COMMUNITY COLLEGE STUDENT SUCCESS IN DEVELOPMENTAL MATHEMATICS COURSES: A COMPARISON OF FOUR INSTRUCTIONAL METHODS

Judith Keller, B.S., M.S.

Dissertation Prepared for the Degree of

DOCTOR OF EDUCATION

UNIVERSITY OF NORTH TEXAS

May 2014

APPROVED:

Beverly Bower, Major Professor
P. Daniel Chen, Committee Member
Kathleen Whitson, Committee Member
Jan Holden, Chair of the Department of Counseling and Higher Education
Jerry Thomas, Dean of the College of Education
Mark Wardell, Dean of the Toulouse Graduate School

The student success rates for three developmental mathematics courses (prealgebra, elementary algebra, and intermediate algebra) taught through four instructional methods (lecture, personalized system of instruction [PSI], hybrid, and online) were examined. The sample consisted of 9,211 students enrolled in a large Texas community college from fall 2009 through spring 2011. Student success was defined as a grade of C or better. Chi-square tests were used to compare the three developmental mathematics courses success rates. Statistically significant differences in student success were found between all four methods of instruction for all three mathematics courses (prealgebra: $\chi^2 [df = 3] = 107.90, p < 0.001$; elementary algebra: $\chi^2 [df = 3] = 88.39, p < 0.001$; intermediate algebra $\chi^2 [df = 3] = 254.18, p < 0.001$). Binary logistic regression modeling was used to determine to what extent age, gender, ethnicity, residency, Pell eligibility and mode of instruction accounted for the community college students’ course success for each of the three developmental mathematics courses. For prealgebra, the independent variables of gender, race, age, residency, and mode of instruction made statistically significant contributions to the model ($\chi^2 [df = 14, n = 1,743] = 159.196, p < .001$; Nagelkerke $R^2 = .119$), with greater success among female, White, younger, out of country students taking the course through lecture. For elementary algebra, the independent variables of race, age, residency, and mode of instruction made statistically significant contributions to the logistic regression model ($\chi^2 [df = 14, n = 2,731] = 816.223, p < .001$; Nagelkerke $R^2 = .358$), with greater success among , younger, out of country students taking the course through lecture, hybrid or PSI. For intermediate algebra, only race and Pell eligibility made a statistically significant contribution to
the logistic regression, with greater success among White, Pell-eligible students, and mode of instruction did not contribute significantly to the model ($\chi^2 [df = 14, n = 3,936] = 53.992, p < .001; \text{Nagelkerke } R^2 = .019$). Recommendations for research and implications for practice are provided.
Copyright 2014

by

Judith Keller
ACKNOWLEDGEMENTS

It takes a village to write a dissertation. So many people (friends and family) inspired, encouraged, and guided me along this journey. Therefore, I say you know who you are and my words cannot express how thankful I am for your support.
# TABLE OF CONTENTS

## ACKNOWLEDGEMENTS .................................................................................................................. iii

## LIST OF TABLES ............................................................................................................................ vi

## Chapter

1. **INTRODUCTION** ..................................................................................................................... 1
   - Purpose of the Study .................................................................................................................. 4
   - Conceptual Framework .......................................................................................................... 4
   - Research Questions ............................................................................................................... 5
   - Definition of Terms ............................................................................................................... 6
   - Limitations of the Study ....................................................................................................... 6
   - Significance of the Study ...................................................................................................... 7

2. **LITERATURE REVIEW** .......................................................................................................... 8
   - Theoretical Background ....................................................................................................... 8
   - Community College and Developmental Education ............................................................ 16
   - Characteristics of Community College Students ............................................................... 30
   - Studies on Characteristics of Community College Students ........................................... 33
   - Student Success in Community Colleges ............................................................................ 36
   - Instructional Delivery Methods ......................................................................................... 43
   - Summary ............................................................................................................................ 56

3. **METHODOLOGY** ................................................................................................................... 58
   - Participants ......................................................................................................................... 58
   - Description of Courses ....................................................................................................... 59
   - Description of the Instructional Methods ............................................................................ 60
   - Data Sources ...................................................................................................................... 61
LIST OF TABLES

1. Percentage Distribution by Gender and Race/Ethnicity, Public Two-Year Institutions........31
2. Percent Distribution by Gender and Ethnicity, Texas Public Two-Year Institutions.........32
3. Coding Scheme for Categorical Variables Included in Logistic Regression Models.........64
4. Number of Students Enrolled in Developmental Mathematics Courses by Semester........68
5. Demographics of the Sample................................................................................................69
6. Student Success in Developmental Mathematics Courses.............................................70
7. Successful and Unsuccessful Grade Distribution for Instructional Modes in Prealgebra .....72
8. Successful and Unsuccessful Grade Distribution for Instructional Modes in Elementary   
   Algebra ...................................................................................................................................73
9. Successful and Unsuccessful Grade Distribution for Instructional Modes in Intermediate 
   Algebra ...................................................................................................................................74
10. Logistic Regression Prediction for Prealgebra .................................................................75
11. Logistic Regression Prediction for Elementary Algebra ..................................................76
12. Logistic Regression Prediction for Intermediate Algebra ...............................................78
CHAPTER 1
INTRODUCTION

Many students graduate from high school without the mathematical skills to be successful in college (Grubb & Cox, 2005). For example, in 1997, O’Banion stated “the Educational Testing Service reported that 56% of American-born, four-year college graduates were unable consistently to perform simple tasks, such as calculating the change from $3 after buying a 60¢ bowl of soup and a $1.95 sandwich” (p. 4). Recently, President Obama emphasized “the critical role of community colleges in educating and training students and adults for the jobs needed to keep the United States economically competitive” (Badolato, 2010, p. 1). It is the role of higher education, including community colleges, “to create a mathematically literate society that ensures a workforce equipped to compete in a technologically advanced global economy” (MAC3, 2011). This role is particularly significant for community colleges as they often serve as a point of entrance for students who otherwise would not have the opportunity to attend a post-secondary institution (Bueschel, 2003).

Community colleges have an open-door policy. They do not turn away students over the age of 16 and holding high school diplomas or GED certificates. Collins (2009), in an Achieving the Dream report, stated:

While community colleges provide people from all walks of life with broad access to credentials and degrees, they are particularly critical pathway to middle-class earnings for those who are most vulnerable in a knowledge-based economy. Yet for too many first-generation college goers, students of color, and low-income students, access to community college does not translate into a degree or other credential—nor, therefore, to increased income and quality of life. (p. 1)
With this open-door policy, many students enter the college underprepared for college level courses and require developmental courses in reading, writing, and/or mathematics.

Currently, 12.4 million students or 44% of undergraduate students enroll in 1,167 community colleges in the United States (American Association of Community Colleges, [AACC], 2012). Forty-two percent are first-generation students, and 43% are first-time freshmen. In addition, of the total enrollment of students in community colleges, 45% of the students are minorities. Minority students are 13% Black, 16% Hispanic, 6% Asian/Pacific Islander, and 1% Native American (AACC, 2012). McClenney (2009) estimated that between 60% and 90% of community college students need at least one remedial course to prepare them for success in college level courses.

Developmental mathematics courses appear to be a barrier for completion of college for a large proportion of community college students (Culliane & Treisman, 2010). In a recent study the Community College Research Center (CCRC, 2010) reported that 69% of the 250,000 students who took developmental mathematics did not complete their sequence of courses. According to the Texas Higher Education Coordinating Board (THECB, 2011), one-fifth of freshman who start at Texas four-year colleges require at least one developmental class. Well over half of the Texas students who begin community college do so academically unprepared to succeed (THECB, 2011). These students need additional strategies to improve their skills and content knowledge so they can be successful in college level courses (THECB, 2011). Many community colleges are responding to these issues.

“Developmental mathematics is a major barrier to college success for many students. In response to this problem, community colleges and other stakeholders are beginning to suggest and implement a range of strategies to move students through the developmental sequence”
(Lassiter, 2011, para. 8). In his introduction to welcome new faculty, Dr. Wright Lassiter, Chancellor of the Dallas County Community College District commented:

Community colleges offer great promise to students. Every fall about 34 percent of our nation’s postsecondary students enroll in a community college. Students who are academically under-prepared for college-level work succeed at even lower rates, particularly those referred into developmental math. Going forward this heads the list of challenges that the community college sector of higher education faces. (Lassiter, 2011, para. 4)

Traditionally, developmental mathematics instructors at the community colleges expect students to learn at the same pace by the same instructional method. The courses usually run the length of the semester with a lecture format. “Students were supposed to learn to do math by watching an instructor do math primarily in lecture format” (Bassett & Frost, 2010, p. 870). In an effort to improve academic achievement, many community colleges offer different methods of instruction to promote student success in developmental mathematics courses. “Herding groups of students through one-hour sessions daily in high schools and three days a week in college, flies in the face of everything known about how learning occurs” (O’Banion, 1997, p. 10).

In addition, developmental mathematics students may benefit from different instructional methods and teaching strategies that address both affective and cognitive factors related to student success (Higbee & Thomas, 1999). Developmental mathematics courses typically are taught in a multilevel sequence of courses (Culliane & Treisman, 2010). Based on their placement scores, students may need to enroll in one, two, or three developmental courses. However, Highbee and Thomas (1999) found that students tend to prefer learning in small group settings and learn through other stimuli rather than just reading a textbook or listening to a
lecture. “Thus, it is not surprising that many enjoyed collaborative problem solving and doing activities designed to enhance spatial visualization skills” (Highbee & Thomas, 1999, p. 8). Taylor (2008) recommended that teachers “evaluate what is best for their students and implement these best practices and possibly give the students a choice” (p. 49).

Purpose of the Study

This study was designed to determine which of four instructional modes was best for student success in developmental mathematics courses in a community college setting. Four different modes (i.e., modalities or methods) of instruction were examined to determine whether there were differences in student success between the four instructional modes as related to student demographics and characteristics. The instructional approaches studied were the traditional lecture style, personalized system of instruction (PSI), hybrid method, and online learning.

Conceptual Framework

Research shows to assist in improving mathematics achievement instructors must investigate many variables to identify strategies for mathematics achievement and then implement different teaching strategies (Higbee & Thomas, 1999). The present studies incorporate student development and constructivist views of teaching and learning. Student development theories have greatly influenced developmental education by emphasizing the student as a whole person, not just focusing on intellectual development (Higbee, Arendale, & Lundell, 2005). The theories view each student as different with individual and unique needs and suggest the whole student environment should be used as part of educating the student, such as the community college environment as well as student characteristics. In addition, the theory of constructivism has dominated mathematics education in the past decades. Constructivists view
learning as a process that allows a student to use the environment to acquire current knowledge and use it to test new knowledge. These processes include instructional methods that contribute to student success. Learning and solving mathematics use several cognitive processes that require students to incorporate current knowledge to learn new problems (Greenes, 1995). “But these are exciting times for college instructors and students because findings in educational and cognitive psychology have changed our views of the teaching/learning process and provide both conceptual and practical information about the ways that students learn and how instructors can use this information to inform their teaching practices” (Svinicki & McKeachie, 2011, p. 292).

This study explored different instructional methods in developmental mathematics courses in an effort to meet the development, cognitive and psychological needs of developmental students. The concepts included in this study were characteristics of community college students, success in developmental mathematics courses, and instructional delivery methods for developmental mathematics.

Research Questions

The following research questions guided this study:

1. Are there statistically significant differences in students’ success using the following methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning?

2. Do student demographics or characteristics influence student success differently for students enrolled in developmental classes using the following different methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning?
Definition of Terms

For the purpose of this study, the following terms were operationally defined.

*Lecture.* The lecture method of instruction usually an instructor presents an overview of a concept by introducing definitions, theorems, and examples. This presentation might have included use of the classroom’s dry erase, chalk, or smart board; an overhead projector; or computer-powered slide presentation. The instructor would determine the pace of the class. The students would take notes and contribute little to the instruction.

*Personalized system of instruction (PSI).* This instructional method has the following components: pre-testing with a customized study plan, mastery-based progression, post-testing mastery before written tests, intervention by instructor, counselors and disability services, frequent communication between instructor and student, and mini-lectures focused on critical thinking, study skills, and common areas of difficulty. This method would have required students to use MyMathLab, an interactive computer program.

*Hybrid delivery.* Hybrid courses can allow face-to-face meetings with online-learning activities. This method required classroom attendance using the PLATO interactive computer program.

*Online learning.* Online learning method does not require classroom attendance. The student does not have to travel anywhere to meet the teacher. The online method used the PLATO interactive computer program.

*Success.* This event occurs when a student passes a course with a grade of C or better.

Limitations of the Study

Student grades were used as a measure of success. There were variations in grading processes between instructors. Each instructor may have graded or measured success differently.
Significance of the Study

By examining different modes of instruction, this study provided community colleges with insights and strategies for student success in developmental mathematics courses. Many colleges have successful completion of developmental mathematics courses as a top priority in their retention efforts. The study provided information to faculty and administrators at community colleges developing pedagogical strategies that may improve retention. Additionally, information from the study might lead to more effective academic advising for advisors working with students regarding which instructional method might be best for specific students and desiring to show evidence of student success based on the various instructional delivery modes. Students might make better decisions in selecting the type of instructional method most advantageous for their success in a developmental mathematics course.
Remedial or developmental education has been part of American education since the beginning of college in the United States. In 1643, a Harvard College brochure announced remedial reading was available to adults “to advance learning and to perpetuate it to posterity; dreading to leave an illiterate ministry to the churches” (Games, 1958, para. 3). Today, most colleges provide a comprehensive package of programs and services including individualized programs, career planning, tutoring, assessment and placement, study skills and orientation (Astin, 1984; Pascarella & Terenzini, 2005; Tinto, 2006). Because community colleges have an open-door policy, they provide most of these services. “Thus, remedial education acts as a gatekeeper and a quality control in higher education, though this function is rarely acknowledged” (Attwell, Lavin, Domina, & Levey, 2006, p. 887).

For years, developmental mathematics in community colleges has been discussed, dissected, reviewed, restructured, and redesigned in an effort to improve student success (Pascarella & Terenzini, 2005; Tinto, 2006). This chapter explores the theoretical background and provides a literature review that pertains to the instructional delivery methods of developmental mathematics in community colleges. The literature review discusses: (a) theoretical background, (b) community college and developmental education, (c) characteristics of community college students, (d) success in community colleges, and (e) instructional delivery methods.

Theoretical Background

This section of the literature review investigates the theoretical background of constructivist and several student development theories. The theory of constructivism has
dominated mathematics education in the past decades. Constructivism view learning as a process that allows a student to use the environment to acquire current knowledge and use to test new knowledge. In addition, student development theories have greatly influenced developmental education by emphasizing the student as a whole person, not just focusing on intellectual development (Higbee, Arendale, & Lundell, 2005).

**Constructivist Theories**

Constructivist theory is a “psychological theory of learning that describes how structures and deeper conceptual understanding come about, rather than one that simply characterizes the structures and stages of thought or one that isolates behaviors learned through reinforcement” (Fosnot, 1996, p. 29). A constructivist approach is a viable model because by definition learning takes place in contexts (Schunk, 2008). Constructivists believe learners are active and must construct the knowledge themselves in their given situation. Schunk (2008) stated, “Mathematical knowledge is not passively absorbed from the environment but rather is constructed by individuals as a consequence of their interactions” (p. 435).

**Jean Piaget.** Piaget is considered one of the earliest proponents of the constructivist approach to understanding learning. According to Pritchard (2009), Piaget was a leader in establishing levels of intellectual development through four developmental stages that include the sensorimotor stage (0-2 years), pre-operational stage (2-7 years), concrete operational (7-11 years), and formal operations (11+ years). Another aspect of Piaget’s work is dealing in understanding how a young person learns. “Piaget’s descriptions of assimilation and accommodation give a good representation of the process of learning for learners of all ages” (Pritchard, 2009, p. 19).
Assimilation and accommodation. Assimilation is the process where new information is merged into the exiting mental structure (Pritchard, 2009). Accommodation is the process where mental structures have to be changed in order to handle the introduction of a new experience. Piaget suggested that intelligence is being able to adapt to one’s environment effectively (Greenes, 1995). “The evolution of intelligence involves the complimentary processes of assimilation, the fitting of the new information into existing cognitive frameworks, and accommodation, the modifying or developing of new structures” (Greenes, 1995, p. 86). So in order for learning to take place, the learner must filter the information, construct a connection between the new information and past experiences, and reorganize existing mental structures to assimilate and accommodate new ideas (Greenes, 1995).

Lev Vygotsky. Vygotsky, a Russian psychologist, proposed a theoretical framework that relates the cognitive and social environment. “Vygotsky’s theory stresses the interaction of interpersonal (social), cultural-historical, and individual factors as the key to human development” (Schunk, 2008). Vygotsky’s theory stated that social interactions are crucial, that “self-regulation is developed through internalization of actions and mental operations that occur in social interactions” (Schunk, 2008, p. 244), human development occurs through cultural language and symbols-language is the most critical tool and the concept of zone of proximal development-ZPD (Schunk, 2008). Vygotsky stated that two levels of development for the ZPD exist as what is known now and what tasks are in the processes of maturing. The first level happens by unassisted problem solving, the second with assisted problem solving (Greenes, 1995). He stated that educators should structure the learning environment so learners can construct understandings and maximize their ZPD. “Thus, the ZPD provides a way of gaining insight into children’s capabilities and the type of instruction required for them to realize their
potential (Greenes, 1995, p. 56). Schunk (2008) stated "Vygotsky’s ideas lend themselves to many educational applications. The field of self-regulation has been strongly influenced by the theory. Self-regulation requires metacognitive mediators such as planning, checking, and evaluating" (p. 246).

There are some general principles of learning derived from constructivism (Fosnot, 1996). One principle is that learning is development, not the result of development. Another principle is “disequilibrium facilitates learning. ‘Errors’ need to be perceived as a result of learners’ conceptions and therefore not minimized or avoided” (Fosnot, 1996, p. 29). Discussions within the classroom stimulate further thinking; students examine and analyze problems to make meaning of them. “Two goals of pedagogy in the constructivist’s view are to facilitate the learner’s in-depth examination of knowledge and to develop multiple perspectives” (O’Banion, 1997, p. 83).

*Student Development Theories*

Student development theories have greatly influenced developmental education by emphasizing the student as a whole person, not just focusing on intellectual development (Higbee, Arendale, & Lundell, 2005). The theories view each student is different with individual and unique needs and that the whole student environment should be used for his education, such as the community college environment as well as student characteristics. “These theories focus primarily on the nature and content of *intraindividual* change, although interpersonal experiences are often salient components of these models” (Pascarella & Terenzini, 2005, p. 21). Since the 1960s, the work of student development theorists Arthur Chickering, William Perry, and Alexander Astin has influenced developmental education.
Arthur Chickering. According to Pascarella and Terenzini (2005), Arthur Chickering had more influence on research of college student development than most psychosocial theorists did. “Recognizing the absence of any systematic framework for integrating or synthesizing the abundant empirical evidence on college students (almost exclusively traditional age and enrolled at four-year institutions) and based on his review of that literature, Chickering identified seven vectors of development, each of which has several subcomponents” (Pascarella & Terenzini 2005, p. 21). Chickering’s theory (2011) emphasized the student as a whole person and identified seven major developmental vectors for college student development:

1. Achieving competence. Chickering stated that the college years lead to increased competencies in the intellectual areas, physical skills, and interpersonal relationships. Increases in intellectual competence are important for learning and involve processes that include knowledge acquisition; improved intellectual, artistic, and cultural awareness; and development of higher-order cognitive skills (Chickering, 2011).

2. Managing emotions. Students have to deal with many emotions that can interfere with their educational growth. Many students have to deal with anger, fear, boredom, and tension. Development occurs when students learn to manage their emotions before they hurt other relationships. The challenge is to get in touch with their emotions and learn how to exercise self-regulation. Growth occurs when students learn to balance their emotional tendencies (Chickering, 2011).

3. Moving through autonomy toward interdependence. A developmental step for students is to take responsibility for their individual goals and not rely on others’ opinions. This requires students to examine both emotional and instrumental independence. Emotional independence means freedom from needs for reassurance, affection, or approval. Instrumental independence is
the ability to organize actions and to solve problems. As this occurs, relationships expand to include not only family, but to include the community, society, and the world (Chickering, 2011).

4. Developing mature interpersonal relationships. Maturing interpersonal relationships reveal openness to other ideas, people, backgrounds, and values. Students develop relationships that are independent, but also develop relationships based on common interests (Chickering, 2011). “Development means more in-depth sharing and less clinging, more acceptance of flaws and appreciation of assets, more selectivity in choosing nurturing relationships, and more long-lasting relationships that endure crises, distance, and separation” (Chickering, 2011).

5. Establishing identity. This vector has the influence of the previous vectors. Students develop a sense of self—self-esteem and consistency improves. “A solid sense of self emerges, and it becomes more apparent that there is an I who coordinates the facets of personality, who ‘owns’ the house of self and is comfortable in all of its rooms” (Chickering & Reisser, 1993, p. 49).

6. Developing purpose. “Development purpose entails an increasing ability to be intentional, to assess interests and options, to clarify goals to make planes, and to persist despite obstacles” (Chickering, 2011). Students develop and set priorities in goals, interests, and family.

7. Developing integrity. This vector requires a student to reexamine his inner self and balance his personal values and beliefs. The student’s core values provide the foundation for assessing experiences and assist in determining behavior and self-respect (Chickering, 2011).

Chickering attempted to combine theory with practice. “Chickering’s seven vectors can be particularly useful in identifying the competing demands on community college students’ time
and in demonstrating that development can occur simultaneously in many aspects of students’ lives” (Higbee et al., 2005, p. 6).

William Perry. In 1970, William Perry’s book titled *Forms of Intellectual and Ethical Development in the College Years: A Scheme* was known for the examination of the cognitive development of college students (Higbee et al., 2005). Perry stated that students move through stages or positions of cognitive and affective development, and each is more complex than the previous one. Perry preferred the term *position* because it is “happily appropriate to the image of ‘point of outlook’ or ‘position from which a person views his world’” (Perry, 1970, p. 48). Perry grouped his sequence of nine positions into three categories, but currently, the positions are grouped into four major categories.

**Dualism** (Positions 1-2). In these positions, all questions have the right and absolute answers. For students at these levels, what the instructor says is the absolute truth (Perry, 1970).

**Multiplicity** (Positions 3-4). In these positions, most questions have no answers; everyone is entitled to their viewpoint. Students may realize that there may be several answers to one question (Perry, 1970).

**Contextual relativism** (Positions 5-6). In these positions, students see ideas from different perspectives and make reasonable decisions (Perry, 1970). Students’ analytical thinking skills appear as they evaluate other perspectives (Pascarella & Terenzini, 2005).

**Commitment within relativism** (Positions 7-9). In these positions, students must learn to think for themselves (Perry, 1970). The students make commitments to values and ideas.

Perry’s work demonstrates that the most powerful learning involves significant qualitative changes in the way learners approach learning and in the ways they perceive, organize, and evaluate experiences and events. “Following Perry’s theory that educators must
work to move students beyond this dualistic perspective, it is critical that community college developmental educators facilitate students’ ability to think for themselves, evaluate the relative merits of different points of view, and make commitments accordingly” (Higbee et al., 2005, p. 7).

Alexander Astin. Astin’s (1984) model of Input-Environment-Outcome examines student achievement. According to Bird, Anderson, Anaya, and Moore (2005), “Astin was one of the first researchers in higher education to present a holistic model for using student outcomes to examine impact” (p. 363). This model has three basic components: input, environment, and outcome.

**Input.** According to Astin’s (1984) model, inputs are the beginning characteristics that students bring with them into the college. These include characteristics such as age, gender, race, GPA, high school or prior achievement, learning styles, and socio-economic status.

**Environment.** Astin (1984) referred to the environmental variables as the learning or educational experience within the college program. These include the various programs and other educational experiences on or off campus that may involve student-student interaction, student-faculty interaction, honors programs, or even class presentations (Astin, 1993).

**Output.** Astin (1993) stated that these are student characteristics after their college environment. These characteristics include knowledge, skills, values, and beliefs. Astin (1993) stated:

> Change or growth in the student during college is determined by comparing outcome characteristics with input characteristics. The basic purpose of the model is to assess the impact of various environmental experiences by determining whether students grow or change differently under varying environmental conditions. (p. 7)
The I-E-O model can provide educators with a basis to develop or achieve desired educational outcomes (Astin, 1993). “Studies adopting this conceptual approach attempt to explain the effects of environmental influences (in the aggregate or individually) on student change or growth, focusing on factors over which college faculty and administrators have some programmatic and policy control” (Pascarella & Terenzini, 2005, p. 53).

In conclusion, although each of these theorists approached learning from a different view, their theories shared some commonalities on instruction that include learners progress through stages or phases; learners require practice, feedback and review; and learners need material to be organized and presented in small steps. In addition, the theorists contend that both motivational and contextual factors influence learning. Pascarella and Terenzini (2005) stated:

Although much remains to be done to validate many of these theories in different settings with different groups of students, as well as to consolidate psychological and sociological perspectives, each of the two approaches to the study of change among college students—development and sociological—has much to offer. Focusing on one to the exclusion of the other is likely to result not only in misunderstanding the college student change process but also in poor theory and inadequate research and practice. (p. 61)

Community College and Developmental Education

Community College History

This section of the literature review offers a brief history of the development of the community college. Since its beginnings, the community college has been a constantly changing institution. According to Cohen and Brawer (2008), “Since its founding, the United States has been more dedicated to the belief that all individuals should have the opportunity to rise to their
greatest potential” (p. 11). The original community college mission was focused on a traditional liberal arts education. Cohen (1998) stated:

The curriculum derived from the seven liberal arts: grammar, rhetoric, logic, astronomy, arithmetic, geometry, and music. What is noteworthy is the way liberal arts studies were adapted to religious purposes, modified to add various forms of philosophy and ethics, and prescribed for all who count themselves among the learned. (p. 30)

Because of the Great Depression (1929-1939), the community college focus shifted to incorporate job-training skills (Badolato, 2010). The land-grant acts and the GI Bill created a new group of students entering colleges with different educational needs. With an eye to increasing enrollment in higher education, in 1946, the President’s Commission on Higher Education (Truman Commission) re-examined the role of higher education. Mellow and Heelan (2008) stated:

The impetus was to create a national system for this new kind of college, one that would be local, non-residential, and aimed at individuals who in times past would have been able to successfully support a family if they had just finished high school. The new college would be a college of and for its community. (p. 6)

The new community college was an open door institution. Its mission incorporated five general categories: 1) academic transfer, 2) vocational education, 3) continuing education, 4) developmental education, and 5) community service (Cohen & Brawer, 2008).

There were several purposes for academic transfer studies. The transfer studies were the starting point for individuals to gain access to a degree and to make the community aware that anyone could attend college and pursue an education (Cohen & Brawer, 2008). Another goal was that community colleges would assist with the high enrollment of students in colleges and
universities by offering freshmen and sophomore transfer classes – continuing the mission of the first junior colleges and allowing four-year colleges to be selective with first- and second- year students.

The vocational education program was designed to be a terminal degree and to teach more complicated skills than those learned in high school. Throughout the years, it has undergone name changes (vocational/technical) as well as shifts in curriculum. By the 1970s, the number of students in vocational education had reached equivalence to that of the transfer programs (Cohen & Brawer, 2008).

The community service function continues today as community colleges offer sponsored community events such as voter registration or blood drives (Cohen & Brawer, 2008). “The open-end nature of continuing education fit well with the idea that the colleges were not to be confined to particular curricular patterns or levels of graded education but were to operate in an unbounded universe of lifelong learning, which would, not incidentally, enhance public support” (Cohen & Brawer, 2008, p. 25). Continuing education courses fit well in the community college mission, providing open access to everyone.

Today, community colleges enroll almost half of the undergraduates (8 million) in public institutions (American Association of Community Colleges, 2011). An additional 5 million students take classes for improvement of job skills or personal interests but are not seeking a degree or certificate (Badolato, 2010). Community colleges are still the most affordable schools “with an average price tag of $2,544 a year compared to $7,020 for four-year public research institutions” (American Association of Community Colleges, 2011). They continue to provide open door access to students. According to Badolato (2010):
These features make community colleges the workhorses of higher education. They serve myriad roles, including helping students catch up through developmental, or remedial, classes; preparing students to transfer to four-year institutions; providing specialize workforce and job skills training; and teaching English as a second language. They also reach a disproportionate share of nontraditional college students—single parent, low income, minority, immigrant, part-time, first generation and adult. (p. 2)

Community colleges continue to provide education opportunities and services to the community and play an important part in preparing students who are academically underprepared. The next section of this review looks at developmental education in higher education.

Developmental/Remedial Education

Developmental education usually refers to services and programs designed to meet the needs of academically underprepared college students (Arendale, 2002b). Many students who plan to attend a higher education institution do not have the necessary skills to succeed in a traditional college academic setting. Throughout the nation’s history, colleges and universities have provided learning assistance and programs to meet the needs of underprepared students as they enter higher education programs. “Their various needs have become the responsibility of postsecondary education (including professional schools, occupational education, and vocation training) and students in these programs now account for an important portion of our higher education efforts” (Dotzler, 2003, p. 1). This section explores the beginning of developmental education and traces its phases from the colonial era until present day. In addition, it discusses the current state of developmental education in the United States and Texas.

The first mention of underprepared students occurred in the mid-1600s. Once the Puritans established the Massachusetts Bay Colony in the Boston area, they shifted their focus to religious
education. Tutoring in reading skills was established to assist privileged White males, as most of the academic courses were taught in the traditional British style with Latin-language textbooks and lectures (Dotzler, 2003). In the earliest American colleges, students who chose not to study the ministry and were not proficient in Greek and Latin were the first set of underprepared students (Payne & Lyman, 1996).

In the mid-1800s, the Morrill Land-Grant Acts allowed for the creation of land-grant colleges. According to Cohen (1998), “higher education and the secondary schools expanded their offerings, presented new types of programs, and attracted students who in earlier times would not have considered education beyond the lower grades” (p. 103). In the beginning, these disciplines required colleges to establish preparatory or precollege academies for the privileged white males who were weak in reading, writing, and arithmetic (Payne & Lyman, 1996).

The University of Wisconsin is considered to have established the first developmental education program in 1849. “This was the first systematic program to accommodate and ready underprepared students” (Arendale, 2002b, p. 8). The university established a formal developmental education department to teach reading, writing, and arithmetic. During this time, other examples of college/preparatory programs also emerged. In 1830, New York University created an early prototype of an academic preparatory academy. In 1861, the University of Alabama created an academic preparatory department for boys 12 years or older. In 1863, the University of Georgia created University High School “and suspended rules prohibiting admission of boys younger than fourteen to the university” (ASHE, 2010, p. 9). The University of Wisconsin in 1865 enrolled only 41 of 331 admitted students in “regular” college-level courses that counted toward graduation requirements. During these years, 40% of all first-year students took college preparatory courses (Arendale, 2002a).
Cohen (1998) stated that “between 1870 and 1944 the number of colleges quintupled, and enrollments increased by several thousand percent” (p. 103). As colleges competed for students, they had to develop new ways to manage the growing numbers of students. At the turn of the 19th century, most colleges and universities were offering developmental courses.

Enrollment continued to increase and one of the new groups to attend college were the veterans from World War II (Casazza, 1999). The Servicemen’s Readjustment Act of 1944 caused a shift in the way Americans viewed college. Cohen (1998) stated, “The belief that everyone could go to college became firmly established in the minds of the American people; college was no longer reserved for an elite few” (p. 183). The G. I. Bill provided the opening for a greater diversity of student population. Following the veterans came more women, students with special needs and students from low-income families (Payne & Lyman, 1996). “This brought funding to colleges that, in turn, helped to create guidance centers, reading and study-skills programs, and tutoring services. Support systems continued to grow and to become more comprehensive in order to meet the increasingly diverse needs of new students” (Casazza, 1999, p. 3). More “neighborhood” post-secondary institutions were established and many technical institutes combined with the early junior colleges to provide learning assistance to the growing number of students.

In 1947, Truman’s Advisory Committee on Higher Education recommended the establishment of publicly supported two-year colleges (Cohen, 1998). The number of students entering colleges and universities increased, and colleges had to offer more remedial courses for the entering students.

In the 1960 and 70s, colleges continued to provide an “open door” policy. In addition to traditional students, nontraditional students were attending colleges in far greater numbers.
(Cohen, 1998). These students included women and other minorities, low-income students, adults over the age of 25, and part-time students. Federal and state aid allowed these students access to higher education programs and the numbers of students continued to increase. “The incursions of these new majorities into higher education led to a proliferation of developmental programs and services. Labels for these programs and services multiplied as well. Chief among them were such terms as preparatory studies, academic support programs, compensatory education, learning assistance, and basics skills” (Payne & Lyman, 2001, p. 3).

The Civil Rights Act of 1964 and the Higher Education Act of 1965 gave underprepared students an opportunity to attend a postsecondary institution. Title VI, from the Civil Rights Act of 1964 stated that no person, based on gender, would be excluded from any education program or activity receiving Federal financial assistance (United States Department of Labor, 2011). The Higher Education Act of 1965 was intended “to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in postsecondary and higher education” (National TRiO Clearing House, 2011). There was easily available government funding, making community colleges more accessible and attractive, and there was an increase in the number of older students who returned to education or attended postsecondary education for the first time (Cohen, 1998). In her classic text, Beyond the Open Door, K. Patricia Cross (1971) introduced us to the ‘new’ students of the 70s. She stated:

Fundamentally, these New Students to higher education are swept into college by the rising educational aspirations of the citizenry. For the majority, the motivation for college does not arise from anticipation of interest in learning the things they will be learning but from the recognition that education is the way to a better job and a better life than that of their parents (p. 15).
Developmental education had to deal with this new type of student – “no longer could they be molded to fit the needs of the institution; rather, institutions had to figure out how to meet the wide ranging needs of students” (Casazza, 1999, p. 5).

Developmental or remedial education continued to grow as more students enrolled who were underprepared for college courses. “The apparent breakdown of basic academic education in secondary schools in the 1960s, coupled with the expanded percentage of people entering college, brought developmental education to the fore” (Cohen & Brawer, 2008, p. 25). Developmental education continued to be part of the community college mission and today, it can be a combination of courses and services (including tutoring, career services, and continuing education courses).

Today’s students have not changed much and higher education has adapted to this type of student. The changes that have occurred are due to the number and the nature of students who need remediation. Demographic changes have shifted the student populations in colleges and universities. Markus and Zeitlin (1998) stated:

An additional challenge to effective teaching and learning is today’s multicultural classroom. Ethnic, racial, socioeconomic, cultural, and gender diversity create a situation where there are differently held customs, values, and beliefs. There is less of a common knowledge base among these students. Students may experience difficulties in basic skills in mathematics and English due to motivational, cultural, religious, and familial considerations. Open enrollment and liberalized admission policies have increased the number of students who are the first of their families entering higher learning institutions. (p. 176)
Institutions continued to develop ways to meet the needs of the students. “A developmental education approach is a comprehensive process focusing on the intellectual, social, and emotional growth and development of all learners” (Casazza, 1999, p. 7). Today, there are developmental programs or departments at most post-secondary institutions from local community colleges to Harvard and Yale.

Not all entering students accept developmental courses enthusiastically, whether because of fear of failure, lack of interest in the subject, a sense of wasting time and money on nontransferable courses, or some other reason. According to Kinney (2001), students took developmental mathematics for several reasons: “(a) they did not take the relevant course in high school, (b) they took the relevant courses but did not master the content, and (c) they have forgotten much of the content that they once had mastered” (p. 10). According to a report by the Community College Research Center (CCRC, 2010), nearly 60% of community college students take at least one remedial course. In Texas, according to the Texas Higher Education Coordinating Board (THECB, 2009), students enrolled in community colleges account for almost half of all students in public degree-granting institutions, and of the total enrollment of 743,252 students, 93,967 (13%) are in developmental education because these are below the mathematics, reading, or writing standards for the Texas Success Initiative (THECB, 2011). Providing these courses can be expensive to students, colleges, and states.

Developmental education has come a long way from the tutoring of underprepared Harvard students in 1836. Most colleges and universities provide a comprehensive package of programs and services including individualized programs, career planning, one-on-one support, assessment and placement, study skills, and orientations. Developmental education is more than just tutoring; it is a complex and comprehensive process designed to reach the learner holistically.
(Casazza, 1999). According to Casazza (1999), developmental education must focus on the intellectual, social, and emotional growth and development of all students; it is the responsibility of educators to identify them and provide support in other areas.

As it was in the 1800s, developmental education is the answer to bringing more people into higher education. Educators look at current and future trends to determine future needs and to be proactive in developing new programs. Technology may be one of the answers for increasing the access of students. In Texas, research (THECB, 2005) showed practices of successful developmental programs had five recurring themes: institutional commitment, centralization, academic advising, alternative pedagogies, and systematic assessment. Institutional commitment was the single most common characteristic among successful developmental programs, including administrative support and a commitment to student success. Centralization was demonstrated by highly coordinated programs with clear goals and objectives. Few institutions of higher education in Texas reported using alternative pedagogies, even though current research (THECB, 2005) suggested the need to use different strategies with the developmental student. “There is in fact no strong consensus about how to carry out developmental education most effectively. As a result, the content and organization varies widely” (Bailey, 2009, p. 2).

However, in the last few years, colleges, state agencies, and researchers have shown an interest in strengthening the academic weaknesses of college students by looking at data analysis of student progression through college and evaluating program interventions that have been successful. “These developments provide an opportunity for a major and much needed effort to rethink and strengthen developmental education” (Bailey, 2009, p. 4).
“It is a mistake to look at learners who need help through a narrow lens; we are all developmental learners depending on the context in which we find ourselves” (Casazza, 1999, p. 7). If higher education’s mission is to educate students to be successful in society, whether the student is underprepared or not, higher education’s responsibility is to provide the support and services.

*Developmental mathematics.* Developmental mathematics is a major barrier for many students while attending community colleges. Most community colleges offer 3-5 levels of developmental courses, beginning with basic arithmetic through intermediate algebra. According to Bailey (2009), most students do not finish the developmental mathematics sequence – only 31%. In addition, only 16% of mathematics students complete the developmental mathematics sequence within three years. This section explored developments in community college mathematics in the American Mathematical Association of Two-Year Colleges and Community College Research Center.

*American Mathematical Association of Two-Year Colleges (AMATYC).* To promote and improve mathematics education in community colleges, in 1995, the American Mathematical Association of Two-Year Colleges (AMATYC) published its first standards document *Crossroads in Mathematics: Standards for Introductory College Mathematics*. This document provided guidelines for selecting content and instructional strategies and “emphasized desired modes of student thinking” (AMATYC, 2006, p. 1).

To provide continuous quality improvement, in 2006, AMATYC published its second standards document, *Beyond Crossroads* in order “to stimulate faculty, departments, and institutions to examine, assess, and improve every component of mathematics education in the first two years of college” (p. 1). AMATYC stated:
Informed citizens in today’s global society need to be quantitatively literate.

Technological advances continue to influence both the mathematics that is used in the workplace and the career opportunities available to college students. Between now and 2012, the number of high-skilled jobs as a percentage of the workforce is expected to increase and the number of unskilled jobs is expected to decrease. (p. 1)

This document contained Implementation Standards with recommends and action items to assist with decision-making processes and strategies for improvement of student learning in mathematics. The Implementation Standards include assessment of student learning, curriculum and program development, instruction, and professionalism (AMATYC, 2006).

According to AMATYC (2006), implementation of these standards involved a commitment to continuous improvement in instruction, student learning, and professional development. Faculty need to accept responsibility for continuous learning about mathematics and mathematics instruction, use different strategies to address different learning styles, and “determine desirable quantitative literacy outcomes for each mathematics course and promote quantitative literacy as an appropriate general education outcome” (p. 3). Higher education institutions need to recruit, hire, and mentor qualified mathematics faculty with coursework or experience in developmental mathematics. Lastly, students need to accept responsibility for their learning and seek the necessary resources to achieve their academic goals, set high expectations for themselves, take mathematics courses early in their program, use a variety of problem-solving strategies, and communicate mathematics both orally and in writing.

Community College Research Center. In 2011, Hodara, through the Community College Research Center, conducted a literature review of the research on programs that improved course completion and learning outcomes among developmental mathematics students. She stated that
the purpose of the review was to identify promising mathematics pedagogy for the community college. However, she discovered that there is very little empirical research for this topic. Therefore, Hodara reviewed literature from the past 20 years incorporating mathematics pedagogy in the elementary and secondary schools as well as in college-level courses. She organized studies into six categories: student collaboration, metacognition, problem representation, application, understanding student thinking, and computer-based learning.

**Student collaboration.** The literature on mathematics pedagogy shows that collaboration has a positive impact on mathematics learning. “While most studies on this subject did not ensure treatment and control group equivalency, five rigorous elementary school student collaboration studies demonstrate that highly structured forms of student collaboration are especially effective for low-achieving mathematics students” (Hodara, 2011, p. 1). In general, in the few college studies, evidence suggested that collaboration such as peer-assisted learning might be more beneficial for low-achieving students.

**Metacognition.** Metacognition refers to a higher order thinking process that includes the ability to think about one’s own cognitive processes. “Instructional practices may promote metacognition through comprehension monitoring, cognitive strategy instruction or using writing and questioning during the problem-solving process to foster self-reflection” (Hodara, 2011, p. 1). There were a number of studies designed to improve problem-solving strategies, but only a second grade study of students with and without disabilities included an experimental design.

**Problem representation.** Problem representation can be defined as information stored and accessed in memory and then expressed later as a representation to a problem (Sutton, 2003). Hodara reviewed five studies in this area, and only one was conducted in higher education--in a
calculus course. All five studies show evidence that improvement of students’ problem representation has a small to moderate effect on mathematics learning.

*Application.* Application problems use real-world situations to teach mathematics concepts. “Research consistently finds a positive association between teaching mathematics through application and improved performance on tests of conceptual understanding” (Hodara, 2011, p. 2). However, in most of the studies reviewed, there were little or no differences in results between the comparison groups.

*Understanding student thinking.* This category incorporated instructional methods to understand how students think. Assessment methods, such as student monitoring and testing, were considered pedagogical practices in this area. “While it is generally accepted that college instructors should adapt instruction to meet the needs of their students through meaningful, ongoing assessment, most studies targeting college and developmental education students did not utilize comparison groups or compared non-equivalent groups, so their findings cannot confirm the positive impact of ongoing, formative assessment” (Hodara, 2011, p. 2).

*Computer-based learning.* With computer-based learning, students work at their own pace through content on the computer, with the instructor serving as a facilitator or tutor during some or all of the class time. “Computer-based learning includes course redesign models, in which some or all of face-to-face instruction is replaced with self-paced online curriculum modules; hybrid or blended learning; and forms of computer-based learning where the traditional course structure is maintained and the instructor still has a role in the classroom” (Hodara, 2011, p. 2). Hodara stated that none of the studies “employed a rigorous research design” (p. 2).

All of the studies she reviewed have potential to improve outcomes of students in developmental mathematics, but because of the poor internal validity of the studies, it was
difficult to determine whether the outcomes could be effective in practice (Hodara, 2011). She recommended:

A final priority for developmental education research is designing and investigating the impact of more balanced instructional approaches that promote all strands of mathematical learning. Studies suggest that application-oriented instructional approaches may support some strands of mathematical proficiency but do not improve procedural fluency. A challenge for researchers and practitioners is to develop model-based approaches that improve students’ mathematics understanding as well as their performance on traditional standardized tests of mathematics achievement. (p.3)

In addition, Hodara (2011) stated in higher education research, “it is important to consider that course scheduling can influence the types of students that register for each course, and the characteristics on which these students differ may be related to educational performances” (p. 3).

Characteristics of Community College Students

Community colleges welcome high school graduates, single mothers, professionals looking for a career change, and high school dropouts seeking another chance (Wilson, 2004). “The community college accepts all these and more, thriving in the creation of a diverse community of learners, and undeterred by the countless challenges that accompany widely varied learning needs” (Wilson, 2004, p. 25). This section of the literature review explores the characteristics of students in community colleges.

Community college students are a diverse group. According to the American Association of Community Colleges (AACC, 2012), minority students (Black and Hispanic) make up almost one-third of the community college population. Table 1 shows recent gender and race/ethnicity percentage of two-year public institutions.
The average age of the community college student is 28; 39% are 21 years old and younger, 45% are between the ages of 22 and 39, and 15% are 40 or older. Forty-two percent are going to college full-time, while 58% are enrolled part-time (AACC, 2012). Almost half (42%) of the students hold first-generation status with their primary goal the completion of a certificate program (AACC, 2012). “Since increased educational attainment is a precursor to increased likelihood of employment, financial security, and civic engagement, community colleges have the opportunity to introduce first-generation students to possibilities they may not have known existed for them” (Wilson, 2004, p. 26).

Many community college students have financial disadvantages. The Federal Pell Grant Program provides money to students based on needs analyses with awards determined by the information provided on the Free Application for Federal Student Aid (FAFSA). The elements in the analysis are the student’s income, parent’s income, the family’s household size and the
number of family members attending a higher education institution (United States Department of Education, 2013). According to AACC (2012), 34% of community colleges received Pell Grants in the 2011-2012 academic year. In Texas, 281,900 students participated in the Pell Grant Program with disbursed funds totaling $951,581,161.54 the 2009-2010 academic year (AACC, 2009). A Federal Pell Grant does not have to be repaid.

In Texas in 2011, two-year public institutions had a total enrollment of 743,252 of which 69.1% attend part-time and 30.9% attend full-time. According to THECB (2011), Hispanics make up over one-third of the total enrollment. Table 2 shows the gender and race/ethnicity percentage of two-year public institutions in Texas.

Table 2

<table>
<thead>
<tr>
<th>Demographic</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>57.8</td>
</tr>
<tr>
<td>Men</td>
<td>42.2</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>41.0</td>
</tr>
<tr>
<td>Black</td>
<td>12.9</td>
</tr>
<tr>
<td>Hispanic</td>
<td>34.4</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>1.9</td>
</tr>
<tr>
<td>Other</td>
<td>9.8</td>
</tr>
</tbody>
</table>

*Note:* Source for data was the THECB’s (2011) institutional profiles.

According to the CCSSE (2008), community college students are: (a) attending part-time, (b) responsible for family and work, (c) likely to have academic challenges, (d) low-income, (e) caring for and supporting dependents, and (f) learning English as their second or third language.
According to McClenney (2004), students attended multiple institutions before completing a degree, enrolled in two or more institutions at the same time, stopped in and out of school frequently, and transferred in many directions. Students could make choices on where to take their courses including on-campus, on the job site or online (McClenney, 2004).

Studies on Characteristics of Community College Students

There is much literature on the characteristics of the community college student (CCSSE, 2008; McClenney, 2004; Wilson, 2004). This section explores current research on student characteristics in the community college done by Walker and Plata (2000), Liu and Liu (2009), and Zavarella and Ignash (2009). Some research indicated that race/ethnicity plays a role in placement and success in developmental mathematics courses.

In the study done by Walker and Plata (2000), enrollment data showed that the older African-American students were placed in basic mathematics courses. Their study used data on three developmental mathematics courses for 500 Anglo and African-American college students at an accredited four-year regional university comparing significant differences in success frequencies. Walker and Plata (2000) grouped the students into categories of gender, age, and ethnicity. Analyzing the data using chi-square analysis, they explored the questions: (a) Was the proficiency level on mathematics placement tests related to gender, ethnicity, or age? (b) Was the successful completion level of developmental mathematics courses related to gender, ethnicity, or age? Walker and Plata found a significant relationship between ethnicity and success in developmental courses. Their results in the first level course (fundamental math) indicated that more than the expected number of Anglo and African-American students passed and fewer than the expected number failed. In the elementary algebra course, the results showed fewer than the expected number of Anglo students passed and more than the expected number of African
Americans failed. In the intermediate algebra course, more than the expected number of Anglo students failed.

In addition, Walker and Plata’s (2000) study also showed significant differences in success in developmental courses for males and females. Fewer than the expected number of males failed two of the developmental mathematics courses. Females failed the basic mathematics course at a less than expected rate but failed elementary and intermediate algebra at a greater rate. There was also a significant relationship between age and success in developmental mathematics courses. More than the number expected of the older students passed the basic mathematics course but fewer than the expected number of older students passed intermediate algebra. Walker and Plata stated: “Placement of African-American students in lower developmental mathematics courses in comparison to their Anglo peers in the present study was consistent with previous research” (p. 5). They suggested that instructors need to be willing to use culturally sensitive and innovative instructional approaches that integrate real world situations into mathematical applications.

Liu and Liu (1999) applied Tinto’s model at a commuter campus. The study was conducted at a medium-size Midwestern commuter college with 14,476 students in the sample. A probit procedure (deviation from the mean of a normal distribution) was conducted on the following variables: grade point average, gender, race, first-time freshmen versus transfer students, age, and dropout versus completion status. Liu and Liu found no significant differentiation between retention rates and gender. They did find that race and age had an impact on retention. According to their study, the gap continued to increase in the retention rate between Caucasian and minority students (Hispanic and African American). In addition, their study found that younger students and transfer students had a higher graduation rate in comparison with adult
learners and first-time freshmen. “The findings of this study mirror the general trend of American higher education in which the variable of race continues to have an impact upon student departure” (Lui & Lui, 1999, p. 540).

A study done by Zavarella and Ignash (2009), examined the student withdrawal rate from three different instructional delivery methods (distance learning, hybrid, or traditional) based on learning style, reasons for choosing instructional format, and placement scores. The study was conducted at a large, urban, multi-campus community college with students enrolled in different sections of the same developmental mathematics course. The nonexperimental quantitative study used college-level institutional data for general student characteristics (gender, race/ethnicity, age) and mathematics entry test scores. In addition, data from the Grasha-Reichmann Student Learning Styles Scales (GRSLSS), and from a modified student survey (Roblyer, 1999) on selecting an instructional method were addressed by logistic regression. The GRSLSS had six different learning style scales: competitive, collaborative, avoidant, participant, dependent, and independent. The modified student survey consisted of a study developed by Roblyer and a questionnaire developed by a full-time faculty member who taught developmental mathematics through distance learning. Roblyer’s 13 item survey incorporated four constructs that included logistical factors (driving to campus, parking, access to computers), control factors (choice of courses and flexibility of time), personal interaction factors (need for personal interaction), and technology attitudes (Zavarella & Ignash, 2009). “This type of regression can be used to predict a dichotomous dependent variable based on either continuous or categorical independent variables” (Zavarella & Ignash, 2009, p. 4).

Although their population was small with 69 students enrolled in a lecture section, 67 students enrolled in a hybrid section, and 56 students enrolled in a distance learning section
(Zavarella & Ignash, 2009). Zavarella and Ignash (2009) stated that “similarity of characteristic to developmental students in other studies further supported some transferability for findings” (p. 4). They found that there was no significant difference between gender and the type of instructional delivery method. They also found that students who enrolled in distance learning courses were older than traditional age college students. However, in their study, race/gender numbers differed from those of Baltzer’s (2002) study, as Zavarella and Ignash had more minority students enrolled in the distance-learning course. Two-thirds of the population of the research study was reported as non-Caucasian; therefore, the proportion of the minority group representation was higher than what was expected based on other similar studies (e.g., Diaz, 2002; Boylan, 1999). In addition, with each of the three instructional methods, the collaborative and participant learning styles were the most predominant. Based on their results, learning styles did not have an impact on whether a student completed or withdrew from the course. Zavarella and Ignash (2009) established three major findings: (a) Students who were enrolled in distance learning or hybrid instructional formats were twice as likely to withdraw from the developmental course as those students enrolled in the lecture format; (b) students who enrolled in developmental mathematics courses for personal reasons were more likely to complete the course; and (c) students’ learning styles and placement scores did not appear to affect successful completion of the course in any of the three instructional delivery methods.

Student Success in Community Colleges

Because the community college has open access for all students, students attend with a variety of expectations and goals, making assessment outcomes difficult to measure (Goldrick-Rab, 2010). For example, in current research, student success can be identified by graduation rate, completing a certificate or degree, or just earning a higher grade. Sometimes, student

36
success is defined as persistence—students move to the subsequent level of their courses or stay in college from semester to semester or year to year (Prince, Seppanen, Stephens, & Stewart, 2009). Goldrick-Rab (2010) stated the following:

Therefore, conditioning rates of success based on initial measures of expectations or primary reasons for enrollment may be problematic (Bailey et al., 2006). Given that intended outcomes vary over time, some observers suggest that community college success is more appropriately measured with intermediate indicators or “milestones” (Calcagno, Crosta, Bailey, & Jenkins, 2006; Moore, Shulock, & Offenstein, 2009). For example, progress can be assessed based on the completion of course credits (either remedial or nonremedial credits), the percentage of a program completed, or whether a student passes the initial college-level or degree-credit “gateway” courses in writing and mathematics. This approach credits incremental progress and takes into account wide variation in student pathways (p.440).

Despite the differences of ways to measure success, community colleges struggle with the problem and have made efforts to improve student success rates. Many colleges offer institutional support services that include tutoring, case management advisement, and student workshops (Nitecki, 2011). This section explores community colleges student success research and best practices.

Research for Best Practices

In 1996, the Community College Research Center (CCRC) was established by the Alfred P. Sloan Foundation to “conduct research on the major issues affecting community colleges in the United States and to contribute to the development of practice and policy that expands access to higher education and promotes success for all students” (CCRC, 2010, para 1). CCRC
conducted quantitative and qualitative studies on community colleges to evaluate their programs and discover best practices (CCRC, 2010). “CCRC’s extensive body of research provides a strong foundation on which to build new policies and initiatives to improve the outcomes of these institutions so integral to the higher education system, employment landscape, and national economy” (CCRC, 2010, para 2).

In 2009, CCRC designed a study for the Virginia Community College System to address the student characteristics and course-taking patterns that were associated with students that required remediation and then passed college-level mathematics and English (Jenkins, Jaggars, & Roksa, 2009). The study included 24,140 first-time college students who enrolled in summer or fall 2004 in the Virginia Community College System. The students were tracked through summer 2008, and CCRC examined data for educational outcomes that included:

- whether students took and passed developmental courses and gatekeeper English and math, the number of terms students were enrolled, the number of credits they accumulated, and whether they earned educational awards (certificates and associate degrees or transferred to a four-year institution. (Jenkins, et al., 2009, p. 1)

CCRC’s analyses used three different indicators for developmental education: placement test scores; course placement recommendations; and whether students took a developmental reading, writing, or mathematics course. “While the three markers were correlated, their correspondence was far from perfect; each provided different insights into students’ educational pathways and outcomes” (Jenkins et al., 2009, p. 1). There were several key findings – the first was that half of the students enrolled in at least one developmental course. However, only 50% to 60% of the students referred to a developmental course enrolled in the course: 39% of the students did not enroll in a developmental mathematics course, 35% of the students did not enroll
in a developmental writing course, and 41% of the students did not enroll in a developmental reading class (Jenkins et al., 2009). In addition, most students did not complete the developmental courses because either they never enrolled in them or they did not pass the courses they did enroll in (Jenkins et al., 2009). Another finding was placement scores in reading and writing did not predict whether students passed English, but mathematics scores predicted outcomes in passing gatekeeper mathematics. Based on findings from their study, some of the recommendations made by the CCRC included: exploring why students recommended to take developmental courses do not take them; investigating alternative enrollment pathways for students in developmental courses; and examining “the practices of their peers that are more effective in enabling student success and should share promising practices (Jenkins et al., 2009, p. 16).

In 2003, the Lumina Foundation started a new initiative, Achieving the Dream: Community Colleges Count, to help students achieve more success and persist in their education. “Achieving the Dream proceeds from the premise that success begets success — and every incremental milestone for every student can be positively affected by community college leaders and educators” (Achieving the Dream, 2010a, para 1). This multi-year, national initiative focused on student groups that traditionally have faced roadblocks to success, including minority and low-income students (Achieving the Dream, 2010a). Over 100 institutions in 22 states participating in Achieving the Dream implemented programs and interventions that resulted in student success improvements (Achieving the Dream, 2010a). Achieving the Dream’s goals included helping more students earn postsecondary degrees, including occupational certificates or degrees. Their objectives included helping more students complete remedial courses, successfully complete their first attempt at college-level courses, complete the courses they take
with a passing grade, continue from one semester to the next, and earn a certificate or associate’s degree (Achieving the Dream, 2010a).

To achieve their goals and objectives, the Lumina Foundation provided grant support to participating colleges. According to Achieving the Dream (2010b), student success progress report included: (a) Valencia Community College, Florida which decreased the achievement gap from 13% to 5% between African-American and Caucasian students and removed the gap between Hispanic and Caucasian students; (b) Jefferson Community College, Kentucky which increased retention by 8% of new-to-college full-time students; (c) Danville Community College, Virginia which increased the percentage of high risk students (22% African American and 20% low-income) that moved on from developmental to college-level math; (d) between 2001 and 2008, Coastal Bend College, Texas which increased its intermediate algebra rate by 28% and; (e) Guilford Technical Community College, North Carolina decreased persistence gap by 11% between African-American and Caucasian males in developmental courses.

Achieving the Dream programs are data-driven. Programs may be attempted and if not successful, they may be discontinued. Dona Ana Community College, New Mexico tried several programs to help students pass developmental mathematics. The college added in-class tutoring, a computer assisted program, and an instructor referral program. The college could not show statistically that the program was working, even though students were using it. When the grant money was gone, the program was discontinued (Gonzalez, 2010).

As an Achieving the Dream college and with grant money, in 2007, Montgomery County Community College (MCCC), in the suburbs of Philadelphia, Pennsylvania, experimented with different course offerings, teaching methods, and academic-support services to improve performance in developmental mathematics. One in four students who took beginning algebra in
the fall 2000 had not passed the course four years later (Blum, 2007). MCCC offered a pilot course which “condenses two semesters of classes into one, and offer a medium-paced course that focuses on algebra but includes some review of arithmetic when needed” (Blum, 2007, p. 62). In addition, MCCC offered 2-week refresher mathematics courses in the summer to give students a review of arithmetic and allow students who scored relatively high on the placement test to skip basic arithmetic and enroll in beginning algebra. In addition, MCCC expanded their tutoring services to include a peer-tutoring program in which tutors worked as teaching assistants both in classes and through weekly tutoring sessions (Blum, 2007). These teaching assistants become role models for the students. The instructor stated:

Students see that it's all right to take more than two years to graduate. That's critical because many of these students are also taking developmental courses in English and reading, and there's little chance they can do all that and finish in two years. We don't want to lose people just because they are discouraged. (Blum, 2007, p. 62)

An example of a best practice was in a redesign of Jackson State Community College, Tennessee, developmental mathematics program. The SMART (Survive, Master, Achieve, Review, and Transfer) mathematics program combined three developmental mathematics courses into one course of 12 modules (Bassett & Frost, 2010). Beginning in the spring of 2008, the college piloted three SMART classes. Student averages were compared to baseline data from traditional classes. According to Bassett and Frost (2010), average posttest scores increased by 15 points. In the fall of 2009, the percent of students passing developmental mathematics showed an increase of 45% (Bassett & Frost, 2010). Jackson State College demonstrated an improvement in students’ retention, achievement, and attitude toward developmental mathematics courses.
Upon discovering that the overall pass rate for their developmental mathematics courses was below 60%, faculty and administrators at Pima Community College in Arizona have been trying to find intervention strategies for their developmental mathematics courses (Gilroy, 2010). The college had developed a system that required students retaking developmental courses to have mandatory advising prior to re-enrolling in the following semester. Faculty and staff worked together to develop supplemental activities that included study skills workshops and online tutorials (Gilroy, 2010).

According to Fink (2003), other classroom strategies to promote student achievement include role-playing—these activities provide students an opportunity to participate in a different experience and small group learning through which “small groups can create powerful kinds of learning—about the subject, the problem-solving process, oneself, working with others, cross-cultural awareness, and so on” (p. 20). Fink recommends problem-based learning in which the problem comes first and students “must learn to make a preliminary analysis, gather information or data, assess the relevance of the new information, propose a solution, and assess the quality of their tentative solution” (p. 21). Fink also supports service learning which combines providing service to the community and a chance for the student to observe a community event.

In Texas, Tarrant County College implemented SureStart in 2004, a learning community for under-prepared, first-time-in-college students at the Southwest campus. Students who required remediation in at least two areas received counseling mentoring and specific course advising. Students also had block scheduling taking at least three classes together. As a result, these students completed more semester hours and had higher grades compared to similar students not in the program – 66% completed TSI reading requirement and 70% returned from fall to spring (THECB, 2011).
Community colleges are searching for ways to improve student success. According to Achieving the Dream (2010b), nearly half of all undergraduate students (approximately 6.7 million) enroll in 1,200 community colleges. However, fewer than half of the students succeed in earning a degree or transferring to a university. “And more than just their hopes and dreams are at stake: the very foundations of our economy depend on increasing student success” (Achieving the Dream, 2010b, p. 2). Investment in higher education yields economic growth by: increased employment – 60% of the jobs are held by employees with some postsecondary education; increased earnings of 20-30% of people who have associates degrees compared with high school diplomas and ; increased economic growth – every taxpayer dollar invested in community colleges gives $3 in taxes for the community (Achieving the Dream, 2010b).

Colleges continue to search for programs to achieve student success in developmental courses. Instead of just offering a course in the tradition lecture method, colleges are investigating different methods of instruction. The next section of the literature review explores different delivery methods.

Instructional Delivery Methods

Many community colleges offer different methods of instruction to promote student success and retention in developmental mathematics courses. With advanced technology, there are many instructional approaches to the delivery of developmental mathematics. Developmental mathematics courses in community colleges, whether credit or non-credit, are offered with varied instructional delivery methods. Community colleges search for interventions to assist the developmental students.

With the introduction of computers, teachers explored alternative ways to deliver instruction. There have been numerous studies (Attwell, Lavin, Domina, & Levey, 2006;
Chernish, DeFranco, Linder, & Dooley, 2005; Eyre, 2007; Taylor, 2008; and Weems, 2002) done over the past decades to determine whether there exists a “best” method for student learning. This section of the review of literature focuses on the instructional methods and delivery that are germane to the present study: lecture or the traditional instructional method; on-campus personalized instruction; a hybrid delivery method, which consists of a combination of lecture and computer instruction; and online learning.

Lecture

The lecture method of instruction has traditionally been one of the most often used for mathematics instruction. Usually an instructor presents an overview of a concept by introducing definitions, theorems, and examples. This presentation can be shown on the board, with an overhead projector, or with a PowerPoint presentation. The instructor determines the pace of the class, and the students take notes and contribute little to the instruction. Occasionally, an instructor may ask questions or use a cooperative group activity. The students practice the concepts outside of class.

According to Svinivcki and McKeachie (2011), lectures are effective teaching methods in several ways. First, a lecturer can provide students with up-to-date information on current research and theories relevant to course topics. Second, a lecturer can summarize or adapt material from different sources. Next, lectures can provide structures or outlines to help students read more effectively. In addition, a lecturer’s own attitude and enthusiasm can have an important effect on students’ motivation. “By helping students become aware of a problem, of conflicting points of view, or of challenges to ideas they have previously taken for granted, the lecturer can stimulate interest in further learning in an area” (Svinivcki & McKeachie, 2011, p. 56).
In the past, there was only one delivery mode—a student attended a lecture, did his homework, and took tests. Current research focuses on lecture courses and compares them to another instructional method. For example, in 1999, Hernandez examined the effect of three instructional methods on student success in developmental mathematics courses in a community college in the Dallas area. The study examined success and end-of-semester grades for 10,095 students enrolled in a lecture, laboratory (students read the book and did problems), or hybrid course (computer with instructor present). She found that the lecture method had higher success rates than the laboratory method or the hybrid method in developmental mathematics courses. No difference was found in the success rates for instructional modes in college algebra of students who had been successful in prior developmental courses. The end-of-semester grades for a sequence of two courses were examined using an analysis of variance (ANOVA). The results showed that students who went from a developmental lecture class to a college algebra lecture class had the highest grade average, and the next highest grade average occurred when students went from the laboratory class to the hybrid class (Hernandez, 1999).

Another example of a study was a dissertation in 2000 in which Blackner explored differences in student success in developmental mathematics with traditional classroom, computer-aided instruction (CAI), and distance learning instruction at a community college. Final grades and persistence of 135 beginning algebra students and 113 intermediate algebra students were indicators of success in the instructional modes. The study investigated individual student differences within locus of control, mathematics anxiety, and learning style. The CAI beginning algebra students received higher final grades than the lecture students did. However, in the intermediate algebra course, the lecture students scored significantly higher than the CAI
Ironsmith, Marva, Harju, and Eppler (2003) conducted a study of motivation and performance on remedial mathematics students enrolled in a lecture course versus a self-paced course. Self-paced instruction, another instructional method tried in developmental mathematics courses, was used in a mathematics lab setting as students worked independently on assignments. The purpose of the study was to examine the instructional formats of lecture and self-paced instruction with four types of achievement motivation using the Goals Inventory scale developed by Roedel et al. (1994). This scale measured learning and performance goal orientations (Ironsmith et al., 2003). There were 272 students in 17 sections of remedial mathematics in a large southeastern university. Students were divided into four categories of goal orientations. “The four categories were (a) low on both learning and performance goals, (b) low on learning but high on performance goals, (c) high on learning but low on performance goals, and (d) high on both learning and performance goals” (Ironsmith et al., 2003 p. 280). The means and standard deviations for the final course grades were completed for the self-paced and lecture course. An ANOVA was performed and determined there was no significant difference for instructional method. However, students enrolled in the lecture class who were high in learning goals received higher grades than those students enrolled in the self-paced classes. The students who were low on both learning and performance goals made the lowest grades (Ironsmith et al., 2003).

Emerson (2005) conducted a study on the effectiveness of four instructional methods on student achievement in two developmental mathematics courses at Texas Woman’s University. The four instructional methods studied were traditional or lecture, computer only, lecture with problem solving and computer with problem solving. Existing data of 262 students over four
Three analyses of covariance were performed on the data, and it was found that the computer with problem solving delivery was the most effective instructional method.

The educational research has demonstrated that students who are actively involved in an activity learn more than students who are passive in their learning. “Some authors have said that increased arousal and motivation are the essential ingredients for learning and are often more important for retention of topic than intelligence” (Chilwant, 2012).

**Personalized System of Instruction (PSI)**

The concept of personalized instruction was introduced by Fred Keller in 1968. The characteristics of PSI are: (a) various methods of instruction—students can use the textbook, or view a video or both; (b) students can move through the course faster and/or slow down when necessary; (c) students are required to take an active part in their learning; and (d) mastery of homework and quizzes of concepts are required in order to move forward to new concepts (Kohrmann & Villarreal, 2011).

There are advantages to the personalized instruction format. One advantage is that the course is individualized for the student. The student can skip already mastered concepts and can view a lecture as many times as necessary to master the concept. Another advantage is students can move through the course at their own pace — a student can do two courses in one semester or if the student is struggling, can take two semesters to complete one course (Kohrmann & Villarreal, 2011). In addition, students can take an active role in their learning. Students can receive one-on-one help and can ask questions of their instructor as they work through the material. The PSI program works when the student works with the program (Kohrmann & Villarreal, 2011). Zhu and Kaplan (2002) summarize the advantages of the use of technology as
an instructional method. “Such environments can provide greater opportunities experience learning activities that are internally driven and constructed, goal oriented and reflective, personally meaningful and authentic, collaborative and socially negotiated, and adaptive to individual needs and cultural backgrounds” (p. 205).

PSI courses became more manageable with the use of computers and the distance learning. Personalized instruction was well suited in the use of hybrid or web-based courses. According to Eppler and Ironsmith (2004), “Online presentation of course material is ideally suited for breaking information into small units and for mastery learning” (p. 133). Eppler and Ironsmith compared distance learning sections of personalized instruction to their lecture sections of developmental psychology. The study was conducted on 814 students enrolled in 14 sections of psychology during four semesters. They assessed the instructional methods by comparing outcome measures including retention rates, final exam grades, course grades, and student opinion of instruction. Eppler and Ironsmith showed more students dropped the Web PSI course compared to the lecture course. However, the reverse was true for the rate of course failures: Lecture students failed twice as much as the Web PSI students. Eppler and Ironsmith reported in their results: “Web PSI students surpassed lecture students on almost every outcome measure and obtained effect sizes were comparable to those found in reviews of PSI research” (p.133).

In another study, Ironsmith and Eppler (2007) investigated the effects of the instructional methods, PSI and lecture, and aptitude (GPA levels) on students’ success and motivation goals. Their study consisted of 576 students in a developmental psychology course over 6 semesters. Eppler and Ironsmith classified aptitude by grouping students into three GPA categories. Then a 2 x 3 (instructional method x aptitude) ANOVA was run on the student final exam data. The
results indicated that PSI students had higher final exam scores than lecture students and the advantages of PSI were greatest for the lowest GPA group. The findings of this study supported the concept of PSI with regard to mastery learning (Ironsmith & Eppler, 2007).

Several research studies (Eppler, 2004; Eyre & Ironsmith, 2007; Ironsmith & Eppler, 2007) showed PSI as an effective instructional method. It would seem the benefits of PSI are a good fit with developmental mathematics and computer technology. “Despite clear evidence of success, use of PI in the classroom and research on PSI have declined sharply since the early 1980s” (Eppler & Ironsmith, 2004, p. 131). There may be several reasons for the decline of the use of PSI.

One reason was college students were different from the students in the 1970s when PSI was popular. The traditional student was no longer 18-to-22 years old, attending full time, and living on-campus. “Universities now serve more nontraditional students who work, have family obligations, and want greater flexibility in class scheduling” (Eppler & Ironsmith, 2004, p. 131). Another student issue was procrastination. “The issue of student procrastination has plagued PSI courses from the beginning and produces a fundamental paradox that cannot be easily rectified” (Eyre, 2007, p. 319). If an instructor tried to decrease student procrastination by imposing deadlines or restrictions, the course no longer was self-paced – one of the requirements of PSI.

Another reason for the decline of the use of PSI was the use of mastery criteria. According to Eyre, “In Keller’s original courses students were not constrained to a traditional semester system” (2007, p. 319). Instructors tended to modify the PSI course to make it fit into a traditional semester. Sometimes, the mastery criteria component was not even used. This may be “due to institutional regulations and the number of incompletes earned by students in PSI courses” (Eyre, 2007, p. 319).
Another reason for the decline was the way a PSI course was viewed by college administrators. Eyre (2007) stated, “Other issues include having university administrators block PSI courses based on the belief that faculty were not actually teaching if they were not standing in front of the classroom lecturing” (p. 318). In addition, a PSI course required more involvement of a faculty member with the students. In the late 1970s, instructors had to develop study guides relating to learning objectives, create multiple versions of tests and give student feedback on each attempt, train and supervise proctors. Therefore, many instructors decided to return to the more traditional methods of instruction (Eyre, 2007).

However, there have been spin-offs of PSI that have been successful. Combining traditional methods with the new technology, Blann and Hantula (2004) designed a course to use the advantages of PSI while using the Internet to assist with the administrative difficulties. Their study used the multiple-cycle Susman and Evered (1978) action research (AR) model to evaluate two social psychology courses. The AR model incorporated five stages of research. The first stage was to identify and define the problem or process. In the second stage, the researcher developed solutions or interventions that addressed the issue. Third, the researcher decided on the most effective action and implemented a plan. In the fourth or evaluation stage, the researcher reviewed the consequences of the action. In the final stage, the researcher listed the significant findings. Blann and Hantula (2004) used two AR cycles for their study, one cycle for each course. They predicted that teaching this course through Blackboard on the Internet would reduce the number of administrative tasks and increase student interaction. Student attitudes were measured by a Likert-scale survey that consisted of statements relating to the course, including overall course satisfaction, instructor effectiveness, Blackboard usability, discussion board satisfaction, quiz and exam satisfaction, and self-pacing satisfaction. The instructor
assessment was positive. “As predicted, characteristics of the Internet eliminated many of the administrative responsibilities, such as quizzing, grading, and providing feedback, which made PSI so onerous to instructors” (Blann & Hantula, 2004, p. 308).

The mathematics department at Cleveland State Community College, Ohio developed a redesign of their mathematics courses in 2008 (Squires, Faulkner, & Hite, 2009). The project involved three developmental and three college level mathematics courses. The college redesigned the structure of the courses with students meeting in class one hour each week and working in a computer lab two hours each week. “The improvement in student learning has been substantial. In fall 2008, the rate of students exiting developmental mathematics increased by 47% compared to previous semesters” (Squires et al., 2009, p. 885). The course curriculum contained 10 to 12 modules with quizzes at the end of each module. Continuous enrollment was allowed, and students could move to the next level at any time. The department incorporated the PSI mastery approach with students having to complete all modules with a score of 70 or better (Squires et al., 2009). According to Squires et al. (2009), “The redesign project at Cleveland State has been a resounding success in all aspects, yet we are most proud of the positive impact it has had in the lives of our students” (p. 886). In addition, the mathematics administration changed its approach to scheduling and faculty workload. Faculty taught ten course sections and worked ten hours in the mathematics lab each week (Squires et al., 2009).

**Hybrid Delivery Method**

With the technology advancements, another method of instruction developed combining the lecture and the new technologies. Hybrid courses can allow face-to-face meetings with online-learning activities. These courses take the best of both the face-to-face and online activities and integrate the components to create a complete course (Guerra, 2010). The use of
technology in a course can initiate the principles of learning theory on the cognitive and constructivist levels (Zhu & Kaplan, 2002). “When an instructor creates a technology-enriched learning environment that places tools in the hands of learners to build, browse, link, draw, juxtapose, represent, and summarize information, the learners are engaged in an intentional process of constructing meaning from information and experience” (Zhu & Kaplan, 2002, p. 205).

Guerra (2010), states there are advantages and disadvantages of hybrid courses. The advantages include the flexibility of the course, different modes of interaction, and the ability for everyone to participate on an equal level. The disadvantages may be technology issues – which include student ability as well as computer access, and issues with poor time-management skills.

Developmental mathematics courses can be offered on campus with a technology or computer component of the class. According to research (Fink, 2003), this type of instruction allows instructors to incorporate students’ various learning styles. Most software packages offer interactive questions and learning activities to increase or master learning objectives of the course.

Teal (2008) did a study comparing academic achievement of students receiving two different modes of instruction in developmental mathematics at a suburban community college in the mid-Atlantic region. A total of 1,318 students were enrolled in the two developmental mathematics courses of pre-algebra and introductory algebra. Test scores were compared between students who received the traditional classroom method of instruction and those who received computer-assisted instruction (CAI). The CAI students used the Educo Learning System software during class lectures and for homework and quizzes. The study revealed there were no statistically significant differences between scores of students taught by the different modes of
instruction. “One unanticipated finding from the study revealed that students who received the computer-assisted mode of instruction in the pre-algebra course had higher retention rates than students who received the traditional lecture mode of instruction” (Teal, 2008, p. 124).

Taylor (2008) examined the effects of a computerized-algebra program on mathematics achievement in developmental mathematics courses and the differences in student achievement, students’ mathematics anxiety, and mathematics anxiety in web-based, computer-assisted course as compared to a lecture course. The sample of this study included 54 freshmen students enrolled in an experimental course using Assessment and Learning in Knowledge Spaces and 39 freshman students enrolled in a traditional lecture course of intermediate algebra at two different universities and three community colleges. Students received three pretests and posttests: (a) National Achievement Test, First Year Algebra Test (NATFYAT); (b) Mathematics Anxiety Rating scale (MARS); and (c) Fennema and Sherman scales (F-S scales). The F-S scales had 47 questions rated on a 5-point Likert Scale that test for positive and negative attitudes (Taylor, 2008). A multivariate analysis of variance (MANOVA) was used to determine any statistical differences between the NATFYAT pretest and posttest. A separate regression analysis was used on NATFYAT and MARS, NATFYAT and F-S scales to determine whether any relationship existed. “The findings showed that success in mathematics is increased or decreased as a result of anxiety, attitude, gender, age, ethnicity, number of mathematics courses taken in the past, or degree plans” (Taylor, 2008, p. 41). On student achievement, results from a paired-samples t test indicated statistically significant differences from pretest to posttest. These results implied delivery method of the experimental course improved achievement for some students; for others the lecture method appears best (Taylor, 2008). “The results of this study suggested that a computer-mediated curriculum does improve mathematical achievement for some students”
Taylor (2008) stated teachers need to determine what mode is best for students in order to offer a choice between lecture and computer-mediated instruction.

Academic Systems Algebra™ (2010) published results from participating colleges using the interactive mathematics program on its web pages. A two and a half-year study at Johnson County Community College, Kansas (JCCC), showed a 15% increase in student success rates in developmental mathematics. According to Juliane Crabtree, lead mathematics instructor at JCCC, “students in her Academic Systems classes have had a success rate of 80 percent or higher, compared with a 60 percent rate in her traditional lecture-based classes” (Academic Systems Algebra™, 2010). Student feedback was positive. Students liked the flexibility and the pace of the course. Instructors found the format useful in identifying student areas of weakness and developing individual plans for each student.

As advancements in technology continued, colleges and instructors discovered that new courses could be taught without the need of an on-campus classroom. The next section of the literature review explores this online learning.

**Online Learning**

Distance education uses many different teaching systems with the common feature that students do not have to travel anywhere to meet the teacher (Northedge, 2002). “Distance teaching is an extended act of imagination. A distance education course may be delivered online, by television, or Internet program. It can be delivered in different forms that include telephone support, online conferencing, Internet chat rooms, or face-to-face meetings.

According to Olsen (2000), California Polytechnic State University (Cal Poly) began using online commercial courseware to help students catch up. A Cal Poly study tracked 271 students enrolled in a precalculus course and found that students who were enrolled in the online
course in intermediate algebra earned 49% more A’s, B’s, or C’s in the precalculus course than the students who completed the intermediate algebra in the traditional setting. Cal Poly administrators have supported the online course and now offer elementary and intermediate algebra courses only online. In addition, five of 23 campuses in the California State system used online courses to prepare their students for college-level mathematics courses (Olsen, 2000).

Weems (2002) did a comparison between an online and a traditional beginning algebra course. Weems conducted the study at an urban university in the mid-South which consisted of 48 students in two sections of beginning algebra taught through the Transitional Academic Studies program. The purpose of the study was to explore student achievement, student attitudes, reasons for choosing an online course and satisfaction with the online approach. Student achievement for both methods of instruction was measured four times during the semester with a teacher-constructed pretest and three teacher-constructed exams. The pretest and posttest was the Scale of Attitudes Toward Mathematics (Aiken, 1974) and measured students’ attitudes toward mathematics. On the first and last day of classes, online students took questionnaires that addressed the issues of choosing an online course and satisfaction with the online approach. The scores from exams and the total attitude measures were analyzed using a repeated measures design. The study determined that there was not a significant difference between the two formats in student achievement and student attitude toward mathematics. However, the study found a significant decrease in overall exam performance by the online students. Students were satisfied with the online format; many stated they planned to enroll in more online courses (Weems, 2002).

Zavarella and Ignash (2009), in their study of instructional delivery in developmental mathematics and retention found that students who enrolled in the hybrid or Internet
developmental course were twice as likely to withdraw from the course as those students enrolled in the traditional lecture-based course. “The high dropout rate within computer-based instruction implies that computer-based instruction is not a panacea for teaching and/or learning in a developmental mathematics course” (Zavarella & Ignash, 2009, p. 12).

The results of these studies indicate a mixed review of which instructional method is better for student learning and success. There is a lot of criticism on which method is best for student learning (Chilwant, 2012). Educational research has shown that students actively involved in the learning activity learn more than passively involved students (Astin, 1993; Chilwant, 2012; Pascarella & Terenzini, 2005; Tinto, 2006).

Summary

Review of the literature indicated that community college students are a diverse and complex group. Evaluating both in their characteristics and in choices of delivery instructional modes, Kim (2002) stated:

Researchers, policy makers, and student affairs professionals may benefit from research that focuses on ways to better understand the community college student population far beyond the nontraditional paradigm. While use of the term nontraditional to define students may have its limitations, the research that addresses the diverse needs of the community college student population is critical to promoting student success. (p. 9)

Community colleges are searching for ways to improve student success and retention. Community colleges need to explore varied ways to deliver developmental mathematics in creative ways for student success. Reyes (2010) stated, “Since mathematics is a subject feared by many students, educators must embrace this challenge and find ways to diminish this fear while increasing student success” (p. 265). Astin (1975) concluded student academic performance has
a direct impact on whether students persist in college and asked “Is it possible that poorly performing students can be motivated eventually to improve their academic performance by controlling the type of evaluative feedback they receive?” (p. 178). Higher education must look for innovative ways to deliver courses and programs to meet the needs of the students.

Our world is changing constantly. As educators, we must continue to explore ways to increase and improve learning in community colleges and adapt as necessary. Educators must learn and use the knowledge from the student development and constructivist theories to develop strategies for student success. The theoretical information from the constructivist and student development theories provide educators necessary information about the motivational and contextual factors that influence learning (Pascarella and Terenzini, 2005). Community colleges must continue to provide quality education to serve the needs of our society and our workforce. Community colleges enroll almost half of the nation’s undergraduate population; by 2015, they are expected to enroll 7.5 million students (Alfred, Boggs, & Glasper, 2008). It is imperative that community colleges look for best practices to improve the success of students in developmental mathematics courses to better prepare them for society and the workplace. This literature review provided support for the current study on instructional methods in developmental mathematics courses.

This research study used previous, related research according to two premises. First, four instructional delivery methods were investigated to determine if any method led to greater student success in a developmental mathematics course at a community college. Second, student success in subsequent levels of the developmental or college level mathematics sequence was explored. Chapter 3 presents the methodology of this study.
CHAPTER 3
METHODOLOGY

This chapter outlines the procedures and methodology used in this study, including the description of the participants, description of courses, data source, research design, procedure, and description of the testing of hypotheses. There were two purposes of this quantitative study. The first purpose was to examine four different modes of instruction to determine whether there were differences in student success between the four instructional modes used in developmental mathematics classes. The second purpose was to examine the effect of student demographics and characteristics with the instructional mode on student success in developmental mathematics courses. The instructional approaches studied were the traditional lecture, personalized system of instruction (PSI), hybrid method, and online learning. The following research questions guided this study:

1. Are there statistically significant differences in students’ success using the following methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning?

2. Do student demographics or characteristics influence student success differently for students enrolled in developmental classes using the following different methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning?

Participants

The site of this study was a community college located in Texas. The average enrollment for a semester at this institution was 10,000 students. This student population consisted of 43% male and 57% female, with 27% of the students between the ages of 16-20, 47% of the students
were between 21-30, 16% were between 31-40, 7% were between the ages of 41-50, and the
over 50 group comprised 3% of the population. The ethnic distributions were as follows: 36%
white, 31% Hispanic, 21% African American, 12% Asian/Pacific Islander, and 1% American
Indian, Alaskan or other. Approximately 25% of the students enrolled in developmental
mathematics courses. Students enroll in developmental courses based on their college placement
test scores or successful completion of prerequisite courses. ACCUPLACER is the placement
test used by this college. The purpose of the ACCUPLACER (2011) test is to determine the
student’s level of mathematics proficiency to ensure correct placement into the appropriate
course. The grades students earn in a developmental mathematics course determine whether they
proceed to the next level mathematics course.

This study included data from four semesters. The population was students who enrolled
in prealgebra, elementary algebra, and intermediate algebra in fall 2009 thru spring 2011. The
courses were offered via four instructional methods: (a) lecture, (b) hybrid, (c) PSI, and (d)
distance learning.

Description of Courses

The following descriptions of the developmental mathematics courses were taken from
the community college’s catalog:

*Prealgebra.* This course is designed to develop an understanding of fundamental
operations using whole numbers, fractions, decimals, and percentages and to strengthen basic
skills in mathematics. The course is planned primarily for students who need to review basic
mathematical processes. This is the first three-hour course in the developmental mathematics
sequence.
Elementary algebra. This is a course in introductory algebra that includes operations on real numbers, polynomials, special products and factoring, rational expressions, and linear equations and inequalities. Graphs, systems of linear equations, exponents, roots, radicals, and quadratic equations are included in the curriculum.

Intermediate algebra. This course includes further development of the terminology of sets, operations on sets, properties of real numbers, polynomials, rational expressions, linear equations and inequalities, the straight line, systems of linear equations, exponents, roots, and radicals. Products and factoring, quadratic equations and inequalities, absolute value equations and inequalities, relations, functions, and graphs are included in the curriculum.

Description of the Instructional Methods

Four instructional methods were used to teach developmental mathematics at the community college:

Lecture. The lecture method is primarily instructor-centered. Students are expected to attend class, take notes, and ask questions while the instructor gives written and verbal explanations and examples. There may be occasions when students work in pairs or groups. Homework is required and is completed using MyMathLab--an Internet-based software program that allows students multiple attempts at problem solving. However, quizzes and tests are administered during class or at the college’s testing center as determined by the instructor.

PSI. Students attend at a regularly scheduled time receive opportunities to ask questions as well as work on the computer. The key components of this course include pretesting to develop a personalized study plan and progressing through the course based on mastery (80%) of content. Additionally, the instructor communicates and intervenes with students frequently. The students can accelerate through the course without being required to complete all the modules in
the course. If a student scores an 80% on a module’s pretest, she/he can skip that module and move forward (Kohrmann & Villarreal, 2009).

**Hybrid method.** Students attend regularly scheduled class time on campus in a computer classroom. The instructor acts as a facilitator during the instructional component delivered through the Internet-based software program PLATO (Academic Systems Algebra™). The course is separated into modules with each module containing activities for a lesson--explain, apply, explore, homework, and evaluate. The evaluations include 8 to 12 problem quizzes. A student has to make a score of 70 on each component before proceeding to the next section. In addition, students take four tests and a final for each class. These tests are handwritten and completed in class or at the Testing Center as determined by the instructor.

**Online learning.** This method of instruction is presented through PLATO (Academic Systems Algebra™), an online interactive, multimedia format accessible from any computer using Windows. The instructor uses Blackboard for students to participate and ask questions. The Blackboard course platform allows faculty to add resources for students to access online, such as Powerpoint, Captivate, video, audio, animation, and other applications to support teaching and learning efforts. The instructional component is the Internet-based software program PLATO (Academic Systems Algebra™). The course has the same platform as the hybrid method detailed in the previous section. All evaluations and the four chapter tests can be taken anywhere with Internet connectivity while the student completes the course. However, a midterm and final exam are proctored at a predetermined designated testing site.

**Data Sources**

The data sources for this study were the college’s records for student enrollments, grades, student demographics, and student characteristics. Students’ course progress data were also
provided through the data source. Data included all sections of prealgebra, elementary algebra, and intermediate algebra from the fall 2009 thru spring 2011 semesters. Data were provided by the college’s Office of Institutional Research. Permission to conduct the study was obtained from the Institutional Review Boards of both the study college and the University of North Texas to use archival data (See Appendix).

Research Design

A quasi-experimental research design was used for this study. The data for this study already existed so it was an *ex post facto* study. Gall, Gall and Borg (2007) defined *ex post facto* research as “that which is done afterward” and as “correlational or causal-comparative research because in these types of investigations, causes are studied after they presumably have exerted their effect on the variable of interest” (p. 639). “These research designs do not permit strong conclusions about cause-and-effect, but are useful for exploratory investigations or in situations where it is impossible to manipulate the independent variable” (Gall et al., 2007, p. 306).

The independent constructs for this study were the four instructional methods. The dependent constructs were the final grade in the course, student demographics, and student characteristics. In this study, the independent variable was not manipulated by the researcher to observe the effect on the dependent variable (Gall et al., 2007). The researcher compared final grades of students enrolled in three levels of developmental mathematics courses in four different instructional delivery methods. The final course grade was used as the indicator of success for each instructional method. Success was defined as a grade of C or better, any other grades, including the grade of D, withdrawals (W), and unsuccessful grades (F), were considered unsuccessful grades for this study.
Data Analysis

To address the first research question, the data analysis consisted of examining student success (grade of C or better) in three levels of developmental mathematics courses offered in four different instructional delivery methods. To decide whether there was statistical significance between instructional delivery methods, grades were analyzed using a non-parametric test. According to Gall et al. (2007), “nonparametric statistics are tests of statistical significance that do not rely on any assumptions about the shape or variance of population scores” (p. 325). The initial success rate was determined with a grade analysis based on the chi-square (χ²) test. “The chi-square test is a nonparametric test to determine whether research data in the form of frequency counts are distributed differently for different samples” (Gall et al., 2007, p. 325). The sample size of this population should be adequate to use the chi-square test. According to McDonald (2009), “The conventional rule of thumb is that if all of the expected numbers are greater than 5, it’s acceptable to use the chi-square” (para. 3). A 4 x 2 chi-square (χ²) table was used for the three different levels of developmental mathematics. The results of this test provided information about whether or not success was independent of modality of instruction.

To address the second research question, the data analysis consisted of examining student success (grade of C or better) in three levels of developmental mathematics courses offered in four different instructional delivery methods controlling for student demographics and characteristics. To determine statistical significance between instructional delivery methods and student demographics and characteristics, grades were analyzed using a logistic regression. “Logistic regression is used to predict categorical placement in or the probability of category membership on a dependable variable based on multiple independent variables” (Starkweather & Moske, 2011). In logistic regression, data transformation using logarithmic terms (called the
logit) eliminate the problem of violating the assumption of linearity required by linear regression (Fields, 2009). Logistic regression requires a binary dependent variable such as successful grade versus unsuccessful grade (i.e., success versus no success). The predictor variables were age, race/ethnicity, gender, residency, Pell eligibility status, and Mode of Instruction. Table 3 provides the descriptions of the coding for each of the categorical variables included in the logistic regression models.

Table 3

**Coding Scheme for Categorical Variables Included in Logistic Regression Models**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description of Categorical Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Success</td>
<td>Dichotomous dependent/criterion variable dummy coded as 0 = no success and 1 = success. This variable represented grade status.</td>
</tr>
<tr>
<td>Gender</td>
<td>Dichotomous independent/predictor variable dummy coded as 0 = male and 1 = female.</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td>Independent/predictor variable categorically coded as White (0), Black or African American (1), Hispanic (2), Asian (3), Race Native American/Alaskan (4), and Race Unknown/Race Not Reported (5). White was the reference group.</td>
</tr>
<tr>
<td>Age</td>
<td>Independent/predictor variable dummy coded as 0 = young adulthood (16-30 years old) and 1 = middle adulthood (31 years old and up). Young adulthood was the reference group.</td>
</tr>
<tr>
<td>Residency</td>
<td>Independent/predictor variable categorically coded as in district (0), out-of-district (1), and out-of-state (2) with out-of-country (3). In district was the reference group.</td>
</tr>
<tr>
<td>Pell Status</td>
<td>Independent/predictor variable dummy coded as no (0) and yes (1). Cases identified as not reported were removed from sample for the hypothesis testing process.</td>
</tr>
<tr>
<td>Mode of Instruction</td>
<td>Independent/predictor variable coded with lecture (0), followed by hybrid (1), PSI (2), and online/Internet (3). Lecture was the reference group.</td>
</tr>
</tbody>
</table>

The logistic regression models were developed using the forced entry method in SPSS. This method was preferable because it addressed the suppressor effects that can occur when a predictor variable has a significant effect due to another variable being held constant (Field, 2009). A significance value of less than .05 indicated that the variables did improve prediction of success versus no success.
To answer the first research question, the following were the null hypotheses:

**H₀₁**: There will be no statistically significant difference among the proportions of successful students enrolled in prealgebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.

**H₀₂**: There will be no statistically significant difference among the proportions of successful students enrolled in elementary algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.

**H₀₃**: There will be no difference among the proportions of successful students enrolled in intermediate algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.

To answer the second research question, the following were the null hypotheses:

**H₀₁**: There will be no statistically significant difference in student success when controlling student demographics or characteristics influence for students enrolled in prealgebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.

**H₀₂**: There will be no difference in student success when controlling student demographics or characteristics influence for students enrolled in elementary algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.

**H₀₃**: There will be no difference in student success when controlling student demographics or characteristics influence for students enrolled in intermediate algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning.
Summary

This quasi-experimental study involved analyzing the likelihood of student success between four instruction modes used in three developmental mathematics courses. The student demographics and characteristics as related to their success between the four different modes of instruction in three developmental mathematics courses were examined. This chapter reviewed the research questions and hypotheses for this study. The research design, participants, descriptions of the courses and instructional methods, data sources, and data analysis were discussed.
CHAPTER 4
RESULTS

There were two research questions for this study. The first research question was used to determine if there were significant differences in students’ success using four methods of instruction. The four different modes of instruction were examined to determine whether there were differences in student success in developmental mathematics classes. The second question was used to determine if there were significant differences in success among demographics and characteristics of students enrolled in developmental classes using the following methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning. This chapter presents the results for the statistical tests. The chapter’s sections include a description of the participants, an overview of the procedures of the study, the overall course grades, and the results for the tested hypotheses.

Data were retrieved from a community college in Texas. The average enrollment for a semester at this institution was 10,000 students with approximately 25% enrolled in developmental mathematics courses. Students must take developmental courses based on their college placement test scores or successful completion of the prerequisite developmental course. Data from four semesters were collected for students enrolled in prealgebra, elementary algebra, and intermediate algebra from fall 2009, spring 2010, fall 2010, and spring 2011. The four instructional methods were lecture, hybrid, PSI, and distance learning.

Sample and Descriptive Statistics

This study included data from the fall 2009, spring 2010, fall 2010, and spring 2011 semesters. Data for students enrolled in prealgebra, elementary algebra, and intermediate algebra in those four semesters formed the sample. The courses were offered via the four instructional
methods of lecture, hybrid, PSI, and distance learning. From fall 2009 through spring 2011 time, the developmental mathematics courses served 9,211 students at the host community college. Table 4 indicates the enrollment in all of the developmental mathematics courses sampled by semester.

Table 4

| Number of Students Enrolled in Developmental Mathematics Courses by Semester |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Semester                        | Fall 2009       | Spring 2010     | Fall 2010       | Spring 2011     |
| n                               | 2,349           | 2,132           | 2,526           | 2,204           |

Participants were community college students enrolled in developmental mathematics courses offered by a north Texas urban community college. A total of 9,211 students were included in this study with 2,043 enrolled in prealgebra, 3,020 enrolled in elementary algebra, and 4,148 enrolled in intermediate algebra (Table 5). Most students were aged 21 to 30 years (76%), resided in the district (76%), attended day classes (63%), and were eligible for a Pell grant (66%). Of the ethnicities reported, Hispanic (30%) and Caucasian (27%) students formed the majority of students and were followed by African American students (17%). Male students numbered 3,846 (42%), and 5,365 were female (58%). Table 5 shows the demographics of the sample for this study.
Table 5

Demographics of the Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total Students $(N = 9,211)$</th>
<th>Prealgebra Students $(n = 2,043)$</th>
<th>Elementary Algebra Students $(n = 3,020)$</th>
<th>Intermediate Algebra Students $(n = 4,148)$</th>
<th>College Population $(10,810)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 - 20</td>
<td>39</td>
<td>6</td>
<td>8</td>
<td>25</td>
<td>2,919</td>
</tr>
<tr>
<td>21 - 30</td>
<td>6,990</td>
<td>1,545</td>
<td>2,184</td>
<td>3,261</td>
<td>5,081</td>
</tr>
<tr>
<td>31 - 40</td>
<td>1,421</td>
<td>320</td>
<td>510</td>
<td>591</td>
<td>1,729</td>
</tr>
<tr>
<td>41 - 50</td>
<td>559</td>
<td>128</td>
<td>219</td>
<td>212</td>
<td>757</td>
</tr>
<tr>
<td>50 and up</td>
<td>202</td>
<td>44</td>
<td>99</td>
<td>59</td>
<td>324</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>2,460</td>
<td>378</td>
<td>862</td>
<td>1,220</td>
<td>3,871</td>
</tr>
<tr>
<td>Black/African American</td>
<td>1,592</td>
<td>459</td>
<td>566</td>
<td>567</td>
<td>2,259</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2,806</td>
<td>627</td>
<td>926</td>
<td>1,253</td>
<td>3,330</td>
</tr>
<tr>
<td>Asian</td>
<td>606</td>
<td>67</td>
<td>134</td>
<td>405</td>
<td>1,276</td>
</tr>
<tr>
<td>Native American/ Alaskan</td>
<td>46</td>
<td>11</td>
<td>19</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>381</td>
<td>61</td>
<td>103</td>
<td>217</td>
<td>74</td>
</tr>
<tr>
<td>Not Reported</td>
<td>1,320</td>
<td>440</td>
<td>410</td>
<td>470</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>3,846</td>
<td>768</td>
<td>1,236</td>
<td>1,842</td>
<td>4,648</td>
</tr>
<tr>
<td>Female</td>
<td>5,365</td>
<td>1,275</td>
<td>1,784</td>
<td>2,306</td>
<td>6,162</td>
</tr>
<tr>
<td>Residency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In District</td>
<td>7,020</td>
<td>1,650</td>
<td>2,407</td>
<td>2,963</td>
<td></td>
</tr>
<tr>
<td>Out of District</td>
<td>1,702</td>
<td>322</td>
<td>533</td>
<td>847</td>
<td></td>
</tr>
<tr>
<td>Out of State</td>
<td>176</td>
<td>52</td>
<td>45</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Out of Country</td>
<td>313</td>
<td>19</td>
<td>35</td>
<td>259</td>
<td></td>
</tr>
<tr>
<td>Pell Eligible</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6,060</td>
<td>1,256</td>
<td>2,075</td>
<td>2,729</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>2,350</td>
<td>487</td>
<td>656</td>
<td>1,207</td>
<td></td>
</tr>
<tr>
<td>Not Reported</td>
<td>801</td>
<td>300</td>
<td>289</td>
<td>212</td>
<td></td>
</tr>
<tr>
<td>Success in Course</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (C &amp; up)</td>
<td>3,270</td>
<td>740</td>
<td>1,012</td>
<td>1,518</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>5,941</td>
<td>1,303</td>
<td>2,008</td>
<td>2,630</td>
<td></td>
</tr>
<tr>
<td>Class Mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>3,859</td>
<td>904</td>
<td>1,271</td>
<td>1,684</td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td>2,572</td>
<td>659</td>
<td>924</td>
<td>989</td>
<td></td>
</tr>
<tr>
<td>PSI</td>
<td>1,281</td>
<td>275</td>
<td>341</td>
<td>665</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>1,499</td>
<td>205</td>
<td>484</td>
<td>810</td>
<td></td>
</tr>
</tbody>
</table>
The sample’s data were consistent with the college’s student demographics. At the college overall, 43% of students were male, and 57% were female. However, the ages of the sample’s students differed from the college’s student demographics because only 47% of the college population fell between the ages of 21 and 30, unlike 76% of the sample for that age category. Ethnic distributions were somewhat similar between the sample and population of the college. Caucasians were 36% of the college population, Hispanics were 31%, and African Americans were 21%. The one observational difference was that only 7% of the sample was Asian even though Asian students account for 12% of the college’s population. For enrollment in the specific developmental mathematics classes, the prealgebra group was the smallest with 22% of the sample, followed by the elementary algebra group at 33%, and the intermediate group showing the largest developmental mathematics course enrollment at 45%. Table 6 displays the descriptive statistics for student success in the three levels of developmental mathematics.

Table 6

Student Success in Developmental Mathematics Courses

<table>
<thead>
<tr>
<th>Success Status</th>
<th>Pre-Algebra n (%)</th>
<th>Elementary Algebra n (%)</th>
<th>Intermediate Algebra n (%)</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (C or Better)</td>
<td>740 (08)</td>
<td>1,012 (11)</td>
<td>1,518 (16)</td>
<td>3,270 (36)</td>
</tr>
<tr>
<td>No</td>
<td>1,303 (14)</td>
<td>2,008 (22)</td>
<td>2,630 (29)</td>
<td>5,941 (64)</td>
</tr>
</tbody>
</table>

Overview of the Procedures

The final grades for the students enrolled in the three levels of developmental mathematics courses in four different instructional delivery methods were compared. The final course grade was considered an indicator of success for each instructional method. Success was defined as a grade of C or better, any other grades including Ds, withdrawals and unsuccessful grades (F) were not included in the study. To answer the research questions, the data analysis
consisted of examining student success for the developmental mathematics courses offered through four different instructional delivery methods. SPSS was used for all statistical processes and tests.

Results for the Research Questions

Research Question 1

Research Question 1 asked if there were statistically significant differences in students’ success using the following methods of instruction: lecture, personalized system of instruction (PSI), hybrid, and online learning. Three null hypotheses were tested among the proportions of successful students enrolled in each of the four different modalities of instruction: lecture section, PSI section, hybrid section, and online section. The chi-square ($\chi^2$) test statistic was employed for these hypotheses’ tests.

Null Hypothesis 1. This null hypothesis was: There will be no statistically significant difference among the proportions of successful students enrolled in prealgebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The $\chi^2$ yielded a 107.90 value with $p < 0.001 (\alpha = .05)$. Based on the result, the researcher rejected the null hypothesis. A relationship existed between the successful/unsuccessful student frequencies versus instructional modes for prealgebra. Table 7 presents the results for the prealgebra students.

Because a relationship existed, strength was measured using the Cramer’s $V$. Cramer’s $V$ is nonparametric correlation coefficient with values ranging between 0 and 1 to measure the effect size for $\chi^2$ when at least one variable has more than two categories (Abbott, 2011). The effect size is interpreted as 0.10 for small, 0.30 for medium, and 0.50 for large (Abbott, 2011). The Cramer’s $V$ for this relationship was 0.226 and fell below medium.
Table 7

*Successful and Unsuccessful Grade Distributions by Instructional Mode for Prealgebra (n = 2,043)*

Note. * indicates statistical significance at \( p < 0.01 \).

Null Hypothesis 2. This null hypothesis was: There will be no statistically significant difference among the proportions of successful students enrolled in elementary algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The \( \chi^2 \) yielded the value of 88.39 with \( p < 0.001 \) (\( \alpha = .05 \)). Based on the result, the researcher rejected the null hypothesis. A relationship existed between the successful/unsuccessful frequencies and the instructional modes for the elementary algebra class. Table 8 depicts the results for the elementary algebra students.

Because a relationship existed, strength was measured using the Cramér’s \( V \). Cramér’s \( V \) is nonparametric correlation coefficient with values ranging between 0 and 1 to measure the effect size for \( \chi^2 \) when at least one variable has more than two categories (Abbott, 2011). The effect size is interpreted as 0.10 for small, 0.30 for medium, and 0.50 for large (Abbott, 2011). The Cramér’s \( V \) for this relationship was small at 0.172.

<table>
<thead>
<tr>
<th>Status</th>
<th>Lecture</th>
<th>Computer Assisted</th>
<th>Personalized Instruction</th>
<th>Internet</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful</td>
<td>419</td>
<td>220</td>
<td>56</td>
<td>45</td>
<td>107.90</td>
<td>3</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Unsuccessful</td>
<td>464</td>
<td>509</td>
<td>195</td>
<td>135</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * indicates statistical significance at \( p < 0.01 \).
Null Hypothesis 3. This null hypothesis was: There will be no difference among the proportions of successful students enrolled in intermediate algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The $\chi^2$ yielded a 254.18 value with $p < 0.001$ ($\alpha = .05$). Based on the result, the researcher rejected the null hypothesis. A relationship existed between successful/unsuccessful frequencies and the four instructional modes for the intermediate algebra class. Table 9 presents the results for the intermediate algebra students.

Because a relationship existed, strength was measured using the Cramer’s $V$. Cramer’s $V$ is nonparametric correlation coefficient with values ranging between 0 and 1 to measure the effect size for $\chi^2$ when at least one variable has more than two categories (Abbott, 2011). The effect size is interpreted as 0.10 for small, 0.30 for medium, and 0.50 for large (Abbott, 2011). The Cramer’s $V$ for this relationship was 0.255 and fell below medium.
Table 9

Successful and Unsuccessful Grade Distribution for Instructional Modes in Intermediate Algebra

\[(n = 4,148)\]

<table>
<thead>
<tr>
<th>Status</th>
<th>Lecture</th>
<th>Computer Assisted</th>
<th>Personalized Instruction</th>
<th>Internet</th>
<th>( \chi^2 )</th>
<th>df</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful</td>
<td>741</td>
<td>498</td>
<td>152</td>
<td>127</td>
<td>254.18</td>
<td>3</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Unsuccessful</td>
<td>926</td>
<td>725</td>
<td>420</td>
<td>559</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. * indicates statistical significance at \( p < 0.01\).

Research Question 2

Research Question 2 asked if the success of students enrolled in developmental classes using the lecture, personalized system of instruction (PSI), hybrid, and online learning methods of instruction was influenced by demographics and characteristics. To determine if student demographics or characteristics influenced student success differently for students enrolled in the three developmental mathematics classes using the lecture, PSI, hybrid, and online learning methods of instruction, logistic regression models were developed. The three models included six independent variables (gender, race, age, residency, Pell eligibility, and mode of instruction) and the dichotomous dependent variable (successful versus unsuccessful). The omnibus tests of model coefficients indicated the goodness of fit for each hypothesis’ model.

Null Hypothesis 4. This hypothesis was: There will be no difference in student success when controlling for the influence of student demographics or characteristics for students enrolled in prealgebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The logistic regression was statistically significant, \( \chi^2 \) \((df = 14, n = 1,743) = 159.196, p < .001\). The model distinguished between students who were
or were not successful in the prealgebra course. The model showed the variance accounted for between the independent variables and student success status as 8.7% (Cox & Snell $R^2$) and 11.9% (Nagelkerke $R^2$) and accurately classified 66.4% of the cases. These values constituted small effect sizes. As shown in Table 10, categories from the four independent variables of gender, race, age, residency, and mode of instruction made statistically significant contributions to the model for prealgebra.

Table 10

*Logistic Regression Prediction for Prealgebra*

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>SE of $\beta$</th>
<th>$p$</th>
<th>$e^\beta$ (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Constant</strong></td>
<td>-.225</td>
<td>.188</td>
<td>.231</td>
<td>.768</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>.289</td>
<td>.111</td>
<td>.009*</td>
<td>1.335</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black/African American $^a$</td>
<td>-.641</td>
<td>.169</td>
<td>&lt;.001*</td>
<td>.527</td>
</tr>
<tr>
<td>Hispanic $^a$</td>
<td>.018</td>
<td>.159</td>
<td>.911</td>
<td>1.018</td>
</tr>
<tr>
<td>Asian $^a$</td>
<td>-.075</td>
<td>.318</td>
<td>.813</td>
<td>.928</td>
</tr>
<tr>
<td>Race Native American/Alaskan $^a$</td>
<td>-.366</td>
<td>.745</td>
<td>.623</td>
<td>.694</td>
</tr>
<tr>
<td>Race Unknown/Not Reported $^a$</td>
<td>-.229</td>
<td>.162</td>
<td>.157</td>
<td>.795</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>.692</td>
<td>.128</td>
<td>&lt;.001*</td>
<td>1.998</td>
</tr>
<tr>
<td><strong>Residency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-District $^b$</td>
<td>.415</td>
<td>.147</td>
<td>.005*</td>
<td>1.514</td>
</tr>
<tr>
<td>Out-of-State $^b$</td>
<td>.082</td>
<td>.359</td>
<td>.820</td>
<td>1.085</td>
</tr>
<tr>
<td>Out-of-Country $^b$</td>
<td>1.700</td>
<td>.625</td>
<td>.007*</td>
<td>5.472</td>
</tr>
<tr>
<td><strong>Pell Status</strong></td>
<td>-.067</td>
<td>.121</td>
<td>.580</td>
<td>.935</td>
</tr>
<tr>
<td><strong>Mode of Delivery</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid $^c$</td>
<td>-.570</td>
<td>.118</td>
<td>&lt;.001*</td>
<td>.565</td>
</tr>
<tr>
<td>PSI $^c$</td>
<td>-1.184</td>
<td>.176</td>
<td>&lt;.001*</td>
<td>.306</td>
</tr>
<tr>
<td>Internet/Distance $^c$</td>
<td>-1.521</td>
<td>.205</td>
<td>&lt;.001*</td>
<td>.218</td>
</tr>
</tbody>
</table>

*Note.* $^*$ indicates statistical significance, $p < 0.05$. $^a$ White was the reference group. $^b$ In District was used as the reference group. $^c$ Lecture was the reference group.

**Null Hypothesis 5.** This hypothesis was: There will be no difference in student success when controlling for the influence of student demographics or characteristics for students enrolled in elementary algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The logistic regression was statistically significant, $\chi^2 (df = 14, n = 2,731) = 816.223, p < .001$. The model distinguished between
students who were or were not successful in the elementary algebra course. The model showed the variance accounted for between the independent variables and student success status as 25.8% (Cox & Snell $R^2$) and 35.8% (Nagelkerke $R^2$) and accurately classified 78.6% of the cases. These values constituted medium effect sizes. As shown in Table 11, categories from the four independent variables of race, age, residency, and mode of instruction made statistically significant contributions to the model.

Table 11

*Logistic Regression Prediction for Elementary Algebra*

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>SE of $\beta$</th>
<th>$p$</th>
<th>$e^\beta$ (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.174</td>
<td>.166</td>
<td>&lt;.001*</td>
<td>.309</td>
</tr>
<tr>
<td>Gender</td>
<td>.020</td>
<td>.101</td>
<td>.840</td>
<td>1.021</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black/African American</td>
<td>-.154</td>
<td>.145</td>
<td>.288</td>
<td>.857</td>
</tr>
<tr>
<td>Hispanic</td>
<td>-.126</td>
<td>.134</td>
<td>.347</td>
<td>.881</td>
</tr>
<tr>
<td>Asian</td>
<td>.294</td>
<td>.242</td>
<td>.223</td>
<td>1.342</td>
</tr>
<tr>
<td>Race Native American/Alaskan</td>
<td>.693</td>
<td>.605</td>
<td>.251</td>
<td>2.001</td>
</tr>
<tr>
<td>Race Unknown/Not Reported</td>
<td>-.501</td>
<td>.157</td>
<td>.001*</td>
<td>.606</td>
</tr>
<tr>
<td>Age</td>
<td>2.815</td>
<td>.123</td>
<td>&lt;.001*</td>
<td>16.695</td>
</tr>
<tr>
<td>Residency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-District</td>
<td>.239</td>
<td>.132</td>
<td>.069</td>
<td>1.271</td>
</tr>
<tr>
<td>Out-of-State</td>
<td>.639</td>
<td>.418</td>
<td>.126</td>
<td>1.895</td>
</tr>
<tr>
<td>Out-of-Country</td>
<td>1.204</td>
<td>.460</td>
<td>.009*</td>
<td>3.335</td>
</tr>
<tr>
<td>Pell Status</td>
<td>-.158</td>
<td>.119</td>
<td>.185</td>
<td>.854</td>
</tr>
<tr>
<td>Mode of Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid</td>
<td>.095</td>
<td>.115</td>
<td>.407</td>
<td>1.100</td>
</tr>
<tr>
<td>PSI</td>
<td>-.225</td>
<td>.166</td>
<td>.175</td>
<td>.799</td>
</tr>
<tr>
<td>Internet/Distance</td>
<td>-1.553</td>
<td>.162</td>
<td>&lt;.001*</td>
<td>.309</td>
</tr>
</tbody>
</table>

Note. * indicates statistical significance, $p < 0.05$. a White was the reference group. b In District was used as the reference group. c Lecture was the reference group.
Null Hypothesis 6. This hypothesis was: There will be no difference in student success when controlling for the influence of student demographics or characteristics for students enrolled in intermediate algebra mathematics classes using the following different methods of instruction: lecture, PSI, hybrid, and online learning. The logistic regression was statistically significant, $\chi^2 (df = 14, n = 3,936) = 53.992, p < .001$. The model distinguished between students who were or were not successful in the intermediate algebra course. The model showed the variance accounted for between the independent variables and student success status as 1.4% (Cox & Snell $R^2$) and 1.9% (Nagelkerke $R^2$) and accurately classified 62.9% of the cases. These values constituted effect sizes considered too low to generate practical significance. As shown in Table 12, only the variables of race and Pell status made statistically significant contributions to the model.

Summary

This study was quasi-experimental and the data represented the fall 2009, spring 2010, fall 2010, and spring 2011 semesters. An analysis of students’ success between four instruction modes (lecture, PSI, hybrid, and online) used in three developmental mathematics courses was conducted. The influences of students’ demographics and characteristics as they related to students’ success in three developmental mathematics courses provided through four different modes of instruction were also examined. To address the research questions, binary logistic regression models determined to what extent age, gender, ethnicity, residency, Pell eligibility, and mode of instruction accounted for these community college students’ course success in three developmental mathematics courses.
Table 12

*Logistic Regression Prediction for Intermediate Algebra*

<table>
<thead>
<tr>
<th></th>
<th>$\beta$</th>
<th>$SE$ of $\beta$</th>
<th>$p$</th>
<th>$e^\beta$ (odds ratio)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-.270</td>
<td>.120</td>
<td>.024*</td>
<td>.763</td>
</tr>
<tr>
<td>Gender</td>
<td>-.104</td>
<td>.067</td>
<td>.122</td>
<td>.901</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black/African American a</td>
<td>-.391</td>
<td>.117</td>
<td>.001*</td>
<td>.676</td>
</tr>
<tr>
<td>Hispanic a</td>
<td>.072</td>
<td>.093</td>
<td>.437</td>
<td>1.075</td>
</tr>
<tr>
<td>Asian a</td>
<td>.144</td>
<td>.132</td>
<td>.276</td>
<td>1.155</td>
</tr>
<tr>
<td>Race Native American/Alaskan a</td>
<td>-.880</td>
<td>.646</td>
<td>.173</td>
<td>.415</td>
</tr>
<tr>
<td>Race Unknown/Not Reported a</td>
<td>-.102</td>
<td>.111</td>
<td>.355</td>
<td>.903</td>
</tr>
<tr>
<td>Age</td>
<td>-.079</td>
<td>.086</td>
<td>.188</td>
<td>.924</td>
</tr>
<tr>
<td>Residency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out-of-District b</td>
<td>.114</td>
<td>.087</td>
<td>.188</td>
<td>1.121</td>
</tr>
<tr>
<td>Out-of-State b</td>
<td>.247</td>
<td>.261</td>
<td>.344</td>
<td>1.280</td>
</tr>
<tr>
<td>Out-of-Country b</td>
<td>.080</td>
<td>.156</td>
<td>.607</td>
<td>1.083</td>
</tr>
<tr>
<td>Pell Status</td>
<td>-.238</td>
<td>.082</td>
<td>.004*</td>
<td>.788</td>
</tr>
<tr>
<td>Mode of Delivery</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid c</td>
<td>-.053</td>
<td>.087</td>
<td>.545</td>
<td>.949</td>
</tr>
<tr>
<td>PSI c</td>
<td>-.192</td>
<td>.102</td>
<td>.059</td>
<td>.825</td>
</tr>
<tr>
<td>Internet/Distance c</td>
<td>.098</td>
<td>.091</td>
<td>.284</td>
<td>1.103</td>
</tr>
</tbody>
</table>

Note. * indicates statistical significance, $p < 0.05$. a White was the reference group. b In District was used as the reference group. c Lecture was the reference group.

All six null hypotheses were rejected. Statistically significant differences in student success were found between all four methods of instruction for all three mathematics courses (prealgebra: $\chi^2 = 107.90$, $p < 0.001$; elementary algebra: $\chi^2 = 88.39$, $p < 0.001$; intermediate algebra $\chi^2 = 254.18$, $p < 0.001$). Statistically significant differences in success among demographics and characteristics of students enrolled in these developmental classes occurred. For prealgebra, gender, race, residency, and mode of instruction made statistically significant ($p < 0.05$) contributions to the model ($\chi^2 [df = 14, n = 1,743] = 159.196, p < .001$; Nagelkerke $R^2 = .119$). For elementary algebra, the variables of race, age, residency, and mode of instruction made statistically significant ($p < 0.05$) contributions to the model ($\chi^2 [df = 14, n = 2,731] = 816.223, p < .001$; Nagelkerke $R^2 = .358$). For intermediate algebra, only race and Pell status
made statistically significant ($p < .05$) contributions to the model ($\chi^2 [df = 14, n = 3,936] = 53.992, p < .001$; Nagelkerke $R^2 = .019$).
CHAPTER 5

DISCUSSION AND IMPLICATIONS FOR RESEARCH AND PRACTICE

This study explored student success in different instructional modes incorporating the concepts of the constructivist and student development theories. Constructivists have dominated mathematics education in the past decades by viewing learning as a process that allows a student to use the environment to acquire current knowledge and use it to test new knowledge. Student development theories have greatly influenced developmental education by emphasizing the student as a whole person rather than merely focusing only on intellectual development (Higbee, Arendale, & Lundell, 2005). This chapter presents the discussion of the findings for each research question and provides recommendations for further study.

Summary of the Study and Findings

This study was designed to determine which of four instructional modes best ensures student success in developmental mathematics courses in a community college setting. Four different modes (i.e., modalities or methods) of instruction were examined for differences in student success between the four instructional modes as related to student demographics and characteristics. Student performance in three developmental mathematics classes of prealgebra, elementary algebra, and intermediate algebra was examined. The different instructional modes were the traditional lecture style, personalized system of instruction (PSI), hybrid method, and online learning. Two research questions guided the study, and the data represented the fall 2009, spring 2010, fall 2010, and spring 2011 semesters.

The first research question asked if there were statistically significant differences in student success using the following methods of instruction: lecture, PSI, hybrid, and online learning. The first three null hypotheses predicted no differences would be observed among
students in prealgebra, elementary algebra, and intermediate algebra taught through one of four different modalities of instruction (lecture, PSI, hybrid, and online). The data analysis consisted of examining student success rates (grade of C or better) in three developmental mathematics courses offered through four different instructional delivery methods using chi-square ($\chi^2$). All three null hypotheses were rejected, and statistical significance between instructional delivery methods and student success occurred for prealgebra, intermediate algebra, and elementary algebra.

The second research question asked if student demographics or characteristics influence student success differently for students enrolled in the developmental mathematics classes of prealgebra, elementary algebra, and intermediate algebra based on method of instruction (lecture, PSI, hybrid, and online). The three null hypotheses, one each for prealgebra, intermediate algebra, and elementary algebra, led to using logistic regression models to determine if age, gender, ethnicity, residency, Pell eligibility, or mode of instruction predicted community college student success in the three developmental mathematics courses of prealgebra, intermediate algebra, and elementary algebra. All three null hypotheses were rejected, and statistical significance between instructional delivery methods and student success occurred for prealgebra, intermediate algebra, and elementary algebra.

For prealgebra, the four independent variables of gender, race, residency, and mode of instruction made statistically significant contributions to the model. The highest odds ratio occurred with residency, as out-of-state students were over five times more likely to be successful. The mode of instruction contributed significantly and demonstrated that the three modes of hybrid, PSI, and internet were less likely to succeed than the lecture mode. Even
though the null hypothesis was rejected, the effect size .119 for the Nagelkerke $R^2$ represented too low of an effect size to consider the model to have practical significance.

For elementary algebra, the variables of race, age, residency, and mode of instruction made statistically significant contributions to the logistic regression model. Age contributed with the young age student having a 1669.5% greater likelihood of passing over the middle age student. Black/African American students were less likely to be successful than the reference group 85.7% of the time. Out-of country students were more likely to be successful than the in-district reference group. The mode of instruction contributed significantly to the model, internet/distance mode of instruction decreased success with a 30.9% likelihood of not passing over the lecture reference group.

For intermediate algebra, only race and Pell status made statistically significant contributions to the logistic regression model. The mode of instruction did not contribute significantly to the model, even though Internet/distance mode of instruction increased the likelihood of success with a 110% greater likelihood of passing over the lecture reference group. Black/African American students were less likely to be successful than the reference group 67.6% of the time, and students with Pell grants were less likely than non-Pell eligible students to be successful 78.8% of the time. Even though the null hypothesis was rejected, the effect size .019 for the Nagelkerke $R^2$ represented too low of an effect size to consider the model to have practical significance.

Discussion

Research Question 1: Differences in Student Success by Mode of Instruction

There was a relationship between success and instructional mode in the three developmental mathematics courses of the community college. However, the Cramer’s $V$
indicated the strength of the relationship to be relatively small. The results were similar to those of other studies showing differences in success between the instructional methods. In particular, prior research on the PSI and hybrid instructional methods showed them to have a positive influence on student success. In this study, the prealgebra model was statistically significant but did not have a positive on student success. Blann and Hantula (2004) and Squires, Faulkner, and Hite (2009) suggested that the PSI method of instruction improves mathematical success for some students. Emerson (2005), Taylor (2008), and Academic Systems Algebra™ (2010) showed the greater likelihood for student success in developmental mathematics courses using hybrid instructional methods. In a 2.5-year study at Johnson County Community College in Kansas (JCCC), a 15% increase in student success occurred for students attending hybrid developmental mathematics classes. Juliane Crabtree, lead mathematics instructor at JCCC, reported “students in her Academic Systems classes have had a success rate of 80 percent or higher, compared with a 60 percent rate in her traditional lecture-based classes” (Academic Systems Algebra™, 2010). Crabtree’s results did not demonstrate the hybrid and PSI modes of instruction lead to student success.

In the current study, high withdrawal and low success occurred for all developmental mathematics classes delivered through online instruction. In prealgebra only 45 out of 180 (25%) students were successful (see Table 7), in elementary algebra only 131 out of 488 (27%) students were successful (see Table 8), and in intermediate algebra 127 out of 686 (19%) students were successful (see Table 9) thus demonstrating a high percentage of students who were unsuccessful in all three levels of online developmental mathematics. This observation is in accord with the Zavarella and Ignash (2009) finding that students who enrolled in hybrid or
Internet-delivered developmental courses were twice as likely to withdraw as students enrolled in traditional lecture-based courses.

Research Question 2: Student Success in Developmental Mathematics Courses and Student Demographics

Mode of Instruction. The purpose of the second research question was to determine if student demographics and mode of instruction influenced students’ success in the three developmental mathematics courses. Overall, the influence of mode of instruction and student demographics led to limited ability to predict student success. In prealgebra, the odds ratios for the instructional mode showed that students were more successful in lecture classes. The other three modes in prealgebra showed a negative influence on student success: hybrid was 56.5%, PS1 was 30.6% and the internet was 21.8% not to succeed. However, in the elementary algebra instructional mode, only the internet showed significance with students being unsuccessful with an odds ratio of 30.9%.

For intermediate algebra, the odds ratio was not statistically significant. The low odds ratio for the intermediate algebra mode of instruction supported findings by Upcraft, Gardner, and Barefoot (2005). Upcraft et al. argued that presence of too many other variables and approaches to developmental education confound the ability to measure quantitatively students’ relative success between instructional methods. In addition, the three models’ multiple $R^2$ proxies represented that between 64% and 99% of the variation in success could be explained by factors other than age, gender, ethnicity, residency, Pell eligibility, and mode of instruction. The low percentage of variance accounted for in these three models was supported by Attewell et al. (2006) who found that preexisting skills, not demographics, contributed to student success in community college classes.
The effect size of prealgebra was between 0.087 and 0.119. The effect size of elementary algebra was between 0.258 and 0.358. According to the Texas Education Agency Best Practices Clearinghouse (2013), an effect size of 0.25 is appropriate as a threshold to meet educational research needs. “We chose this effect size threshold because it represents a conservative estimate of effects and because it was defined by the U.S. Department of Education’s What Works Clearinghouse as a ‘substantively important’ effect” (p.1). Therefore, the effective size of prealgebra shows promise for practical application and the effect size of elementary algebra was an acceptable effect size that shows evidence for practical application.

**Ethnicity.** There were no common predictors between the three levels of mathematics courses. However, the prealgebra and the intermediate algebra models showed statistical significance with regard to the Black/African American student. The effect size of the prealgebra model (0.12) and the odds ratio in prealgebra (0.527) is useful for practical application. While the effect size for intermediate algebra was small (0.02), the odds ratio was 0.676 and is useful for practical application. These results demonstrated that the Black/African American student was more likely to be unsuccessful in the developmental math courses compared to White students. In other studies that mirror the current findings, race also predicted retention (Liu & Liu, 1999; Pascarella & Terenzini, 2005; Walker and Plata, 2000; Zavarella & Ignash, 2009). According to Liu and Liu (1999), the gap in success increased for the retention rate between Caucasian and minority students (i.e., Hispanic and African American students). Lui and Lui stated that their findings “mirror the general trend of American higher education in which the variable of race continues to have an impact upon student departure” (p. 540).

**Age.** With regard to age, the students’ ages contributed statistical significance for prealgebra and elementary algebra. However, in the intermediate algebra model, age
demonstrated no statistical significance. Upcraft et al. (2005) stated that little research connects age to success, and adult learners are academically underprepared and have work and childcare responsibilities as well as other outside commitments. However, the supposition that many adult learners show more focus toward their academic goals and career goals (Upcraft et al., 2005) was supported by the prealgebra and elementary algebra findings in this study.

Gender. In the prealgebra model, gender demonstrated a statistically significant contribution to the logistic regression model. This study showed that women are 133.5 times more likely to be successful in prealgebra than men. These findings supported Upcraft et al.’s (2005) conclusion that women are more persistent and more successful in developmental mathematics than men. In addition, Walker and Plata (2000) showed significant differences between males’ and females’ successes in developmental courses. In their findings, fewer than the expected number of males failed two of the developmental mathematics courses. Females failed the basic mathematics course at a less than expected rate but also failed elementary and intermediate algebra at a greater rate.

Residency. Residency was statistically significant in both the prealgebra and elementary algebra models but was not statistically significant for the intermediate algebra model. For prealgebra, residency resulted in out-of-country students having a 5.472 times greater success likelihood than in-district students. For elementary algebra, residency resulted in out-of-country students having a 3.335 times greater success likelihood than in-district students. This finding does not support the assertions by Upcraft et al. (2005) that living at home or near family and living close to the college positively contribute to student success and family support, including support from spouses and children, is critical to student success (Upcraft et al., 2005).
Pell Eligibility. Pell eligibility was statistically significant in only the intermediate algebra logistic regression model. One of the components of eligibility for a Pell grant is financial need. Astin (1993) stated that students from a high socioeconomic family status are more likely to be successful in college than students from a lower socioeconomic family status. However, Upcraft et al. (2005) argued the lack of a relationship between student aid and success. The current findings align to those of Upcraft et al. (2005).

Implications for Practice

This study had four different instructional delivery methods. All of them were semester length courses (i.e., 16 weeks). The findings showed a relationship between student success and mode of instruction. Statistically significant differences in student success were found between all four methods of instruction for all three mathematics courses. There were statistically significant differences in success among demographics and characteristics of students enrolled in developmental classes. Binary logistic regression modeling was used to determine to what extent age, gender, ethnicity, residency, Pell eligibility, and mode of instructional accounted for the community college students’ course success for each of the three developmental mathematics courses. For prealgebra, the four independent variables of race, age, residency, and mode of instruction made statistically significant contributions to the model. For elementary algebra, the five independent variables of gender, age, residency, Pell eligibility, and mode of instruction made statistically significant contributions to the logistic regression model. For intermediate algebra, only Pell eligibility made a statistically significant contribution to the logistic regression, but mode of instruction did not contribute significantly to the model.

Mode of instruction did show a statistically significant contribution to student success in prealgebra and elementary algebra classes. However, one of the limitations to this study was that
the measures of student success could be different because of variations in the grading standards of instructors. Nevertheless, instructional mode merits consideration in the delivery of developmental mathematics courses according to these findings. In particular, with the prealgebra model, the hybrid, PSI, and internet modes of instruction demonstrated a negative effect on student success. In the elementary algebra model, the internet mode of instruction had a negative impact on student success. Based on these findings, community colleges may want to reconsider the lecture mode of instruction for entry-level developmental math courses.

Community colleges should consider exploring other options to deliver successful developmental mathematics courses. “Successful programs utilize multiple teaching and learning strategies to improve students’ success in developmental mathematics” according to Bonham and Boylan (2011, p. 3). Currently, many community colleges are investigating different delivery methods in an effort to improve student success in developmental mathematics courses. Some of these experimental courses do not represent the traditional semester-long course, as students attend these experimental developmental mathematics courses only until they master concepts they have been unable to demonstrate previously. These experimental courses may also include noncourse-based remediation programs such as mathematics refresher courses and mathematics boot camps. The findings of the current study indicate that there may be benefit to providing additional formats particularly for prealgebra and elementary algebra classes.

Community colleges should also explore economical ways to offer developmental courses, improve retention, and reduce the number of years beyond the second year for completing a supposedly two-year degree. Successful programs, similar to components included in this study, utilize different teaching and learning methods that offer technology as a supplement to classroom instruction, a combination of classroom and lab instruction, and
appropriate student assessment and placement (Bonham & Boylan, 2011). For students who could benefit from an alternative program and those who only need a review, enrollment in a 16-week class does not make good use of their time or money. Different instructional approaches could include fast-track courses, combined levels of developmental courses, or module-based courses.

In the current study, only approximately one-third of students passed the developmental courses: 36% of students passed prealgebra, 34% of students passed elementary algebra, and 37% of students passed intermediate algebra. It is disturbing that most developmental mathematics students do not pass developmental mathematics courses and remain ineligible to enroll in higher-level mathematics courses. Boylan (2011) argued that colleges need to determine whether students who place into a mathematics course have a higher success rate than those who take the developmental sequence. “If this is true at your institution, you may have a curriculum gap or a high number of students who had Cs in their last algebra course” (Boylan, 2011, p. 26). In addition, if a student makes a C or lower in an algebra course, this grade usually means the student will not be successful in the subsequent course.

Anthony S. Bryk (2012), President of Carnegie Foundation for the Advancement of Teaching, stated that “developmental mathematics courses represent the graveyard of dreams and aspirations” (p. 1). Because this study included different modes of instruction, the findings can provide community colleges with insights and strategies for student success in a variety of developmental mathematics courses and for eliminating the presence of this graveyard on college campuses. College presidents and other administrators must address their mathematics programs’ needs for reinvention. Boylan (2011) stated that top-level pressure to induce change is required to help developmental students as well as all students’ progression toward degree completion. As
enrollment in developmental courses grows, colleges need to offer more variations in instructional delivery methods. Since the successful completion of developmental mathematics courses has become a top priority for community college retention, the findings of the present study offer information to faculty and administrators at community colleges developing successful retention strategies.

Several states’ lawmakers are working to force community colleges to examine their developmental education programs. For example, in Texas, the Texas Higher Education Coordinating Board (THECB) is mandating community colleges examine their instructional methods and institutional practices. The THECB Almanac (2012) used simple ratios:

Of every 100 two-year college students who are below the state readiness standard when they enter college, only 29 have graduated or are still enrolled in higher education after three years, compared to 40 out of every 100 students who enter college ready. (p. 13)

The THECB (2012) listed several key strategies and initiatives including expanding access to higher education by restructuring financial aid, providing low-cost degrees, and strengthening community colleges by improving transfer rates and aligning outcomes with workforce needs. In addition, the THECB recommended improving higher education outcomes by reinventing developmental education. The findings of this study provide some indications of possible directions for this effort. In addition, just recently the Texas Board of Education gave preliminary approval to drop algebra II as a requirement for high school graduation. According to Gay (2013, November 21) who wrote in the Dallas Morning News, “The shake-up was meant to give students the flexibility to focus on career and vocational training – not just college prep courses” (p. 1). Without change in expectations for college readiness in mathematics, dropping this high school graduation requirement will put more responsibility on developmental
mathematics programs in Texas community colleges as they serve more students who arrive with fewer math skills.

Another example was found in Florida. According to Morgan (2013), state lawmakers voted to make developmental education courses optional for recent high school graduates and active duty military members. The new law also requires colleges to offer different modes of instruction for students to catch up while enrolled in college courses. Suggested recommendations in the law include compressing two developmental courses into one, more tutoring in credit courses, and offering specific modules in students’ weak areas. While not studying the methods suggested in Florida, the current study does indicate that variety of teaching methods can benefit students.

The study’s findings provide information on which instructional method may lead to student success by developmental mathematics course (prealgebra, elementary algebra, and intermediate algebra). Additionally, advisors can use these findings when advising students regarding the instructional method that might represent a best fit for their students. For example, showing advisors the low success rate in the Internet courses suggests that they carefully advise students who want to enroll in that method of instruction. In this study, the online mode’s success rate was lower than the other instructional methods. Some colleges require students to take a pretest to show readiness for an online course. For example, Northwest Community College (2013) requires students take a pretest before enrolling in an online course. The pretest is designed to help students determine whether they have the computer skills necessary to be successful in the class. According to Upcraft et al. (2005), students who enroll in online courses may not have access to or may lack the technology skills necessary for success in an online
course. Students who enroll in a developmental online mathematics course might feel challenged to both learn mathematics course content and use technology.

Recommendations for Research

Both community colleges’ enrollments and the need for offering developmental mathematics courses continue to increase. Therefore, more research is needed regarding different instructional modes and institutional practices. Pascarella and Terenzini (2005) stated that higher education has learned much about community college students and the impact of two-year schools. They emphasized that since these colleges enroll more than 40% of postsecondary students, community college researchers should continue to study these students to develop better methods for meeting their diverse needs. A number of recommendations follow.

First, researchers could employ qualitative methodologies to examine instructor and student attitudes and expectations about the different instructional modes and to better understand the continuing increase in the number of students who never complete the sequence of developmental mathematics courses. Understanding student expectations in depth may assist college leaders’ efforts to better define general educational goals. Upcraft et al. (2005) provided an excellent explanation for this need:

Perhaps if we had a bit more insight into students and their expectations for college--expectations very similar to those that faculty and staff hold for them in personal, social, and academic domains--we would not have to work so hard of convincing them of the things we think would be good for them. (p. 113)

Second, in this study, instructional mode was only one of the variables related to enrolling and retaining developmental mathematics students. A study employing interventions
such as tutoring, supplemental instruction, or a combined developmental math course with a college level course could lead to improved student success rates (Upcraft et al., 2005).

Third, because a large amount of variance was not accounted for by the variables in the study and because affective factors (e.g. students’ beliefs, motivations, and expectations) that could influence student success in mathematics were not explored, a study including both cognitive and affective variables as predictors of developmental mathematics success is needed. Bonham and Boylan (2011) also suggested that affective factors could be important to predicting student success. An intervention study that incorporates developing students’ self-efficacy as well as mathematics success skills into a developmental education course or into an introduction to college mathematics courses is suggested. Suggested topics for intervention include teaching students how to read a mathematics textbook, use appropriate test strategies (preparation skills, stress reduction, test taking skills), reap the benefits of class attendance, and work effectively in study groups. In addition, Astin’s (1993) student input variables (prior academic achievement, educational attainment of parents and other family members, first time in college, work schedule, and student commitment) as well as Astin’s environmental variables (grade point average, full-time or part-time, advising, participation in college activities, and interpersonal interactions with other students and faculty) could be explored in relation to student success in developmental mathematics courses.

Fourth, further research should be done as to why African Americans struggle with developmental math courses. In two of the three models in this study, African American students had significantly lower success rates of what were generally already low success rates raising the question why? Should community colleges provide additional or different support for this student population? Student characteristics were examined in this study, however there was no
examination of instructor characteristics or inputs. While beyond the scope of this study, the influence of instructors on student success in developmental mathematics courses could shed light on the question of African American student success.

The fifth suggestion is for further research exploring why the PSI model did not show statistical significance in promoting student success. The current literature (Eyre & Ironsmith, 2007; Ironsmith & Eppler, 2007; Kohrmann & Villarreal, 2011; Squires, Faulkner, & Hite, 2009) shows that many community colleges are using a similar model with great success, but such findings were not seen in this study.

Lastly, this study did not investigate how students do in subsequent developmental mathematics courses. There is little research that examines how students do in sequentially subsequent developmental mathematics courses, i.e. studies that follow individual students on the journey through the development mathematics sequence. This is in part because community college students attend multiple institutions before completing a degree (McClenney, 2004) making them difficult to track over time. These students enroll in two or more institutions at the same time, stop in and out of school frequently, and transfer in many directions (Borland, 2004; Jacobs, 2004; McClenney, 2004). Because this study included data from only a single institution, an interinstitutional approach could be the next research step. Therefore, to measure success in a subsequent course, it is suggested that future researchers examine more than one college’s developmental and transferrable mathematics courses’ success rates to trace the progress of students who attend multiple institutions.

In conclusion, many challenges to achieving student success in developmental mathematics courses remain for colleges to overcome. According to Upcraft et al. (2005), the greatest challenge with higher education is the commitment of college resources to promote
student success. “The institutional challenge is to provide developmental education programs that maintain academic standards, while providing the support necessary for the under-prepared first-year students to succeed” (Upcraft et al., 2005, p. 292). Collaboration among colleges, universities, and professional organizations to conduct research will contribute to making better instructional decisions concerning student success in developmental mathematics courses.
APPENDIX

APPROVAL TO CONDUCT STUDY
Dear Ms. Keller:

On behalf of the North Lake College Institutional Review Board (NLC-IRB), I am pleased to report that your request for North Lake College as a site for your study, *Community College Student Success in Developmental Mathematics Courses: A Comparison of Four Instructional Methods*, has been granted by the NLC-IRB. Our interim college president, Ms. Christa Slejko, in compliance with Dallas County Community College District Board policy, has also approved North Lake College (NLC) as a site for your study.

Approval for this study has been granted for a period of one year. Any changes to your study procedures will require additional review by the NLC-IRB. If your study extends beyond one year, you should submit a request for a continuation to the NLC-IRB. Please contact me at 972/273-3392 or tisbell@dcccd.edu when you are ready to proceed with your study.

Sincerely,

Teresa Isbell,
Dean, Planning, Research and Institutional Effectiveness
Chair, Institutional Review Board

cc: Christa Slejko
Interim President, North Lake College

---

IRB Extension

February 14, 2013

Judy,

I just reviewed your IRB stuff from last year.

Since you had an exempt status last year, I don't think the addition of the demographic data will change that. However, I am including the IRB on this reply, and attaching the relevant information, because your approval was for a single year, which is ending in March 2013. I am recommending to the IRB that we extend the approval for an additional year, in order for you to have time to complete your dissertation.

Dr. Karen C. Laljiani
Dean, Planning, Assessment, and Research
North Lake College
972-273-3392
laljiani@dcccd.edu
From: Harmon, Jordan On Behalf Of untirb
Sent: Monday, December 12, 2011 10:29 AM
To: Bower, Beverly
Subject: RE: FW: Minimal Review
Importance: High

Dr. Bower,
The UNT Institutional Review Board has jurisdiction to review proposed “research” with “human subjects” as those terms are defined in the federal IRB regulations. The phrase “human subjects” is defined as follows:
“A living individual about whom an investigator (whether professional or student) conducting research obtains (1) Data through intervention or interaction with the individual, or (2) Identifiable private information.
Since the data you will be obtaining from North Lake College has been totally de-identified, then your use of that data falls outside the scope of the “human subjects” definition and UNT IRB review and approval is not required.
We appreciate your efforts, however, to comply with the federal regulations and sincerely thank you for your IRB application submission!
If a formal letter is needed for your records, please let me know.
Thank you and good luck with your study!

Jordan Harmon
Research Compliance Analyst
University of North Texas
REFERENCES


http://dx.doi.org/10.1080/10668926.2010.509232.


Community College Survey of Student Engagement. (2008). *Essential elements of engagement: High expectations, high support*. Austin, TX: The University of Texas at Austin, Community College Leadership Program.


