practices in the redesign efforts in NC and the success of the redesign in NC.

What about privacy and confidentiality?
The only people who will know that your college is a research participant are members of the research team. No information about you, or provided by you during the research will be disclosed to others without your written permission, except:

- if necessary to protect your rights or welfare (for example, if you are injured and need emergency care or when the SHSU Protection of Human Subjects monitors the research or consent process); or
- if required by law.

When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

Surveys will only be handled by the researcher and destroyed upon completion of the research report.

What are the costs for participating in this research?
There is no cost to participate in this study.

Will I be reimbursed for any of my expenses or paid for my participation in this research?
Participants will not receive compensation for their participation.

Can I withdraw or be removed from the study?
You can choose whether to participate in this study or withdraw at any time. If your college volunteers to be in this study, and later changes their mind, you may withdraw the college at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

Consent Form

Who should I contact if I have questions?
The researcher conducting this study is Tammy Bishop. You may ask any questions you have now. If you have questions later, you may contact the researchers at: Phone: 252-917-2025, or Dr. Nara Martirosyan at 936-294-2493.

What are my rights as a research subject?
If you feel you have not been treated according to the descriptions in this form, or you have any questions about your rights as a research participant, you may call the Office of Research and Sponsored Programs – Sharla Miles at 936-294-4875 or e-mail ORSP at sharla_miles@shsu.edu.

You may choose not to participate or to stop your participation in this research at any time. Your decision whether or not to participate will not affect your current or future relations with the University or Wayne Community College.

You will not be offered or receive any special consideration if you participate in this research.

Agreement to Participate
I have read the above information. I have been given an opportunity to ask questions and my questions have been answered to my satisfaction. I grant permission for my college to be a participant in this study.

Consent: I have read and understand the above information, and I willingly consent to allow my college to be a participant in this study. I understand that if I should have any questions about my rights as a research subject I can contact Tammy Bishop at 919-739-6826 or by email at tjbishop@waynecc.edu. I have received a copy of this consent form.

College ____________________________________

Title ____

Your name (printed):__________________________

Signature: ______________________________ Date: __________________

APPENDIX D

I
R
B

Sam Houston State University

Willing to Participate in Study

Subsequent Course Pass Rates in Modularized Developmental Mathematics Courses in Select Community Colleges in North Carolina: The Differences Between Teacher-centered, Student-centered, and Computer-centered Delivery

A research study is currently going through IRB Approval that will be conducted by Tammy Bishop, a graduate student in the Developmental Education Administration Program at Sam Houston State University and Department Chair of the Pre-Curriculum Department at Wayne Community College in Goldsboro, NC. This research will be conducted to complete her dissertation under the direction of dissertation chair, Dr. Nara Martirosyan. This study will compare subsequent course pass rates of developmental mathematics courses prior to the NC redesign with rates after the redesign. Also included in this study is a comparison of subsequent course pass rates between colleges whose delivery method in developmental mathematics is either teacher-centered, student-centered, or computer-centered.

The purpose of this letter is to ask if your college is willing to participate in the study. Willing to be in this study does not constitute consent to participate in the study. If your institution is chosen as a participant in the research, a representative of the college will be asked to complete an informed consent and a short five question survey regarding information about your DMA/DMS delivery method. All subsequent course data will be provided by the NCCCS office. All responses to the short survey are confidential and your college will not be named in the research.

If your institution is willing to participate, please provide a letter on your institution's letterhead that states your college is willing to participate in this study. A sample letter is attached. Return the signed form to tjb038@shsu.edu in PDF format, or you may mail the letter to Tammy Bishop, 2543 Jackie Field Rd., Greenville, NC, 27834. If you have any questions please feel free to email or call me at 252-917-2025.

Thank you for your time and consideration of this matter,

Tammy J. Bishop
Doctoral Student, Sam Houston State University

VITA

Tammy J. Bishop

Department Head
Pre-Curriculum
Wayne Community College

Education

Doctor of Education, Sam Houston State University, 2013-present
Masters of Education, MidAmerica Nazarene University
B. S. in Math Education, Olivet Nazarene University

Other Education

Completion of Advanced Kellogg, "Working with the media and policy makers," Appalachian State University, 2015
Completion of the Kellogg Institute at Appalachian State University, Certified Developmental Education Specialist, 2012

Peer-Reviewed Presentations

Blake, J., Bishop, T. & Mullins, G. (2006, February). *Frustration, persistence, and the pursuit of online success.* Paper presented at National Association for Developmental Education Conference, Philadelphia, Pennsylvania.

Bishop, T. (2009, February) Generating *success.* Paper presented at National Association for Developmental Education Conference, Greensboro, North Carolina.

Bishop, T. (2010, April). *Learning styles, brain-based learning, and pre-curriculum.* Presented at the Eastern Regional North Carolina Association for Developmental Education Conference, Tarboro, North Carolina.

Bishop, T., Spencer, S., Enecks, D., & Franklin, E. (2012, February). *Putting the pieces Together for a successful chapter.* Presentation at National Association for Developmental Education Conference, Orlando, Florida.

Bishop, T., & Kalbaugh, L. (2012, October). *Developmental math redesigned curriculum materials: Achieving a balance of conceptual, contextual and skills.* Presentation at the North Carolina Community College System Conference, Raleigh, North Carolina.

Bishop, T. (2012, October). *Facing the giants: Helping students deal with out of class obstacles.* Presentation at the North Carolina Community College System Conference, Raleigh, North Carolina

Bishop, T., & Mullins, G. (2013, October). *Developmental math reform in the state of North Carolina.* Presentation at the American Mathematics Association for Two-Year Colleges National Conference, Anaheim, California.

Bishop, T. (2014, March). *Faculty training: Handbook, orientation, and mentoring.* Presentation at the National Association for Developmental Education National Conference, Dallas, Texas.

Anaya-Vega, A., Bishop, T. Cerra, M. (2015, February). *Math redesign: Eating the developmental math elephant one bite at a time.* Presentation at the National Association of Developmental Education National Conference at Greenville, South Carolina.

Faucette, J., Bishop, T., & Taylor, L. (2015, February). *Time travels: Strategies from the past – successful learners in the present.* Presentation at the National Association of Developmental Education National Conference at Greenville, South Carolina.

Work Experience

Department Head, Pre-Curriculum, Wayne Community College, Goldsboro, NC, May 2007 to present

- Supervise 11 Full-time Instructors, 15+ Adjunct Instructors, 1 Achievement Coach, and an Administrative Assistant
- Project Director for Title III, $400,000 grant
- Quality Enhancement Plan (QEP) Director
- Instructor for Developmental Mathematics and Study Skills courses

Instructor, Developmental Studies, Pitt Community College. Greenville, NC, January 2003 to May 2007

- Taught Developmental Math Courses
- Lead Instructor for Intermediate Algebra, developed course and oversaw instructors teaching this course

Professional Experience

- Co-chaired the North Carolina Developmental Mathematics Redesign Task Force.
- Member of the North Carolina Diagnostic Assessment Placement Committee.
- Awards Committee Chair, National Association for Developmental Education and North Carolina Association for Developmental Education
- Leadership Institute, Pitt Community College, June 2006.

Awards

Bell Distinguished Chair Award, Wayne Community College, September 2012