AN ABSTRACT OF THE DISSERTATION OF

Joyce D. Hammer for the degree of Doctor of Philosophy in Education presented on December 19, 2011.
Title: The Relationship Between Completing the Applications of Mathematical Reasoning Course and High School to Community College Transitions.

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Darlene F. Russ-Eft

In 2004, the Transition Mathematics Project (TMP), funded by the state of Washington and The Bill and Melinda Gates Foundation, was established to create projects to help high school students gain the necessary skills to become college and work-ready. Aligned to TMP's College Readiness Mathematics Standards, a fourth-year capstone mathematics course was developed and implemented, titled *Applications in Mathematical Reasoning* (AMR), a rigorous course option for students to take during their senior year of high school. The purpose of this study was to explore any relationship between taking the AMR course and preparation for college level mathematics. Using causal-comparative study design and matching participants in the sample, variables were examined based on the number of precollege courses taken; college level math course completed and grade earned; and placement test results for students who took the AMR course compared to those students who took no mathematics during their high school senior year. Though findings for precollege and college level course-taking were inconclusive, mathematics placement test scores were found to be significantly higher for those students who completed the AMR course. The placement test findings supported other research that links rigorous mathematics courses taken in high school with

improved college placement and persistence. Based on the research examined and the study findings, there was support to consider the following: (a) creating alternate but rigorous math course offerings for the high school senior year; (b) striving toward a four-years of mathematics graduation requirement for all high schools; (c) enacting mandatory placement at the community college for students placing into precollege courses; and (d) reducing barriers to successful transition between high schools and post secondary institutions by fostering K-16 communication, aligning standards, and improving course alignment.

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The Relationship Between Completing the Applications of Mathematical Reasoning Course and High School to Community College Transitions

by
Joyce D. Hammer

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Dean of the College of Education

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Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Joyce D. Hammer, Author

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CHAPTER 1

Focus and Significance

According to the Bureau of Labor Statistics (2010), between 2008 and 2018, it is projected that there will be approximately 50.9 million job openings. Out of those job openings, the highest rate of growth will be in areas that require some postsecondary education and in fields requiring coursework in mathematics such as biomedical engineering, network systems, and computer software engineers (Bureau of Labor Statistics, 2010). Expected to fill these jobs are over 2.5 million high school students graduating from public high schools, with 70% of these students seeking postsecondary education within two years of graduation (Kirst & Bracco, 2004; Venezia, Kirst, & Antonio, 2008). These graduates will find themselves part of an economy that has been transformed into a wave of technological innovation and globalization, demanding that students have advanced knowledge and skills in mathematics and science (Carnevale, 2007; Strong American Schools, 2008; U.S. Department of Education, 2008). In general, today's generation has more high school graduates, more of those graduates seeking postsecondary education, and more of those students less prepared than ever for positions requiring knowledge of mathematics and science (Bailey, Kienzl, & Marcotte, 2004; Kirst & Bracco, 2004; Venezia et al., 2008; U.S. Department of Education, 2008). This lack of preparation also applies to ethnic groups. White students are more likely to complete degrees from two and four-year colleges compared to African Americans and

Latinos, illustrating a growing gap in degree attainment for minority students (Bailey & Morest, 2006; Callan, Finney, Kirst, Usdan, & Venezia, 2006; Venezia et al., 2008).

Researchers have turned their attention to the transition from high school to postsecondary education as a main reason students are unprepared for college level work (Achieve, 2007; Bailey & Morest, 2006; Conley, 2007ab; Kane & Rouse, 1999; U.S. Department of Education, 2009). Since over 50% of students entering postsecondary education institutions will need to take precollege or below college level courses in basic skills areas like mathematics (Bailey, Jeong, & Cho, 2010; Bailey & Morest, 2006), and the cost of remediation to taxpayers approaching an estimated $1.88-$2.34 billion during the 2004-2005 academic year (Strong American Schools, 2008), policymakers are eager to find a solution to the growing problem of students struggling to transition from high school to college. The focus of this research study was to explore one proposed solution: the offering of a rigorous mathematics course during the senior year of high school that is designed to encourage high school students, many of whom stop taking mathematics before their senior years, to continue with their mathematics training.

Research Purpose

The Transition Mathematics Project (TMP), funded by the state of Washington and The Bill and Melinda Gates Foundation, was established in 2004 to create projects that help high school students gain the necessary mathematics skills to become college and work ready (TMP, 2008a). College-readiness standards that align curriculum, placement, and instruction were developed as a result of this statewide effort. Faculty involved with Project TIME (Transitions in Mathematics Education), one of the partnerships funded by TMP, worked with administrators and high school teachers from local school districts to implement a fourth-year high school capstone mathematics course titled *Applications in Mathematical Reasoning (AMR)*, an optional course for students to take during their senior year of high school.

The AMR course was designed by a partnership among community college mathematics faculty and K-12 mathematics instructors with support from administrators from both the K-12 and college sectors. The course was piloted in 2007-2009 with over 200 students from school districts in the south Puget Sound region. The primary audience for the AMR course was seniors in high school who took the course after completing Algebra II, the second year of algebra, and preferred an alternative to the precalculus track (TMP, 2008b). AMR course goals included: (a) providing a rigorous alternative to the precalculus/calculus track; (b) investigating interesting mathematical topics while reinforcing algebra skills; and (c) developing quantitative literacy with engaging, meaningful, and relevant mathematical activities (TMP, 2009).

The module-based curriculum for the course was aligned with the College Readiness Mathematics Standards (CRMS) that "define the core knowledge and skills expected of students entering college-level mathematics courses and courses with quantitative components" (TMP, 2008c, p. 1). The CRMS also outlined information for students to succeed in mathematics when transitioning from high school to a postsecondary institution and were developed by K-12 schools, community and technical colleges, and baccalaureate institutions under the guidance of the Transition Mathematics Project. The content in the modules included modeling discrete structures (e.g. game theory, fair division, voting) and management science that included graph theory, scheduling, and linear programming. Probability, statistics, right-triangle trigonometry, two and three-dimensional geometry, and modeling with continuous functions were additional topics covered in the course. Pedagogical strategies were based on a constructivist approach that focused more on small group activities involving problem solving skills rather than a lecture-type format and required extensive professional development for high school instructors teaching the course. In addition, many of the activities required the use of graphing calculators, computer labs, motion and temperature sensors, DVD video clips, measurement tools, and the textbook, *For All Practical Purposes*, published by the non-profit organization, Consortium for Mathematics and Its Applications (2011).

The purpose of this research study was to explore the rigorous AMR course to determine whether there was significant evidence to indicate a relationship between taking such a course and preparation for college level mathematics. Using a nonexperimental, causal-comparative study design, variables were examined based on the number of precollege/remedial[1] courses taken, college level math course completed and grade earned, and placement scores for students who took the AMR course compared to those students who took no mathematics during their senior year of high school. Hopefully, results from this study can contribute to research knowledge about

[1] *precollege* and *remedial* are terms used interchangeably and represent below college-level coursework.

K-16 transitions as well as support future studies that examine types of mathematics courses needing to be offered during the senior year of high school.

Research Questions

In order to examine the impact of taking the AMR course on mathematics preparation for college, the following three questions provided a guide for conducting the research:

Question 1. To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters (summer excluded) compared to similar students who took no mathematics course their senior year of high school?

Rationale. Investigating the impact of the AMR course on remediation rates at the community college contributed to a well-rounded examination of all the participants in the study. Taking a precollege class when transitioning to college was easily measured through transcript data, and depending on the level of precollege class taken, could indicate to what degree a student was prepared or not prepared for college level mathematics. In addition, students seeking to take precollege courses may have indicated a persistence with and interest in completing college level math course prerequisites. The issue of remediation in general also addressed major concerns of policymakers at the state and national levels.

Null hypothesis. There is no difference between recent high school graduates who took the AMR course and those who took no mathematics during their senior year in terms of precollege courses taken during the first three quarters when transitioning to the community college.

Alternative hypothesis. Recent high school graduates who took the AMR course during their senior year of high school seek to take fewer precollege courses when transitioning to community college than those who took no mathematics during their senior year of high school.

Question 2. To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a minimum passing grade of a 1.0 compared to those students who did not take any mathematics during their senior year?

Rationale. Examining the impact of taking a rigorous course during the senior year of high school in preparation for college was the main thrust of the study with completing a college level math course a significant factor in degree completion and college success (Jenkins, 2008). The grade of a 1.0 is the minimum grade required for a student to be able to transfer a course as part of the Direct Transfer Agreement (DTA) between community colleges and baccalaureate institutions in the state of Washington. The comparison to college bound students who did not take a mathematics course during their senior year of high school will help provide a statistically credible analysis.

Null hypothesis. There is no difference between recent high school graduates who took the AMR course in high school and those who took no mathematics their senior year of high school in terms of enrolling in a college level mathematics course and earning at least a passing grade of a 1.0.

Alternative hypothesis. Recent high school graduates who took the AMR course during their senior year of high school will be more likely to enroll in a college level mathematics course and earn a passing grade of a 1.0 when transitioning to community college than those who took no mathematics their senior year of high school.

Question 3. To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

***Rationale*.** Understanding the relationship between the AMR course and students' placement scores provided data that may influence policy at the statewide and local levels. Typically, students take mathematics placement tests upon entering the community college, thus providing a valid data set for analyzing their college preparation in mathematics.

Null hypothesis. There is no difference between recent high school graduates who took the AMR course in high school and those who did not take any mathematics their senior year of high school in terms of earning a higher score on the mathematics placement test when enrolling at the community college.

Alternative hypothesis. Recent high school graduates who took the AMR course during their senior year of high school will score significantly higher on mathematics placement tests when transitioning to community college than those who took no mathematics their senior year of high school.

Significance of the Study

This study is significant because of the following reasons: (a) the changing demographics of high school graduates and workforce needs, (b) an increase in the need for mathematics remediation in community colleges, (c) a need for more rigorous mathematics course offerings during the senior year of high school, (d**)** a call for improving mathematics transitions from high school to college, and (e) a paucity of research on this topic.

Changing demographics and workforce needs. According to Kirst and Bracco (2004), " There are approximately 2.5 million high school graduates in the United States each year" (p. 1), and recent demographic data show that this age group continues to increase in number (Conley, 2007b; Kane & Rouse, 1999). The National Center for Educational Statistics (NCES) reported that an increasing number of high school graduates are seeking postsecondary education and taking additional mathematics courses (Nord, et al., 2011). These graduates will face a 21st century economic landscape that requires stronger academic skills particularly in mathematics beyond the second year of algebra (Adelman, 1999; Adelman, 2006; Grubb, 1996; National Commission on the High School Senior Year, 2001). As students are being encouraged to pursue postsecondary degrees, graduation rates are not keeping up with the workforce demand, and degree completion is being compromised due to lack of college preparedness (Kane & Rouse, 1999; Kirst & Bracco, 2004; McCormick & Lucas, 2011; Venezia et al., 2008). In addition, students seeking careers with higher wages and lower unemployment rates are encouraged to complete postsecondary degrees as outlined in Prince and Jenkins'

(2005) “Tipping Point” research and other studies (Bailey et al., 2004; Baum & Ma, 2007).

The study investigated whether taking the AMR course during the senior year of high school improves college preparedness and may provide insight into what courses high school students should take to be prepared for college and work. The design of the AMR course was based on the College Readiness Standards, developed by the TMP as standards that determine a student’s readiness for college level mathematics and work preparedness (TMP, 2008b). Understanding the degree to which the AMR course is connected to college preparedness could open the possibility for future exploration of high school course-taking and its impact on degree completion and workforce preparation.

Increased remediation in mathematics at community colleges. As community colleges expect to see enrollments grow in response to a demographic increase in the number of high school graduates attending college, there continues to be an increasing number of students who are underprepared for college level work in the area of mathematics. According to research by the Washington State Board of Community and Technical Colleges (SBCTC) (2009a), “Forty-eight (48) percent of community and technical college students who graduated from high school in 2008 took precollege math courses, up two percent from 2007” (p. 1). A significant number of students stop taking mathematics prior to their senior year of high school. This creates a need to enroll in precollege mathematics defined as remediation when high school graduates attend postsecondary institutions, and such remediation can lead to students being unable to complete degrees when they aspire to do so (Bailey & Morest, 2006; Kane & Rouse, 1999; National Commission on the High School Senior Year, 2001; Newton, 2010). The skyrocketing remediation trends over the past decade contributed to increased cost for students and the postsecondary institutions they attend as more and more students need to be accommodated in precollege classes (Levin & Calcagno, 2008). Research has shown that any rigorous high school curriculum in mathematics beyond the second year of algebra and during the senior year can improve the likelihood that students will succeed in college (ACT, 2005; Adelman, 2006; Hoyt & Sorensen, 2001; Hudson-Hull & Seeley, 2010; Karp & Hughes, 2008; Ma & Wilkins, 2007; Zelkowski, 2011). This study attempted to determine if there is a connection between a specific rigorous course taken during the senior year and success in college as defined by (a) not having to take remediation courses, (b) enrolling in and passing a college level mathematics course, or (c) earning higher scores on placement tests when entering college.

Rigorous math course option during the high school senior year. Typically, the senior year of high school has limited options for coursework compared to postsecondary institutions, yet there is research to support the need for requiring additional mathematics courses beyond the second year of algebra in high school. (ACT, 2005; Adelman, 2006; Bailey, Hughes, & Karp, 2002; Berry, 2003; Hudson-Hull & Seeley, 2010; Zelkowski, 2011). Though students who take mathematics their senior year of high school typically have the option of taking precalculus, calculus, or statistics courses, some research recognized the need for a greater variety of course offerings that can prepare students for success in college (Bellomo & Strapp, 2008; Cavanagh, 2008;

Charles A. Dana Center, 2006; Jago, 2000). Recent data also indicated that there are more students completing courses beyond the Algebra II level when satisfying their graduation requirements. From 1982 to 2004, specifically, the percentage of students taking more advanced mathematics increased from 26 to 50 percent (National Center for Educational Statistics, 2007). High schools may need to increase the course offerings to encourage students to continue taking mathematics courses all four years of high school as well as offer alternatives to the traditional precalculus/calculus courses.

In addition to the importance of mathematics level and rigor, other course subjects of the senior year of high school have been in the national spotlight. The National Commission on the High School Senior Year (2001) was formed in 2000 to improve the P-16 alignment, increase achievement, and enhance the rigor of coursework during the senior year, a significant gateway between the secondary and postsecondary experience. The AMR course combined the rigor of mathematics supported by research with the national call for increasing the number of challenging courses during the senior year (Adelman, 2006; Charles A. Dana Center, 2006; Kirst & Bracco, 2004; National Commission on the High School Senior Year, 2001). During my own career as a community college mathematics instructor, the value of that senior year became apparent to me when students who did not take mathematics during their last year of high school seemed unprepared for college mathematics. Because the AMR course takes place during the senior year of high school, the proposed study is timely by contributing additional research information regarding the connection between mathematics course-taking during the senior year and preparation for college mathematics.

Secondary/postsecondary transitions in mathematics. From a societal viewpoint, improving the mathematics transition of high school graduates attending college is an important step in preparing a generation for work in the age of globalization. Orr and Bragg (2001) found the following:

> Increased cooperation between secondary schools and community colleges and other higher-education institutions is thought to improve how well all students are prepared, academically and vocationally, for the future, particularly to meet the demands of growth industries and changing labor markets for the global economy. (p. 101)

By supporting student aspirations for college through more seamless transitions, these future employees will earn higher wages and increase their standards of living (Bailey, et al., 2004; Bragg, Kim, & Rubin, 2005; Carnevale, 2007; Grubb, 1996; National Commission on the High School Senior Year, 2001; Prince & Jenkins, 2005; Rose & Betts, 2001). Currently, a disconnect in K-14 collaboration efforts exists, as there is little opportunity or desire for communication among high school teachers, administrators, counselors, and community college personnel (Achieve, 2007; Bailey, et al., 2002; Hoffman, Vargas, Venezia, & Miller, 2007; Orr & Bragg, 2001). Even so, there is a strong surge in dual enrollment programs as research recognizes that dual or concurrent enrollment in college and high school can improve college preparedness (Bailey, et al., 2002; Bailey & Morest, 2006; Hoffman et al., 2007). By studying the impact of the AMR course on students at the community college, the effort is being made to connect with secondary curriculum, thus supporting the importance of community college/high school partnerships in regard to mathematics education and success at the college level.

The present study is based on the work by the TMP (2008a), an organization characterized as "a collaborative project bringing together educators from K-12 schools, community and technical colleges, and baccalaureate institutions to help all students prepare and be ready for post-secondary, college-level math…" (p. 1). The AMR course curriculum was also created by a team of high school and community college mathematics instructors with support from administrators from both sectors, exemplifying a shared effort to implement a rigorous, standards-based course that would meet the needs of high school seniors as well as represent content rigor from the community college perspective.

A paucity of research on this topic. Though there is a nationwide focus on mathematics during the senior year of high school with the goal of improving mathematics education for students transitioning to college, there is a significant gap in the literature as to how alternate courses to precalculus and calculus, such as AMR, impact future success in college. As Long, Iatarola, and Conger (2009) noted in their study, the research is particularly limited in regard to the effect of high school courses on the need for remedial coursework during the first year of college. There is also a need for longitudinal studies on alternative, rigorous mathematics courses that have been developed nationwide and their impact across all educational sectors including community colleges. This research could suggest future investigation on this topic that would be more longitudinal and of a greater national scope. From a nationwide perspective, there is also a call for general research around the area of mathematics education to which this study will relate (U.S. Department of Education, 2008).

Summary

The results of this study were significant as educators work to improve the transition between high schools and community colleges in the area of mathematics education. Students often lack choices of rigorous mathematics courses to take their senior year and choose not to take mathematics. Currently, students enrolling at the community college are underprepared for college level work in mathematics so they take precollege classes, have trouble passing their college level mathematics courses, choose not to take any mathematics courses beyond degree requirements, or are unable to graduate. This research could also help educators and state policy leaders determine if it is worthwhile to invest resources in the further development and implementation of the AMR course and whether there is indeed a connection between taking the course and students successfully transitioning to college level mathematics. As TMP and K-12 leadership ascertains whether the AMR course should become a statewide model, similar to the Advanced Mathematical Decision Making course developed in Texas (Charles A. Dana Center, 2009), that exemplifies a rigorous alternative for students beyond the Algebra II level, additional scholarly research is needed to assess the validity of such a consideration.

CHAPTER 2

Review of the Literature

The purpose of the literature review was to examine the most current and relevant scholarly research that provided a context and basis for this study. For this topic, the research was guided by the previously-stated research questions that required information regarding what mathematics courses students should take and when they should take them in high school to be prepared for and eventually successful in college mathematics. Information on how high schools and postsecondary institutions, particularly community colleges, guided that transition was also examined. Historical views, curriculum characteristics, psychological considerations, and placement strategies also guided the literature review.

Approach to Review of Literature

The Oregon State University (OSU) online library and Google Scholar search engines were two main sources of research used in gathering research material reviewed for this study. Within OSU's online library including the Summit Catalog, the Academic Search Premier and Education Research Complete were the two main databases utilized, both of which are linked to the EBSCO host database. Dissertations, peer reviewed journals, books, and government reports were the main reference materials, and many of the sources were accessible online.

Criteria for inclusion in the literature review were based on answers to the following questions: (a) Were the articles from peer-reviewed journals? (b) Were the sources primary and often referenced in other articles? (c) By examining the authors and political factors, were the government documents and reports from reputable and non-biased sources? (d) Were qualitative and quantitative studies from peer-reviewed sources or conducted at an accredited research university or college? And (e) Was the research current for the subject, preferably within the past decade (not including the historical section of the literature review)? Rationale for using these criteria were based on work by Glattern and Joyner (2005) who listed guidelines for conducting focused literature review and Creswell (2008) who provided organizational tools for classifying literature. When conducting online searches, key words or phrases used in finding articles or books included (a) mathematics college preparation, (b) high school college transitions in mathematics, (c) senior year high school mathematics, (d) community college high school transitions, (e) community college remediation, and (e) mathematics education high school college preparation.

Organization of Review of Literature

The review of the literature for the proposed study was organized under the following three themes: (a) mathematics preparation for postsecondary success, (b) K-16 transitions in mathematics education, and (c) Applications in Mathematical Reasoning (AMR): a senior year capstone course. These three themes emerged after constructing a literature map based on the research questions and reviewed literature (Creswell, 2008). There appeared to be significant research for each of the areas particularly around the topic of mathematics preparation for postsecondary success. The literature review begins with definitions of key vocabulary and concepts necessary for understanding the research topic. Each section includes an overview of the literature findings and how these findings were linked to the overall study.

Key terms. The following are key terms utilized throughout this study:

Algebra I and II. Terms applied to the first and second years of algebra in high school. Typically, Algebra I (sometimes referred to as Algebra 1-2) covers beginning algebra material. Algebra II (sometimes referred to as Algebra 3-4) encompasses topics in intermediate algebra.

Applications in Mathematical Reasoning (AMR)**.** The aforementioned course that was developed for local high schools through the Project TIME grant at Green River Community College (GRCC). The course requires Algebra II skills and is an alternative to precalculus at the high school level. Students in the AMR course learn a variety of topics that have real-world applications, topics that are similar in content to college liberal arts classes yet encourage the development of algebraic thinking beyond intermediate algebra.

College readiness. As Conley (2007b) determined, college readiness can be defined as "the level of preparation a student needs in order to enroll and succeed—without remediation—in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program (p. 5). Zelkowski (2011) concurred and distinguished college-ready from college-eligible with the latter referring to high school graduation and postsecondary admission requirements.

Placement testing. When students enter community colleges in Washington State, they are placed into courses for reading, writing, or mathematics using a placement test.

All but two of the 34 community colleges in the state of Washington use one of the following (a) The American College Testing Program's (ACT) Computerized Adaptive Placement Assessment and Support System (COMPASS) (b) ACT's Assessment of Skills for Successful Entry and Transfer (ASSET) or (c) The College Board's ACCUPLACER with the majority (two-thirds) of the institutions using COMPASS (SBCTC, 2011). COMPASS and ACCUPLACER are adaptive exams taken on the computer, whereas ASSET is a paper/pencil exam. Scores from one of these placement tests are used to place students in college-level versus remedial courses. For math course placement, each institution determines cutoff scores based on mathematics curriculum with some colleges offering alternate placement options such as instructor permission, high school transcripts, or "home-grown" placement tests. Most colleges allow for at least one retest with the option to challenge score results with the appropriate administrator or mathematics department faculty (SBCTC, 2011).

In Washington State beginning with fall, 2009, a College Readiness Mathematics Test (CRMT) was administered to high school juniors across the state to determine if they achieve a specific cut score that determines college readiness (TMP, 2008c). Students who successfully test into college level will be required to continue taking mathematics their senior year if their CRMT "college readiness" cut score is to be honored by the two-year or four-year colleges and universities. The CRMT, which is a non-adaptive computerized test, will be required for high schools to offer dependent on available funding. For the purpose of this study, the CRMT and the previously-mentioned placement tests were included when determining student placement into remediation courses or college-level mathematics.

Persistence. College persistence can be defined in terms of (a) degree completion (Camara, 2003; Kirst & Bracco, 2004) or (b) continuing along a track toward completion (Warburton, Bugarin, Nuñez, Carroll, & National Center for Education Statistics, 2001) that includes course completion or continued enrollment (Grimes, 1997). Prince, Seppanen, Stephens, and Steward (2010) considered "persistence" as students moving from one level to the next in terms of their educational goals. "Success" is determined as earning a certificate or degree (Prince, et al. 2010). Hawley and Harris (2005) recognized that many research studies consider the terms "persistence" and "retention" as being used synonymously (p. 120). For the purpose of this study, college persistence will follow the definition that describes student progression toward the successful goal of degree or certificate completion with continued enrollment in courses at the community college. Those students who complete degrees will be considered as having been successful at persistence.

Postsecondary institutions. This term refers to any two or four year institution beyond high school. Community colleges, junior colleges, two-year colleges, universities, colleges, and four-year colleges or institutions may all be considered a subset of *postsecondary institutions*.

Remedial/ developmental education. There is recent research to support the use of the word "remedial" to characterize students who are taking below college-level courses. Bettinger and Long (2005) used the word "remedial" exclusively in their work and interchanged it with the words “underprepared” and “pre-college.” Oudenhoven (2002) similarly used the word “remedial” but acknowledged that students at the below college level were often grouped using either the word “developmental, remedial, or underprepared.” Boylan (2004) referred to the term “developmental” as encompassing courses or services at the college or university that are precollege in scope as did work by Karp and Hughes (2008). Bailey (2009), however, interchanged the words “development education” and “remediation” throughout his work but clearly implied that both terms refer to coursework representative of below college level. The stated definition for “remediation” utilized in the report by Jenkins and Boswell (2002) was: “those courses in reading, writing or mathematics offered to students lacking the necessary academic skills to perform college-level work” (p. 2). In contrast, the Washington State Board for Community and Technical Colleges (SBCTC) (2009a) has utilized the term “pre-college” exclusively for course below the college level. For the purpose of this study, the words “developmental,” “precollege,” and “remedial” will be considered one and the same with the term “precollege” and “remedial” more commonly used and interchanged. Students enrolled in adult basic education programs (ABE), English as a Second Language (ESL), and general equivalency diploma (GED) programs will not be included in the definition of precollege.

***Rigorous*.** Though often not adequately defined in research, this study used Adelman’s (1999) definition that “rigorous” represents a course in mathematics beyond Algebra II or a course for which Algebra II is a prerequisite. Additional research supports this definition (ACT, 2005, 2007; Cavanagh, 2008; Charles A. Dana Center, 2006;

Zelkowski, 2011). In some high schools, geometry is taken before or after Algebra II, so some definitions, like the one from the National Center for Education Statistics determine "rigorous" as beyond geometry or Algebra I/II, and on the same curriculum level as precalculus (Nord et al., 2011).

Senior year capstone course. This term refers to a rigorous mathematics course offered during the senior year of high school. In terms of mathematics taken during the senior year of high school, Achieve (2008) defined *capstone* as beyond Algebra II and an alternative to precalculus. The Charles A. Dana Center (2006) also referred to capstone in the same context.

Mathematics Preparation for Postsecondary Success

This section of the literature review investigated research relating to high school graduates being prepared for college mathematics at postsecondary institutions. Because the goal of this study was to examine the effectiveness of the AMR course, mathematics preparation is the main measure by which the course was analyzed. Therefore, scrutinizing research that investigates connections between high school course-taking and preparation for mathematics was warranted. Research reviewed was focused on four areas for measuring success for transitioning students: (a) placement into college level classes, (b) college persistence in mathematics, (c) need for remediation, and (d) higher grades in college mathematics courses.

Placement. Students who take mathematics courses in high school beyond the Algebra II level appear more likely to place into college-level mathematics. For example, Berry (2003) conducted a study that sampled first-time freshmen at North Arkansas

College who had graduated from specific state secondary schools during the previous year. Transcript data were analyzed over a three-year period with the primary independent variable being the highest math course completed and the dependent variable was college math placement. Results showed that 73 percent of students who completed courses higher than Algebra II placed into college-level mathematics; only 29 percent of students whose highest course was Algebra II placed into college level mathematics. Limitations to this study included that criteria for successfully completing a high school mathematics course varied significantly among schools, and high school graduation requirements differed throughout Arkansas. In contrast, Roth, Crans, Carter, Ariet, and Resnick (2001) maintained that taking higher-level math courses in high school had a less significant impact on passing a computerized placement test (CPT) than GPA or high school test scores. Their work was based on transcripts of 19,736 students graduated from high school in 1994 and then took a CPT upon entry to a community college. Additional research supports the connection between rigorous mathematics courses taken in high school and improved placement test results (ACT, 2005; Hoyt & Sorensen, 2001).

Work by Conley (2005b) established a link between placement test performance and taking mathematics during the last year of high school or the senior year. His book, *College Knowledge: What it Really Takes for Students to Succeed and What We Can Do To Get Them Ready,* was based on a two-year study that developed the Knowledge and Skills for University Success (KSUS) including mathematics. Four hundred faculty and staff from 20 research universities were interviewed around the topic of academic content standards, and national documents/reports were also reviewed (Conley, 2005b). Results showed that students who took mathematics their last year of high school and immediately enrolled in math during the first year of college were more successful than those who took no mathematics their senior year. The author recognized the negative impact of the “senior slump” and how that year without mathematics instruction reduces placement test scores (p. 78). Most of Conley’s (2003, 2005b) research relied on interviews and document reviews which can raise concerns about dependability, yet Conley’s research has a solid reputation in educational research circles (Walling, 2006, Zelkowski, 2011). As Walling (2006) noted, “This book’s main value is… the specificity of the KSUS standards and the detailed descriptions of college expectations” (p. 541). Additional work by Conley (2007b), Newton (2010), Charles A. Dana Center (2006), and Zelkowski (2010) recognized the importance of taking mathematics courses all four years of high school including the senior year. However, Hoyt and Sorensen (2001) did not find a delay of entry from high school to college having significant influence on placement scores in their study, but the authors acknowledged that the small sample size of these types of students who delayed attending college for more than a year may have impacted the results. Other studies have supported the claim that taking no mathematics during the senior year before attending college can impact student placement when transitioning to college (Hudson-Hull & Seeley, 2010; Long, et al., 2009; National Commission on the High School Senior Year, 2001). Some preliminary research by Lagerquist and Stern (2009), however, did not show any significance in taking mathematics during the senior year and improved placement test results. In addition, a study of the AMR course by Stern and Pittman (2009) using regression analysis did not show any significant difference between students who took the course and their peers in regard to preparation for college-level math based on placement test results. However, the study population had taken the AMR course as seniors during the 2007-2008 pilot year, contained a number of subgroups with varying mathematical backgrounds, and included students transitioning to four-year baccalaureate institutions in addition to community colleges which may have created confounding factors.

Additional research supports aligning high school and college assessments for placement particularly at the community college. Brown and Niemi (2007) investigated the degree of alignment between placement tests used by community colleges and the California Standards Tests (CST) that assess California's high school students. Utilizing a workshop approach, a representative committee examined the most prevalent placement exams; created a core of placement objectives; compared results to predetermined testing objectives for diagnostics like ACCUPLACER, COMPASS, and the Mathematics Diagnostic Testing Program (MDTP); and analyzed the content of the CST tests. Results showed a disconnect between the placement exams and the assessments of high school students in the high school curriculum. Because California's number of community colleges is so large compared to other states and the fact that there is no standardized placement test across the system, some question as to the reliability of the results can be raised because of variance in test types, the administration of each placement test from college campus to college campus, and student test-taking attributes.

The research does imply, however, that there exists a lack of continuity among high school, community college, and four-year college standards and the assessment standards. The sentiment that there is a disconnect among the educational sectors in regard to assessment standards is echoed by a number of other researchers (Achieve, 2007; ACT, 2005, 2007; Brown & Niemi, 2007; Collins, 2008; Conley, 2005b, 2007ab; Kirst, 1998, 2008; Long, et al., 2009; National Commission on the High School Senior Year, 2001). Further, the American Mathematical Association of Two-Year Colleges (2007), Armstrong (2000), Hughes and Scott-Clayton (2011), Marwick (2002), and the SBCTC (2011) recommended that the utilization of a variety of placement tools (transcripts, GPA, etc…) in mathematics is preferable to any single standardized placement test.

Using multiple measures for placing students at the community college or baccalaureate institution in mathematics stemmed from concern that existing placement tests are inadequately placing students, and/or the research is not definitive as to their usefulness. Achieve (2007) reviewed college admissions and placement tests, including national placement tests like COMPASS and state or system wide tests. Admission tests such as ACT and SAT were also included in the study. For placement testing, over 2000 sample questions were analyzed and compared to how they measure up to readiness benchmarks set forth by Achieve (2007). It was determined that the placement tests were narrowly focused, based on knowledge and skills rather than rigor, not reflective of the full range of content such as statistics and geometric reasoning, and less demanding than admission tests. More specific to Washington State, Achieve (2006) reviewed local placement tests at Washington public universities and two community colleges for alignment to the TMP developed College Readiness Mathematics Standards, on which the AMR course was based. Though applauding the development of the CRMS, the study expressed a concern that the placement tests did an inadequate job of assessing the CRMS. For COMPASS, Hughes and Scott-Clayton (2011) examined research on "predictive validity evidence" for both COMPASS and ACCUPLACER (p. 15). Some threats to the validity deemed problematic were: (a) validity was determined by a student achieving a minimum grade in the placed course which may overlook other factors such as degree completion and persistence; (b) the accuracy of the placement is an estimation whereas the testing companies do not often provide sufficient evidence that their test is an accurate measure; (c) little evidence exists as to whether COMPASS or ACCUPLACER are better than alternatives (high school performance, etc…); and (d) concern that math and reading/writing assessments are used for college-level courses in other subject areas that have not been thoroughly researched for effectiveness. Even with these concerns, Hughes and Scott-Clayton (2011) recognized that other tests would do no better than COMPASS and ACCUPLACER and that the abovementioned limitations may be more due to the fact that the test is a single measure of college-readiness rather than including other factors such as prior academic performance. As Hughes and Scott-Clayton (2011) maintained: "The assessments currently in use at community colleges may be reasonably good at predicting whether students are likely to do well in college-level coursework" (p. 19). Furthermore, the COMPASS manual detailed the logistic regression models used to calculate the probability that a student would be successful in the placed course and carefully published all probabilities based on recommended cut-scores (ACT, 2006). Additional research by Donovan and Wheland (2008) and Bailey (2009) implied that, though far from perfect and with cut-off scores varying among institutions, COMPASS is a recognized placement tool being utilized at colleges nationwide.

Summary. The research reviewed indicated that the likelihood of placing into college level classes after graduating from high school can be increased by (a) taking a course beyond Algebra II in high school, and (b) taking a course during the senior year (Conley, 2005b, 2007a; The Charles A. Dana Center, 2006; Hudson-Hull & Seeley, 2010; National Commission on the High School Senior Year, 2001; Newton, 2010; Nord et al., 2011). The literature is not as strong in regard to whether the timing of taking a mathematics course, particularly a rigorous course, is beneficial for students in terms of college preparation. A significant number of research articles, however, recognized the "senior slump" issue and called for improving that year for high school seniors in terms of rigorous coursework in mathematics (Conley, 2005b, Newton, 2010). Similarly, research indicated a gap in placement testing alignment between high schools and colleges, though evidence to support *how* alignment could be achieved was difficult to find. Investigating the AMR course could provide some additional insight as to whether the timing of taking mathematics courses during the senior year relates to improved placement testing scores at the postsecondary level and may support more abundant research that investigates the impact of taking rigorous courses beyond Algebra II. How to align placement testing effectively among secondary and postsecondary institutions, though recognized as problematic in the research reviewed, were not specifically addressed through this study.

College persistence in mathematics. There appears to be a connection between high school mathematics coursework and persisting in college shown in college readiness skills or ability to complete the mathematics coursework. For example, Gilbert (2000) conducted a study that analyzed pre- and post-test data with the results detailing skills needed to persist in college mathematics. The sample consisted of 135 American Indian students who completed a five-week summer program called the Nizhoni Academy. However, the student subjects were self-selected, so it would be difficult to generalize the findings to the rest of the American Indian population. In addition, a control group was not used; and there was no randomization of student participants, which further threatened the ability to generalize the results of the study. Even so, this analysis suggested that increasing mathematic skills and knowledge in high school can influence student persistence particularly when a program included metacognitive, cooperative learning, process focus, and critical thinking skills in its Nizhoni Academy curriculum.

Arguably the most cited research that examined a correlation between high school rigor beyond Algebra II taken during the senior year of high school and the impact on college degree completion rates was the work by Adelman (1999, 2006) who studied what contributed most to a bachelor's degree completion by students attending four-year colleges. The author determined that high school academic intensity and quality appeared to be better indicators of degree completion than high school GPA and class rank. Adelman (1999) analyzed a random sampling that constituted a national cohort following students from grade 10 for the next 13 years and then eventually through December 2006 in a follow-up study. The study relied on high school and college transcripts, test scores, and surveys. Even with the 2006 follow up, high school rigor beyond Algebra II and quality of mathematic courses continued to be a significant factor influencing college persistence. This nationwide study sponsored by the U.S. Department of Education appeared to be considered a leading source in the field, as many studies cited Adelman's (1999) statement: "Finishing a course beyond the level of Algebra 2 (for example, trigonometry or precalculus) more than doubles the odds that a student who enters postsecondary education will complete a bachelor's degree" (p. 3). Even though Adelman's work was often quoted (ACT, 2005;; Bailey et al., 2002; Berry, 2003; Conley, 2005a, 2007b; Karp & Hughes, 2008; Lundin, Oursland, Lundgren, & Reilly, 2004; Zelkowski, 2011), there was some concern that the transcripts for the study may have been difficult to interpret as they are not standardized among institutions. In addition, there continued to be a lack of research that controlled for highest level of parent's education which may have been a contributing factor to student motivation in taking additional mathematics courses.

Another study of national significance that recognized the connection between mathematics level and degree completion was Stanford University's Bridge Project that examined policies related to K-16 transitions. Kirst and Bracco (2004) analyzed the data from the Bridge Project study that included data from 70 percent of students who attended postsecondary education within two years of graduating from high school. The authors determined that the level of high school math taken was a significant indicator of a student's chance to complete a bachelor's degree. As with much of the research focused on college persistence and degree completion, lack of motivation as a factor among students was not fully addressed. Even so, numerous studies and reports demonstrated that the level of coursework beyond Algebra II or higher taken during high school impacts college persistence (Achieve, 2004, 2005; Berry, 2003; Hoffer, 1997; Lundin, et al., 2004; National Commission on the High School Senior Year, 2001; Nord et al., 2011; Rose & Betts, 2001). Additional research emphasized the level and taking mathematics during the senior year (Adelman, 2006; Bailey, et al., 2002; Hudson-Hull & Seeley, 2010; Newton, 2010), with Conley (2005b) advocating that students immediately take mathematics their first year of college after taking a mathematics course during their senior year in high school. In addition, Zelkowski (2010), analyzing existing data from the 2005 National Assessment of Educational Progress (NAEP) High School Transcript Study and the National Education Longitudinal Study of 1988 (NELS:88), concluded that continuous enrollment in mathematics throughout high school is a significant factor contributing to a student being college-ready in terms of bachelor degree completion. In regard to overall success in mathematics, Ma and Wilkins (2007) maintained that more math courses taken at the rigorous level led to the most significant growth in mathematics achievement for high school students.

Summary. The research reviewed for this study indicated that mathematics preparation in terms of college persistence is impacted by courses taken in high school. Any coursework that helps maintain skills and does not allow for students to have a significant break in which no mathematics is studied can positively increase persistence in mathematics at college (Conley, 2005b; Gilbert, 2000; Hudson-Hull & Seeley, 2010; Zelkowski, 2011). Algebra II is also the significant threshold; if students can take

Algebra II in high school and beyond, they are more likely to persist in college mathematics (Achieve, 2005; Adelman, 2006; Lundin, et al., 2004; Nord et al., 2011)

In terms of degree completion, taking a course beyond Algebra II is supported by the research (Adelman, 1999, 2006). Adelman's work also maintained that the intensity and quality of the mathematics course was an even better indicator than GPA and class rank that a student would complete a degree in college. The Stanford University Bridge Project (Kirst & Bracco, 2004) further linked course rigor past Algebra II with degree completion. Though there was not an abundance of research showing a strong association between taking a mathematics course during the senior year of high school and specific placement test scores, studies by Adelman (2006), Bailey, et al. (2002), Conley (2005b), Kirst and Bracco, (2004), Nord et al., (2011), and Zelkowski, (2010) did show a connection between senior year course-taking and degree completion. Since the AMR course is designed as an alternative course for high school students to take their senior year, it would follow that such a course may improve college persistence in mathematics course- taking and degree completion based on the above-mentioned research.

Less need for remediation. A critical issue among postsecondary institutions is the goal of reducing the need for remediation in mathematics among incoming freshmen. Perin (2006) conducted a study that investigated state and institutional practices for remediation in 15 representative community colleges as part of the National Field Study conducted by the Community College Research Center. The study determined that issues around reducing remediation are at the forefront of college goals. Though this study did not explain *how* to reduce remediation rates at postsecondary institutions, it did acknowledge that remediation is perceived as impeding student success at college and is problematic for higher education, a perception supported by other researchers (Achieve, 2004; Bahr, 2008; Bailey, 2009; Bailey & Morest, 2006; Bettinger & Long, 2005, Conley, 2005b; Kirst & Bracco, 2004; Levin & Calcagno, 2008). Some of the reasons attributed to why remediation rates are so high include a lack of: (a) an interconnected K-16 system (Achieve, 2007; ACT, 2005, 2011; Hoyt & Sorensen, 2001; Kirst, 2008; Strong American Schools, 2008; U.S. Department of Education, 2009), (b) standardized and timely placement exams (ACT, 2005, 2007; Conley, 2005b; Kirst, 1998; Kirst, 2008; Long, et al., 2009; National Commission on the High School Senior Year, 2001; Perin, 2006), and (c) curriculum standards alignment (Achieve, 2004; ACT, 2007; Conley. 2005b; Kirst, 1998).

One of the reasons that the issue of remediation is so closely scrutinized is the increasing cost to students, their families, and postsecondary institutions. Strong American Schools (2008) maintained in their organization’s report that the cost of remediation for public two-year institutions is approximately $1.88-$2.34 billion nationwide. The estimated cost per student based on 2004-2005 data for two year institutions was between $1,607 and $2,008, and the total cost to families for all two and four year colleges was $708-886 million in remedial education tuition and fees (Strong American Schools, 2008). Bailey (2009) and Levin and Calcagno (2008) also noted the financial and psychological costs to students as they pay for classes that do not earn college credit and spend a longer amount of time completing a degree which takes them away from job earnings. Furthermore, the cost of remediation has a greater impact on community college students who tend to have lower incomes (Long, et al., 2009). The report, "Diploma to Nowhere," was based on research and survey results that analyzed perceptions of students regarding their preparation for college, estimated remediation rates, and provided cost estimates. As with any data that represent the scope of numerous states in the nation, students attending local community colleges may find their costs varying from the estimates in this report. However, this information does support the concept that cost of remediation is a strong factor influencing lawmaker policy and is on the rise (Strong American Schools, 2008).

Once a student places into precollege or remedial mathematics courses, degree completion is impacted (Bailey, 2009). According to Bailey (2009), "Less than one quarter of community college students in the NELS [National Education Longitudinal Study] sample who enrolled in developmental education complete a degree or certificate within eight years of enrollment in college" (p. 14). Kirst (2008) also determined that "Remediation is a poor pathway from high school to college; entering college and taking credit-level courses leads to better outcomes" (p. 116). Attewell, Domina, Lavin, and Levey (2006) also examined the NELS:88 data that included college transcripts for students who went to college and considered the number of remedial courses taken. NELS:88 data also included math test results for high school seniors. Results from research by Attewell et al. (2006) that controlled for demographic characteristics and prerequisite skills suggested that students who pass remedial courses do better than similar students who never took remedial math courses in terms of reaching academic performance goals. Bettinger and Long (2005) investigated first-time freshmen attending colleges in Ohio and found students in mathematics remediation more likely to persist than students with like backgrounds who did not take remedial courses. However, both Attewell et al. (2006) and Bettinger and Long (2005) study results are not representative of all students attending college. Because of the nature of cut-off scores for placement, a student placed into a mathematics precollege course may be only a few points away from another student who tested into college level. Students with very low math skills and older students were not adequately represented in the research (Bailey, 2009). Even so, reviewing studies that examine remediation in mathematics, particularly for community college students, was welcome in a scholarly field that has experienced a dearth of rigorous research designs targeting the precollege population (Attewell et al., 2006; Bahr, 2008; Levin & Calcagno, 2008; Long, et al., 2009)

Summary. The Transition Mathematics Project (TMP) was funded in part because of the concern that the cost to students and the state of Washington was too high for those students who needed to repeat the same courses they took in high school when they enrolled in community colleges. Research reviewed for this study recognized that remediation is a growing problem because the K-16 system is disconnected, placement tests are not standardized across institutions, and the secondary/post-secondary sectors and high school/college curricula are not aligned adequately (Bailey & Morest, 2006; Levin & Calcagno, 2008; Perin, 2006). Strong American Schools (2008) emphasized that the cost of remediation for college students can be as high as $2,000 per student and further fuels the policy concerns at the state and federal level. Since the AMR course was aligned to the College Readiness Mathematics Standards, designed and implemented by the work of TMP, and developed through a partnership of high school and community college mathematics faculty, research would indicate that this course is worthwhile to study in terms of its connection to remediation at the community college. The literature also recognized that the lack of standardized placement exams may impact placement into remediation courses, a factor that was a growing concern for Washington State (SBCTC, 2011) and addressed in the design for the AMR course study.

Higher grades in college mathematics courses. There appears to be some evidence to support an association between taking a higher level of mathematics course in high school and obtaining higher grades in college (Adelman, 2006; Berry, 2003; Conley, 2005b; Kirst & Bracco, 2004). Lundin, et al. (2004), however, maintained that mathematics educators do not agree on what is important when preparing students for high school and college, and many students get conflicting messages about college requirements. This belief fueled their correlational study that sampled GPA's of traditional-aged freshmen (n= 856) during the 2001-2002 year at Central Washington University. Their study led these researchers to conclude that students who took Algebra I or Integrated Mathematics as high school freshmen had a significantly higher mean college freshman GPA. Similarly, those taking Algebra II had significantly higher GPA's, and the GPA's increased as the level in high school mathematics increased. Similarly, those students who took a rigorous course during their senior year had a significantly higher GPA than those who took a non-rigorous course their senior year or no course at all. The study, though, only focused on one institution, and its specific student population could account for these results. Furthermore, causal evidence is non-existent, and the authors did not clearly define what they meant by *rigorous*.

GPA's at college were also examined in a study by Sadler and Tai (2007) who used multiple linear regression to predict the relationship ship between the number of math and science courses taken in high school and the impact on college science courses. The study involved 77 colleges and universities that were randomly selected from a list of approximately 1,700 four-year institutions and included 122 professors teaching introductory biology, chemistry, and physics courses. The total sample consisted of 8,474 undergraduate students who were enrolled in one of the three introductory science courses and included data collected from surveys and final grades. The study showed a significant correlation between students' years of mathematics instruction and better performance in all college science subjects. This correlational study contained a generalizable sample size and, though the data relied on student surveys, the authors cited research that determined that self-report studies were reasonably accurate. However, this was not a causation study so other factors like motivation and parent occupations were not analyzed. In addition, this study focused on college science classes, not college mathematics courses, but the study illustrated a probable connection between high school mathematics and college level coursework.

A study in the United Kingdom conducted by Hoyles, Newman, and Noss (2001) echoed research findings that implied a link between rigorous high school mathematics course-taking and higher final grades in college mathematics courses. In addition to analyzing transcripts, this qualitative case study involved survey responses administered to mathematics faculty and undergraduates attending college in the United Kingdom (UK). These surveys revealed that students believed they were more prepared for college when they had taken additional mathematics courses in high school. A limitation of this study was the difference in content and structure between mathematical courses taught in the UK compared to the U.S. so the findings may not be applicable to U.S. mathematics course-taking in high schools and postsecondary education. Even so, this research provided some support for the benefits of high school mathematics course-taking, as students in the UK are also realizing the educational and future employment benefits of a strong mathematics education.

Summary. Though there was a paucity of research linking course-taking in high school to higher grades in mathematics courses, some evidence existed that participation in mathematics during the senior year and the level of mathematics courses taken can improve overall college GPA (Lundin et al., 2004). There were two studies that saw evidence of high school mathematics course-taking relating to improved final grades in mathematics courses in college (Hoyles, et al., 2001; Sadler & Tai, 2007). Since a research question of this study asks “to what extent taking the AMR course will make students more likely to enroll in and pass a higher in college level mathematics courses,” it is beneficial to know that, though scarce, there was some evidence to support such a connection. If a relationship is shown to exist between the AMR course and grades earned in the college level mathematics course, then the study will contribute to the overall research base that examines high school course-taking and college mathematics.

Finding additional research in this area would also be advised for this research topic and future work in high school to college transitions.

Section summary. The major significance of this study was to address issues in mathematics preparation when students transition from high school to the community college. There were four ways that students were deemed ready for college in terms of mathematics preparation: (a) higher placement scores, particularly placing students into college level classes; (b) college persistence in mathematics; (c) reduced need for students to enroll in remedial or developmental classes; and (d) higher grades in mathematics courses in college. These categories are often assessed on college campuses, particularly in the state of Washington with the enactment of the Student Achievement Initiative. The Student Achievement Initiative is a performance funding system for community and technical colleges that assigns reward points when students make progress through college-level coursework including a "point" for completing a college-level computation or quantitative reasoning course (Prince, et al., 2010).

Though some areas provided stronger research than others, several studies showed a connection between taking a rigorous mathematics course during the senior year of high school and success in college mathematics. Even so, there was clearly a call for more research to bridge the high school and colleges, particularly community colleges, in the area of mathematics course-taking in high school. This call for additional research influenced the current study by supporting the investigation of the AMR course and its connection to community college mathematics preparation. In hopes of influencing educational agencies that are vested in research that improves mathematics preparation, a quantitative study was chosen for an audience that recognizes the value of data and statistical analysis (Patten, 2009).

K-16 Transitions in Mathematics Education

At the present time, a record number of high school students aspire to participate in higher education, with approximately 70 percent of high school graduates actually attending college within two years of their high school graduations (Venezia, Kirst, & Antonio, 2003). The National Center for Education Statistics (NCES) (2011) determined that, in 2009, 70 percent of high schools students attend college immediately after graduating from high school. There was also an increase in students of color seeking college degrees and taking more college preparatory curriculum in secondary schools (Bailey & Morest, 2006; NCES, 2007; National Commission on the High School Senior Year, 2001; Nord, et al., 2011), though there continues to be a gap in success rates for these students as compared with white students (Attewell, et al., 2006; NCES, 2011; Nord, et al., 2011; Venezia, et al., 2003). The increase in pressure to meet the postsecondary educational needs of additional students, in general from diverse backgrounds, occurs within a K-16 educational system that has a history of disconnect (Achieve, 2007; Conley, 2007a; Kirst & Usdan, 2007; Kirst, 2008; Tell & Cohen, 2007). From 1635 with the founding of the Roxbury Latin School by the Puritans, the birth of the high school in the first half of the 1800s, and the rise of the two year college in the 20th century, the establishment and redefinition of various elementary, secondary, and postsecondary levels have dominated educational policy for high schools and colleges to the present day (Barger, 2004; Cohen & Brawer, 2008; Kirst, 2008; Levinson, 2005).

Historical context for secondary/community college relationships. It was the 1892 creation of the "Committee of Ten" by the National Educational Association that began the process by which academic goals were attempted to be standardized across secondary/postsecondary lines. The Committee of Ten's report recommended that all high school graduates be prepared for various life paths by implementing academic subjects like history, science, and classical languages; the College Examination Board be created for clearer expectations and standards for college placement; and the number of high schools and postsecondary universities be expanded for accessibility (Kirst & Usdan, 2007). Kirst and Usdan (2007) maintained that the years following the policy work by the Committee of Ten saw the rise of the Cardinal Principles of Secondary Education that appeared to weaken the traditional academic curriculum yet supported the development of practical, engaging, and vocational training that prepared students for life and society. As a result, today's American comprehensive high school is designed for many often conflicting purposes; these competing purposes have weakened the college preparation emphasis of high schools and encouraged the development of aptitude, high stakes testing for college admissions (Kirst & Usdan, 2007).

The senior year of high school appeared in the research to be the pivotal year that has historical significance. There was debate in the early 1900s regarding the "6-4-4" plan that would combine two year colleges with secondary education (Cohen & Brawer, 2008; Eells, 1931). However, curricular issues, lack of senior year assessments, strong focus by K-12 leaders on high school graduation rates, separate fiscal structures among K-12 and postsecondary institutions, and the cultural tradition of having a graduation ceremony after grade 12 sabotaged the 6-4-4 plan, and these same issues continue to stand in the way of an effective K-16 pipeline (Bragg, 2007; Cohen & Brawer, 2008; Eells ,1931; Venezia, et al., 2003). Eells (1931) wrote, "America has a fairly definite concept, too, of the high school and of a definite point in educational progress marked by high school graduation" (p. 727), a concept that continues today. Researchers with The Stanford Bridge Project maintained that the weak bridge between secondary and postsecondary institutions greatly influences course-taking patterns of students during the senior year of high school (Kirst & Bracco, 2004; Venezia, et al., 2003), and as a result, student success in college is impacted.

The current K-16 educational system. There is research that recognizes the disconnect among sectors in today's K-16 educational system, particularly the transition from secondary to postsecondary education. Callan et al. (2006) wrote a report based on the collaborative effort of the Institute for Educational Leadership, National Center for Public Policy and Higher Education, and the Stanford Institution for Higher Education Research. State-level policies, programs, and governance structures that connect K-12 postsecondary education in Florida, Georgia, New York, and Oregon were the focus of this research based on a case-study analysis. The authors determined that much of the existing research has focused too heavily on the K-12 reforms or issues with colleges and universities rather than the K-16 system as a whole, in some cases perpetuating barriers between the two systems. Additional concerns included: (a) standards for college readiness are unclear; (b) points along the K-16 system impede transition (particularly between the secondary and post-secondary levels); (c) few reform efforts target college readiness and recognize that preparing students for work and college are now synonymous; and (d) standards for K-12 often end at grade 10 rather than at grade 12 for college and work preparation. Limitations to the study included a question as to whether any recommendations and concerns could be generalized to community college and four-year institutions in other states besides those examined for the study. Orr and Bragg (2001) stated that "The current extent and limits of collaboration between secondary schools and community colleges in particular is not well understood…" (p. 101). However, these authors advocated for a K-14 integration between the K-12 and community college systems and echoed additional research that recognized a disconnect along the K-16 pipeline (Achieve, 2004, 2007; Bailey, et al., 2002; Conley, 2005a, 2007a; Hoyt & Sorensen, 2001; Karp & Hughes, 2008; Kirst, 2008; Kirst & Bracco, 2004; National Commission on the High School Senior Year, 2001; Strong American Schools, 2008).

Why should connecting the sectors in the K-16 system be considered? Besides the fact that there is an aforementioned historical precedence for such a connection, research shows the following to be reasons why a congruent educational pipeline would be advantageous:

1. Improves school to work transitions. Students who graduate from high school could seamlessly enter workforce training programs through career pathways (Bragg, 2007; Orr & Bragg, 2001; Tell & Cohen, 2007; U.S. Department of Education, 2009).

2. Encourages, strengthens, and solidifies the role of community college in workforce development. Grubb (1996) advocated for "vertical ladders" in which workforce education proceeded upwards from high school to community college to four-year institution with the focus of the community college in the "middle" (p. 121). Conley (2005b) also recognized the importance of high school and postsecondary alignment in regard to workforce preparation.
3. Improves social mobility. Historically, the separation of the high school from post-secondary has inhibited social mobility. Improving access to the community colleges will increase the current stream of minority students who pursue postsecondary education (Bailey & Morest, 2006; Orr & Bragg, 2001).
4. Increases academic achievement. Nunley and Gemberling (1999) described focus group research as part of the Maryland Partnership for Teaching and Learning. The focus groups coupled with additional reviews of research found that high school/partnerships that involved the integration of the two systems improved academic preparation for college and encouraged more students to attend college. Though this work was limited in terms of data analysis, the work in Maryland showed some benefits to bridging the high school/college divide. Conley (2007a), Achieve (2007), and U.S. Department of Education (2009) also emphasized high school alignment with college expectations in order to increase academic achievement.

There was little current research to support the cost effectiveness and eventual cost-savings of integrating the K-16 system; though future research around this area would be welcome. In addition, there is historical recognition that the high school senior year is a delineated marking point because of social and cultural observations like high school graduation ceremonies as a rite of passage (Eells, 1931). What little research on high school graduation existed appeared to focus more on the social implications rather than the structural barrier between high school and college caused by this traditional event (Burnett, 1969; Fasick, 1988; Kirst & Usdan, 2007).

How secondary and post-secondary institutions, particularly community colleges, should integrate is found in numerous studies. Policy work by Callan, et al. (2006) recommended the following areas be incorporated into state policy so that collaboration can occur between the high school and college systems and ease the transition for students. Additional research also supports these areas: (a) align coursework and assessments (Achieve, 2007; ACT, 2005, 2011; Conley, 2005a, 2007b; Kirst, 1998; Kirst, 2008); (b) incorporate K-16 collaboration in state finance and governance policy (National Governors Association et al., 2008; Orr, 2000); (c) establish a statewide data system (ACT, 2011; National Governors Association et al., 2008; Strong American Schools, 2008); (d) increase accountability for student transitions (Strong American Schools, 2008); (e) enable high school students to take college placement exams before their senior year (Bailey, et al., 2002; Brown & Niemi, 2007; Hughes & Scott-Clayton, 2011); (f) connect high school teachers and college faculty (ACT, 2005, 2007; Conley, 2007a; Karp & Hughes, 2008); and (g) implement dual credit opportunities (Bailey & Morest, 2006; Bragg, 2007; Karp & Hughes, 2008).

Section summary. Researchers Orr and Bragg (2001) claimed that community colleges in today's system are well positioned for a better integration between high schools and community colleges. Though history has shown that consideration for a more seamless K-16 educational pipeline has been debated, there are numerous reasons why eliminating the existing barrier between high school and community college would benefit students who transition on to college and work. Many states like Washington have formed P-16 councils and hope to implement the numerous ideas for integrating the systems more effectively in terms of governance as suggested by the National Governors Association et al. (2008). Of these ideas, the development of the AMR course required aligning the course to the College Readiness Standards and connecting high school teachers and college faculty in the development, planning, and implementation of the course. Researching this course and possibly encouraging research on rigorous capstone courses during the senior year of high school may lead to states working together to finance such a course, offering dual credit and having the effect of further disintegrating the secondary/postsecondary divide.

AMR: A Senior Year Capstone Course

The AMR course was developed based on work of Project TIME (Transitions in Mathematics Education), a grant sponsored by the Transitions Mathematics Project (TMP) and funding from the Bill and Melinda Gates Foundation. The course was originally housed at Green River Community College. Its design was based on the goal of the grant to increase enrollment of high school seniors in mathematics courses and align to the College Readiness Mathematics Standards (SBCTC, 2009b). The targeted audience was determined to be seniors in high school who were taking the course after completing Algebra II during their junior year and looking for an alternative to precalculus. The level of rigor for the course was also determined to be sufficient to engage students who had completed calculus and sought another course to take during their senior year of high school (Moore-Mueller, 2008). Content of the course included (a) modeling with discrete structures, (b) quantifying uncertainty (e.g. probability and statistics), (c) quantifying shape, and (d) modeling continuous functions. Graph theory, planning and bin packing, voting theory, linear programming, fair division, finance, and game theory were just a few of the key curriculum components of the course, based on recommendations from Project TIME (Green River Community College [GRCC], 2008) and the University of Texas (Charles A. Dana Center, 2006). A similar course, titled Advanced Mathematical Decision Making (Charles A. Dana Center, 2009), was designed through the Charles A. Dana Center, and developers of the AMR course visited this organization for training in how to develop a rigorous senior year capstone course. Pedagogical strategies were also shared, thus impacting the development of the AMR course by emphasizing active group engagement rather than traditional lecture-style, and including quantitative literacy strategies, problem solving, real-world activities, and inquiry-based activities that encourage communication among students (Moore-Mueller, 2008; TMP, 2009).

There is significant evidence to support the benefits of taking a rigorous mathematics course during the senior year of high school. The National Commission on the High School Senior Year (2001) recommended that state and local educators needed to reshape the senior year to include alternative paths, rigorous courses (particularly in mathematics), aligned standards, and options for service and work-based learning opportunities. Though the Commission maintained that minimum requirements for mathematics in high school should be comprised of three credits including Algebra I, geometry, or Algebra II, the taking of an additional course in mathematics or science was recommended during the senior year. The report was based on analyses of relevant literature, interviews with focus groups made up of high school graduates, survey data, and expert testimony involving model programs. The Commission included nationally recognized educators, leaders, college administrators, teachers, politicians, and scholars from across the nation. Additional national reports also called for requiring more rigorous course work for students during their senior year of high school (ACT, 2011; National Governors Association, et al., 2008; U.S. Department of Education, 2009).

Qualitative case studies administered by Karp and Hughes (2008) showed the value of taking courses in high school with a college preparatory perspective. Though the research focused on Credit Based Transition Programs (CBTP), there was evidence to support the importance of academic groundwork in high school curriculum laying the foundation for college preparation. The authors also acknowledged that the role motivation plays for students as they transition to postsecondary institutions was not examined.

Research supporting the benefits of taking a rigorous course during the senior year was also evident in Hill’s (2006) dissertation work that was a quantitative study examining 34 high schools and approximately 3000 students who attended Michigan

State University over a four-year period. Students who took no mathematics their senior year placed into lower-level courses at college and tended to be unsuccessful. Though this study seemed to support calculus as the best college preparation course taken during the senior year, the researchers stated that the level of student achievement and the quality of the course were important factors. Hill’s (2006) research only included 34 high schools and students during their senior year. There is a strong need for the research community to conduct longitudinal studies that include additional high schools and grade levels.

Additional research also espoused the benefit of taking a rigorous math course beyond Algebra II. The National Center for Education Statistics considered information about high school graduates from the class of 2009 including high school credits earned, mathematics course-taking behavior, and math and science performance on the National Assessment of Educational Progress (NAEP) (Nord, et al., 2011). The study analyzed transcripts from 610 public high schools and 130 private schools for the 2009 High School Transcript Study (HSTS) and consisted of a representative sample of 30,100 high school graduates who also took the NAEP assessment in math and science. Through this analysis it was determined that there was a significant correlation between taking rigorous mathematics courses and higher NAEP scores, though high school dropouts and those students receiving certificates of completion or special education diplomas were not included in the study and sampling errors could have occurred. However, the NCES utilized acceptable statistical analysis practices. Based on the study results, the researchers recommended that high school students should take four credits of mathematics including a course at the precalculus or higher level (Nord, et al., 2011). This research corroborated other study findings such as Ma and Wilkins (2007) and Zelkowski (2011),

There was one research article found that called to question the correlation of taking additional mathematics courses to an increase in achievement (Hoffer, 1997). This analysis of the National Education Longitudinal Study of 1988 (NELS: 88) showed little support for the notion that requiring more mathematics helps or hinders student achievement. Results showed that more students were taking Algebra II and geometry but not necessarily increasing achievement. However, there was a concern discussed in the article that the focus on the number of years of mathematics is misguided; course content and learning outcomes should be researched instead, a belief echoed by other researchers (Adelman, 1999; Jago, 2000). Furthermore, the study is dated and does not reflect the recent course-taking patterns and achievement of current high school graduates found in more recent studies (Nord, et al., 2011).

Few researchers espoused the development of a course similar to the breadth and scope of the AMR course. The Charles A. Dana Center at the University of Texas at Austin outlined a fourth-year capstone course that contained rigor similar to the AMR course; required Algebra II as a prerequisite; encouraged higher level thinking skills through rich, conceptually-based activities; focused on problem solving; and included the Advanced Mathematical Decision Making AMDM) course as an example, which was a course after which the AMR course was modeled (Charles A. Dana Center, 2006, 2008). The benchmarks for the AMDM course were modeled after the American Diploma

Project (Achieve, 2004). Additional researchers who also supported a senior level mathematics course similar to AMR and an alternative to the traditional precalculus course included Bellomo and Strapp (2006) and Hudson-Hull and Seeley (2010). Cavanagh (2008), though not focusing on a specific senior mathematics course design, emphasized the importance of such a course, with Conley (2007a), Dougherty, Melor, and Jian (2006), and Dougherty (2008) suggesting that not all advanced course alternatives are the same; such a course must meet acceptable levels of rigor and standards.

Section summary. With students taking additional mathematics courses in high school and significant research addressing issues around transitions from secondary to postsecondary in mathematics education, there appeared to be support from the literature for developing a rigorous course during the senior year of high school. Research exists that recognized the senior year math curriculum as a pivotal point in the K-16 educational pipeline in terms of preparing students for college and easing the transition among the various levels. A historical perspective is also evident through the literature that recognized the high school/college relationship as one that evolved rather than resulted from sound, research-based decision making. Unfortunately, there are very few longitudinal studies that analyze specific alternative courses like the AMR course, partly due to the fact that such capstone courses are neither consistently offered nor widespread and any data on them were relatively new. Additional research needs to be conducted that examines taking the AMR course compared to other mathematics courses during the senior year of high school such as precalculus, calculus, and statistics. In addition, much of the current research available is based on government reports and existing data analyses rather than carefully designed studies that could show significant relationships. Hopefully, future researchers conducting literature reviews will have the opportunity to review research that investigates alternative senior mathematics courses more thoroughly, a goal to which this study's findings may contribute.

Summary of Review of the Literature

The review of the literature section of this study began with criteria used for including relevant research. Key terms were also presented and clarified concepts defining senior year capstone courses, rigorous mathematics in high school, and college success. The literature reviewed was organized into these three main sections with each section containing numerous quantitative and qualitative research studies and reports: (a) mathematics preparation for postsecondary success, (b) K-16 transitions in mathematics education, and (c) Applications in Mathematical Reasoning (AMR): a senior year capstone course. Research in these three areas established a clearer view of the literature that links high school course-taking to college success but also illustrates a gap in the research that specifically addresses alternative mathematics courses taken during the senior year of high school such as the AMR course.

The findings and interpretations from the literature review were summarized based on the research questions that guided this study:

1. To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters (summer excluded) compared to

similar students who took no mathematics course their senior year of high school?

There was significant research that recognized that remediation is a critical issue facing incoming students to two and four-year colleges. The National Field Study (Bailey & Morest, 2006) continues to be a recognizable qualitative study emphasizing that reducing remediation must be a main goal for post-secondary institutions. Work by Bailey and Morest (2006), Bailey (2009), Conley (2005a), Kirst and Bracco (2004), Levin and Calcagno (2008), Long et al. (2009) and Achieve (2004) brought to light the severity and ubiquitous nature of the remediation problem. Some of the solutions proposed by the literature included doing more to connect the K-16 educational systems and aligning curriculum standards between the high schools and colleges. The research findings from the literature would suggest that students taking the AMR course may decrease the likelihood that they will need remediation when transitioning to community colleges as the course was (a) based on the College Readiness Standards and (b) produced by the joint efforts of high school and community college faculty.

Though historical research supports the concept that the senior year is a pivotal point in the bridge between high schools and colleges, the research findings were not as abundant regarding specific connections between the senior year of high school and decreased remediation at college. Reports published by Achieve (2004) recognized the link between the *number* of years a student takes mathematics in high school and the reduction in remediation rates but did not specifically address that one of those years should be the senior year of high school. Work by Hill (2006), however, did target the senior year of high school and found that students who took no mathematics their senior year enrolled in lower level courses at college, implying remediation. The benefits of taking a senior year math course in order to avoid a "senior slump" were detailed by Conley (2005b), Newton (2010), and the Charles A. Dana Center (2006). Continuous enrollment in high school mathematics, including taking math during the senior year, was additionally encouraged by Newton (2010) and Zelkowski (2010). Support for developing a course designed like the AMR course was established through the work of Bellomo and Strapp (2008), Hudson-Hull and Seeley (2010), Charles A. Dana Center (2006), and TMP (2009), The overall number of these findings and studies suggest, though, that more research could be completed regarding mathematics in the senior year itself and connections to remediation at college.

In addition to the connection between remediation trends and taking a mathematics course during the high school senior year, a student enrolled in precollege courses can demonstrate persistence in completing mathematics courses leading to an eventual degree or credential. Work by Nord et al. (2011) specifically detailed the connection between rigorous course-taking in high school and degree completion, echoed by the work of Achieve (2004, 2005), Adelman (2006), Gilbert (2000), and Kirst and Bracco (2004). Prince et al. (2010) also spoke to persistence at the community college with reference to "tipping point" research.

2**.** To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a minimum passing grade of a 1.0 compared to those students who did not take any mathematics during their senior year?

Some research findings established a relationship between taking a rigorous mathematics course and higher GPA's in college mathematics courses (Adelman, 2006; Hoyles, et al.,2001; Lundin, et al., 2004; Sadler & Tai, 2007). The strength in the research, however, can be found in numerous studies that link taking rigorous course work beyond the Algebra II level as affecting persistence in college, defined as successfully completing college mathematics coursework (Achieve, 2004, 2005; Adelman, 2006; Bailey, et al., 2002; Berry, 2003; Hoffer, 1997; Lundin et al, 2004; NCES, 2007; National Commission on the High School Senior Year, 2001). The Stanford University Bridge project (Kirst & Bracco, 2004) was a significant study that linked high school course rigor and persistence. Based on all of the before mentioned research, there is evidence to support that students who take the AMR course may be more like to persist in college and successfully complete a college level mathematics course.

3. To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

Findings from the literature suggest that students who take a rigorous mathematics course will place higher on placement tests. Work by ACT (2005), Berry (2003), Hoyt and Sorensen (2001), and Roth, et.al, (2001) supported the connection between rigorous high school coursework and higher placement scores. Conley (2003, 2005b) emphasized in his research that taking no mathematics during the senior year would reduce placement test scores. The research would suggest that students who take the AMR course should score higher on mathematics placement tests compared to students who took no mathematics their senior year. An additional revelation found in the literature was the emphasis on the importance of aligning placement tests and high school assessments and overall alignment of standards (Achieve, 2007; ACT, 2005, 2007; Brown & Niemi, 2007; Conley, 2005b; Conley, 2007ab; Kirst, 1998, 2008; Long, et al., 2009; National Commission on the High School Senior Year, 2001). Though this study does not involve such alignment, the collaborative efforts that took place to design the course based on the College Readiness Standards may lead to such alignment in the future.

Implications for the Design of Study from the Review of Literature

The purpose of this subsection is to analyze the studies found in the literature and to suggest how their findings and methods influenced the design of this study. Both quantitative and qualitative studies were reviewed with most of the quantitative data based on existing transcript records. In some cases quantitative data were incorporated into a qualitative study, particularly with the use of transcript data analysis (Achieve, 2004). Most of the data analysis involved correlational methods which provided a framework for my study design.

Significant quantitative studies included the work by ACT (2005) that analyzed data from the ACT assessments that high school students take for entrance into college and determined that high school coursework rigor, cost of remediation, and curriculum alignment were significant factors affecting K-16 transitions. Adelman (1999) utilized quantitative methods in following the college transcripts, test scores and surveys of a cohort group of students and undertook a further follow-up with his (2006) study. Work by Berry (2003) employed quantitative methods around transcript data in which the primary independent variable was the highest math course; dependent variables were college mathematics placement and college success in mathematics as measured by students who completed their college courses. Quantitative analysis by Achieve (2007), Ma and Wilkins (2007), Newton (2010), and Nord et.al (2011) were also important contributors to the research base of this study. All of the abovementioned quantitative studies supported the focus of the present study but, in some cases, were limited in their ability to: (a) entirely control for socioeconomic status and parents' education; (b) effectively define terms such as rigor or college persistence; (c) account for the difficulty in interpreting high school transcripts and grade variations among high schools and colleges; and (d) consider the variance among high school courses in terms of curriculum and grading.

The present study addressed these limitations by narrowing its focus to include only students who transition to the community college, which characterizes a particular set of students who seek education at a two year college, typically come from low income households, and are first generation college students (Bailey & Morest, 2006). By choosing a course to examine such as AMR, variation in curriculum was limited as the course contains a uniform set of module lessons, and all teachers of the course received similar pedagogical training. Because the course was based on the College Readiness

Standards and has Algebra II as a prerequisite, it was an appropriate course to study in terms of rigor and met a national standard for a rigorous, capstone course. To account for grade variations among high school and colleges, this study included placement test scores in addition to number of precollege courses taken and grades in a college level mathematics course. Placement test scores provided another data set not dependent on specific grading policies. The quantitative research reviewed in the literature also revealed that there are many variables associated with college persistence, so a carefully designed, causal-comparison study was an effective design. Reviewing the work by Lundin, et al. (2004) who used linear regression methods and showed an association between students who took a rigorous course their senior year and college freshman GPA, provided a high quality sample for how this study could employ similar methods.

In addition to quantitative research, significant qualitative studies were also reviewed in the literature and included work by Achieve (2005) that was based on interviews from high school graduates, key employers, human resources personnel, and mathematics instructors at two and four year colleges. The American Diploma Project (as cited in Achieve, 2004), involved interviewing K-12, postsecondary, and business leaders in five states. A National field Study analyzed by Bailey and Morest (2006) and work by Conley (2005b) are significant qualitative studies that based their findings on interviews, case studies, observations, pilot studies, and current readings. Though the present study is of a quantitative nature, there is a recognition that qualitative studies, like those included in the review of literature, attempt to delve more deeply into issues affecting student success when transitioning from high school to colleges. With this in mind, the present study was narrowed to a more specific population: those students taking the AMR course, from local high schools, and attending local community colleges in the same geographical region. This narrowing will not only help control for confounding variables, but provide results that could be generalizable to the specific community college population.

The majority of the research reviewed for this study did not distinguish between students who attended four-year universities and those students who attended community colleges. This study will bring findings that relate to the community college students who are unique in their socioeconomic backgrounds and academic skills. Bailey and Morest (2006) wrote, “community colleges students are more likely to come from lower-income households, to be first-generation college students, to attend part-time or part-year, to have dependent children, and to be older” (p. 8). These community college students have unique goals and needs that may differ from 18-22 year old students who attend four-year universities or colleges (Bailey & Morest, 2006). The fact that many of the research studies did not focus on community colleges gives credence to this study in terms of what it can contribute to our knowledge of community college students and their success patterns.

CHAPTER 3

Research Design

Numerous students who graduate from high school are unprepared for college level mathematics. The purpose of the following chapter is to describe the design of this study that examined the relationship between completing the AMR mathematics course during the senior year of high school and preparation for and success in college mathematics compared to students who took no mathematics their senior year. The worldview behind this quantitative study represents a positivist philosophy, a catalyst for designing a nonexperimental research design that analyzed transcript and placement data regarding students who took the AMR course and attended community college. This chapter outlines the design for the study that included the philosophical approach, information about the researcher, research method, and research procedures for completing the study.

Philosophical Approach

One of the most widely known philosophical approaches to research among social scientists is positivism (Gall, Gall, & Borg, 2007; Neuman, 2011). Sometimes referred to as conventional or traditional, positivism is based in science and values logic, structure, orderliness, and deductive reasoning when carrying out research that satisfies a "never-ending quest for knowledge" (Neuman, 2011, p. 96). Though French philosopher and social theorist, Auguste Comte, introduced the concept, "positivism"(Bredo & Feinberg, 1982; Carr & Kemmis, 1986; Neuman, 2011), Gall, Gall, and Borg (2007) defined positivism as, "the epistemological doctrine that physical and social reality is independent of those who observe it, and that observations of this reality, if unbiased, constitute scientific knowledge" (p. 16). Developed during the early 1800s by Comte and further defined by John Stuart Mill and Emile Durkheim (Neuman, 2011), positivism is grounded in the science-based belief that truth can be discovered through deductive reasoning and that knowledge learned brings one closer to nature's true laws (Comte & Martineau, 1855). Positivist researchers utilize quantitative data analysis and embrace experimentation and surveys (Neuman, 2011). Furthermore, a positive epistemology continues to be a lens through which social science, particularly educational research is viewed (Gall, et al., 2007).

Criticism of positivism includes beliefs that objective reality could only be ascertained imperfectly as it is nearly impossible to eliminate a researcher's beliefs and biases (Gall, et al., 2007; Schutt, 2009). Bredo and Feinberg (1982) supported this criticism through their concern with positivism's focus on observation and explanation. They wrote, "The positivistic approach assumes a strict subject-object dichotomy in which the knower is uninvolved with the known" (p. 6). However, on subsequent pages, the authors countered with, "What you see depends upon how you look" (p. 23) as they recognized a strong connection between the theoretical basis of positivism and personal observation, a connection often denied by positivists. Neuman (2011) also criticized positivism's treatment of individuals as numbers and opined that researchers embracing this philosophy lacked an understanding of the real lives of people. As with other scientific and statistically-based research in which large data sets are used to generalize for a population, there is also a concern that findings limit what can be determined for a small group of individuals (Manning & Stage, 2003).

In response to some of these criticisms, further fueling of debate among those researchers embracing positivism, and the influx of work by Karl Popper in the 20th century, a new form of positivism emerged, titled postpositivism (Gall, et al., 2007; Phillips & Burbules, 2000). Postpositivism is an epistemology that maintains that objective reality cannot be proven absolutely but can be validated through continuous research that supports those theories (Gall, et al., 2007). Key components of postpositivism include (a) accessibility of key concepts and procedures to the public, (b) findings are encouraged to be replicated, and (c) a recognition that even refuting a knowledge claim can aid in scientific advancement (Gall, et al., 2007). Postpositivists also uphold that our understanding of reality is restricted because of the complexity of knowledge. The biases of researchers and limitation inherent in educational research further inhibit one's ability to know truth (Gall, et al., 2007).

Purpose of postpositivism. According to Manning and Stage (2003), the purpose of postpositivism is to conduct research studies on samples of representative individuals and be able to generalize findings to a wider population. Through such studies there is also the goal of searching for causality by identifying key factors or categories and measuring those factors for causation. When defining postpositivism, which he refers to as "positivist social science," Neuman (2011) wrote that it was, "an organized method for combining deductive logic with precise *empirical* observations of individual behavior in order to discover and confirm a set of probabilistic causal laws that can be used to predict general patterns of human activity" (p. 95). Bredo and Feinberg (1982) maintained that postpositivist knowledge strives to determine how a change in one variable may affect the change in another variable which is a key component of the design of this study. There appears to be a greater purpose to postpositivist social science by connecting social science to the natural sciences in hopes of discovering the true laws of the natural world and building scientific knowledge (Comte & Martineau, 1855; Gall, et al., 2007; Neuman, 2011; Schutt, 2009).

Because of its focus on a mathematics course, the utilization of a study design based on the research work of social scientists and educators, and the use of quantitative analysis in its methods, this study exemplified the bridging of science and the social science. Furthermore, an objective of this study was to add to the collective knowledge about what is needed for student success in college mathematics when transitioning from high school to postsecondary institutions. In general, postpositivism embraces the concept of "intersubjective agreement" whereby a number of social researchers agree on "what is happening in the natural or social world" (Schutt, 2009, p. 89), which would support the aim of this research study.

Assumptions and key concepts of postpositivism. The fundamental belief behind the postpositivist social science is that truth exists, and the main goal of research is to reveal these truths (Gall, et al., 2007; Neuman, 2011). Similar to behaviorism, there is an assumption made by postpositivists that human behavior is caused by uncontrollable laws of nature and that free will is insignificant and downplayed (Neuman, 2011). Studies that embrace postpositivism attempt to predict human behavior through causal laws that "operate according to strict, logical reasoning" (Neuman, 2011, p. 98). It also assumes that laws of human nature are universal and that science is the best way to obtain true knowledge. Comte and Martineau (1855) maintained that all phenomena are subject to these natural laws and that our goal should be to pursue knowledge of these laws "with a view to reducing them to the smallest possible number" (p. 28).

Postpositivist researchers must be objective, independent, and detached emotionally and politically from all proceedings within research (Manning & Stage, 2003), and logic is a key component of searching for truth through the scientific process. Mills (1884) wrote, "Logic is not the science of Belief, but the science of Proof, or Evidence" (p. 9-10). There is also a strong focus on reliability as replication is highly valued by postpositivists. As part of objective researching, categories are assigned before analysis of data, and there is a strong emphasis on quantitative data gathering through experiments and surveys. In addition, postpositivist social science relies heavily on statistics and embraces quantitative rather than qualitative research methods (Gall, et al., 2007; Neuman, 2011).

For the purpose of this research, postpositivism was considered the epistemological lens through which the study is conducted as it is the most representative of my own beliefs and worldview, and considered a more modern form of positivism though still true to its roots (Phillips & Burbules, 2000). When describing the design of this study, the term *postpositivism* was used exclusively and represented not only its new orientation based on 20th century redefinitions but positivism's earlier philosophical underpinnings first established by Comte's work.

Strengths and limitations of postpositivism. As with any approach to research, positivist social science has strengths and limitations. The main strength of this approach is that its emphasis on reducing bias, initial categorization of key ideas, and deductive reasoning approaches enabled it to be viewed positively by applied researchers (Neuman, 2011). Positivism's endurance over the last two centuries and its widespread use make it a popular research choice for social scientists and scientific thinkers alike (Manning & Stage, 2003).

The limitations of postpositivism lie in its inherent risk of making causal determinations. When findings are generalized to a larger population, individual stories and characteristics can be overlooked. In addition, if the sample population contains individuals who vary from the average, the findings could be less reliable for the population. As Neuman (2011) wrote that proponents of interpretive social science criticize postpositivism for "failing to deal with the meanings of real people and their capacity to feel and think, for ignoring social context, and for being antihumanist" (p 108). A lack of humanism could cause postpositivists to ignore key findings of a more qualitative nature.

Research guidelines for a postpositivist research. To address the limitations of postpositivist theory, this study attempted to control bias but also utilized demographic data not only to control for intervening variables but characterize better the participants and their backgrounds. This allowed for readers of the study to connect with the participants at a more human level. In addition, strict guidelines were followed that not only embodied the postpositivist tradition but helped to achieve a more valid research study.

According to work by Schutt (2009), such guidelines for research should include the following: (a) test ideas against experiential reality without becoming too vested in a particular outcome as a researcher: i.e. the researcher should be neutral and approach the research from a logical, deductive reasoning approach rather than hoping to see a particular outcome; (b) plan and implement a systematic investigation: i.e. a study should be well thought out in advance and with careful documentation, carried out methodically; (c) document all procedures and make available to the public: i.e. all conclusions should be disclosed and available for scrutiny by the research community; (d) clarify assumptions: i.e. all background assumptions should be revealed; (e) define all terms and key concepts: i.e. because of the power of words, terms can have different meanings for readers of research-clearly defining words can mitigate confusion; (f) be critical and skeptical toward current research: i.e. critically analyze all research studies on which study is designed; (g) replicate research findings so as to build upon social theory: i.e. because no one study is “definitive by itself” (p. 91), the researcher must consider how the research contributes to the knowledge base of social research as a collective whole and replicating results is highly encouraged; and (h) search for patterns and trends: i.e. because postpositivists believe that there is a specific “underlying order of relationships” in the natural world, the goal of research is to uncover this order through the discovery of patterns and recurring themes (p. 92) . Gall, et al. (2007) also supported these practices characterizing a postpositivist philsophy and included strong emphasis by researchers to control bias and errors through sound statistical procedures and careful data collection. All of the above-mentioned guidelines will be revisited later under the Strategies to Ensure Soundness section.

Personal disclosure. Researchers embracing postpositivism assume an objective reality but recognize that absolute reality cannot be reached though it can be approximated or strengthened through numerous research efforts to support one's claims (Gall, et al., 2007). In other words, our understanding of the world is limited, because research evaluation and observation is imperfect and researchers in general maintain some bias (Schutt, 2009). My own bias as a researcher is evident because of the nature of my former position as a mathematics instructor and work with the TMP grant that oversees the development of the AMR course. In addition, having interacted with many of the instructors of the course, there is an underlying interest on my behalf for their work to be validated and be deemed successful. In my work at GRCC for 14 years as a mathematics instructor, I observed that many students who struggle with mathematics had stopped taking math classes in high school after their sophomore year when they reached the minimum required credits for a high school diploma. In contrast, students who continued to take mathematics all four years of high school appeared to place into higher level mathematics courses when transitioning to the community college. Based on postpositivist theory, it is important for my biases to be disclosed and my research focus to be one in which this research study contributes to a community of social science knowledge (Schutt, 2009). Because I work in the educational arena in which the AMR class was developed and implemented, bias and subjectivity may arise but they have been minimized in the pursuit of accurate research findings; a claim that postpositivists can accept. Furthermore, my current position at GRCC as Dean of Transfer Education in the area of humanities and English will remove my direct contact with the mathematics division where the Project TIME grant work was housed.

In addition to recognizing bias, a researcher can limit it by conducting a study that follows objective guidelines and is completed in a systematic, scientific way. In the postpositivist guidelines provided by Schutt (2009), the procedure for carrying out this study was grounded in (a) testing ideas objectively, (b) carrying out investigations systematically, (c) documenting and disclosing all procedures, and (d) clarifying assumptions. The study's data analysis relied on inferential statistics that can be carried out with impartially. Creating a well thought-out, systematic research study that employs quantitative research methods was conducted in order to maintain the neutrality of the researcher (Gall, et al., 2007).

Research Method: Nonexperimental

A research method that bests reflects the positivist social science perspective falls under the quantitative research category (Gall, et al., 2007; Neuman, 2011). The process for conducting a quantitative study involves: (a) deciding on a focus, (b) determining narrow and concise questions to guide the research, (c) reviewing literature, (d) determining a possible hypothesis or explanation to be tested based on the literature review, (e) creating an objective tool for gathering and collecting quantitative data from carefully selected and representative participants, and (f) utilizing statistically sound data analysis techniques (Creswell, 2008; Gall, et al., 2007; Glatthorn & Joyner, 2005; Patten, 2009; Rea & Parker, 2005). With a history of development for physical science fields, quantitative research has an emphasis on analyzing information based on numbers, measuring attributes of individuals and organizations, and using experiments, correlational studies, and surveys to compare two or more groups (Creswell, 2008; Suter, 2006). According to Creswell, quantitative research incorporates research problems that are characterized as “a description of trends or an explanation of the relationship among variables” (p. 51).

All three of the study’s research questions involved comparing students who took the AMR course their senior year of high school to their experiences as mathematics students when they transitioned to the community college. Therefore, quantitative research was the best fit to address these questions and examine any connections between these AMR students and success in community college mathematics as defined by the study. Furthermore, because the results of the study can be used to support the development and dissemination of the AMR course to various school districts, quantitative research was a better choice to influence policy among educational leaders, legislatures, and funding agencies such as the Bill and Melinda Gates Foundation, a prominent private supporter of educational initiatives in the state of Washington (Creswell, 2008; Patten, 2009).

Nonexperimental research. According to Johnson and Christensen (2012), nonexperimental research is “Research in which the independent variable is not manipulated and there is no random assignment to group” (p. 42). As is the case in many research studies in the field of education, the ability to design a random experimental study is not always plausible (Johnson, 2001; Johnson & Christensen, 2012). Two popular types of nonexperimental research are causal-comparative and correlational study designs (Gall, et al., 2007; Johnson, 2001; Johnson & Christensen, 2012; Mertler & Charles, 2004).

Rationale and purpose for selection of a nonexperimental study. A nonexperimental method was chosen for this study, because a specific treatment was not administered to selected groups of participants and numerous intervening variables challenged the validity of conducting an experimental study. For practical purposes, the groups were naturally occurring based on their mathematics courses and high school attended rather than chosen through a randomization process. Creswell (2008) recognized that in some studies, randomization, though preferred, is not always plausible when using existing data or when there is a concern about population size. When the researcher is unable to manipulate the independent variables and randomly assign participant group, nonexperimental is an appropriate research design for researchers interested in examining the relationship between variables (Johnson, 2001; Johnson & Christensen, 2012). Nonexperimental research is considered an important contributor to the field of education, partly due to the fact that there can be numerous independent variables (Johnson, 2001; Johnson & Christensen, 2012). Gall, Gall, and Borg (2007) also maintained that nonexperimental research is useful for studying problems in education as there are often numerous variables affecting student behavior.

Because the primary independent variable for this study involved categorical data, a causal-comparative design was more appropriate as opposed to a correlational research design that typically has a stronger quantitative focus for its variables (Johnson & Christensen, 2012). In contrast to what its name implies, a causal-comparative design would strive to uncover a relationship between the independent and dependent variables without implying causation. This study has implications for follow-up studies using experimental or quasi-experimental research methods that would explore causal relationships more effectively (Suter, 2006). The results of this study, however, suggest a *possible* causation or association between two or more variables, though it does not determine a definite cause-effect relationship that is often the result of experimental research. Results can also have predictive value by determining the probability that one variable will affect the other (Creswell, 2008; Gall, et al., 2007; Glatthorn & Joyner, 2005; Mertler & Charles, 2004).

Conducting a nonexperimental study as a research method is appropriate when the researcher desires to determine and explain an association between two or more variables (Gall, et al., 2007). The following are some characteristics of a nonexperimental study that could be used in determining if it is an appropriate method for a particular topic (Creswell, 2008) and how this study applies to that rationale:

1. There is an interest in correlating two or more variables. Application: My three research questions were focused on any correlation between students who have taken the AMR course and (a) seeking remediation, (b) enrolling in and passing a college level course, and (c) scoring higher on mathematics placement tests. The students taking the AMR course were compared to students who did not take any mathematics their senior year of high school.

The use of bivariate analysis techniques involving descriptive and inferential statistics analyzed variance of scores for those students within the group who took no mathematics their senior year, the variance of those students within the group who took the AMR course, and the variance between these two groups (Muijs, 2011).

2. Quantitative data can be obtained from a participant group that represents a specific population. Application: Using transcript data and placement test results provided by the State Board of Community and Technical Colleges (SBCTC), quantitative data can be produced for the participant group (students enrolled in the AMR course).
3. The researcher is comfortable with correlation statistical tests or an augmentation of these tests for data analysis. Application: As a former mathematics instructor at a community college, numerical analysis and statistics are subjects with which I am familiar, and training in statistics has been an integral part my doctoral degree requirements. The statistical tests will be performed using SPSS 18.0/19.0, a statistical software program mirroring the software program employed at my own institution. For verifying the results and conducting nonparametric tests not available with SPSS, XLSTAT and Excel were also utilized.
4. As with other quantitative methods, the researcher is in a non-biased, objective role. Application: Though I have been indirectly involved with the implementation of the AMR course, I have not taught the course nor personally

developed its curriculum. I have had no direct involvement with the participants who did or did not take the course. All data were de-identified and provided by the SBCTC for the purpose of this study. Even so, creating a non-biased study required careful data analysis as my involvement with the TMP and my experience as a former community college mathematics instructor may have skewed any interpretations toward the AMR course being successful for students.

5. Researcher is interested in associations between scores based on variables and the degree, direction, and form of that association. Application: Through statistical analysis of transcript data and placement scores, the association between taking the AMR course and success in college mathematics as defined by the study was examined in terms of degree, direction, and form of that association. The use of inferential statistical tests enabled the researcher to determine statistical significance within and between the representative and comparison groups. The significance level or *p* value determined by chi-square, exact tests, *t* tests, and additional nonparametric tests allowed for the acceptance or rejection of the null hypotheses determined for this study, all three of which examined an association between taking the AMR course and success at the community college as defined by the study.
6. Research questions may ask, "What is the relationship between…" or "To what degree is ______ [predictor variable] a predictor of _______ [criterion variable]?" Application: Research questions asked if there was a relationship

between taking the AMR course and the extent to which taking this course made it more likely that students will (a) need less remediation (b) enroll in and earn at least a 1.0 in a subsequent college mathematics course taken, and (c) score higher on mathematics placement tests. Descriptive and inferential statistics including chi-square, exact tests, *t* tests, and additional nonparametric tests were tools used to determine the statistical significance of the above-described relationship.

Limitations of nonexperimental research. A main limitation of nonexperimental research is that due to the inability to manipulate the independent variable and the inability to assign participants randomly to the representative and comparison groups, the "…evidence gathered in support of cause-and-effect relationships…is severely limited and much weaker than evidence gathered in experimental research (especially experimental research designs that include random assignment)" (Johnson & Christensen, 2012, p. 42). According to Johnson and Christensen (2012), nonexperimental research is subject to "ambiguous temporal precedence" or an inability to determine which variable is the actual cause and which one is the effect (p. 248). Gall et al. (2007) also noted that the ability to make inferences about causality are compromised with a nonexperimental study. A strong experimental research design, however, can manipulate the independent variable and utilize random assignment in a way that allows the effect to be clearly observed and a case for causality strengthened.

With nonexperimental research there is also the possibility that extraneous or variables can explain particular outcomes in a study (Gall, et al., 2007; Johnson & Christensen, 2012). Schutt (2009) referred to extraneous variables that create a spurious relationship between the independent and dependant variables as "the Achilles heel of nonexperimental designs" (p. 237). In order to control for extraneous variables, this study utilized a data set provided by the SBCTC that employed an individual matching strategy to create a representative and comparison group that were closely aligned based on control variables such as gender, ethnicity, GPA scores, participant site, and college attended. The goal with matching was to have the representative and comparison groups only differ based on the categorical independent variable so any results could be likely attributed to the independent variable (Gall, et al., 2007; Johnson & Christensen, 2012; Suter, 2006). In the case of this study, the categorical independent variable was taking the AMR course during the senior year. Suter (2006) noted that matching by variables that could impact the measured outcome in educational research would include age, sex, and socio-economic status. By matching students within the same school district and in most cases, the same high school, the representative and comparison groups would contain students from similar socio-economic status based on geographic region. Gender was also a matching variable, and all of the students were of the same age based on graduation date from high school. Suter (2006) also encouraged matching variables to be meaningful as would describe high school GPA and Algebra II GPA which could impact grade performance in mathematics for students transitioning to college. Using high school GPA and Algebra II GPA as the initial sorting variables, the specific technique used to conduct the matching process was utilizing a nearest neighbor stratification process as advocated by Johnson and Christensen (2012).

Though matching is an effective technique for holding extraneous variables constant in order to observe any relationship between the hypothesized independent and dependent variables, there are also significant limitations in its use. According to Johnson and Christensen (2012), the following are the seven major limitations when using matching: (a) matching is cumbersome as the researcher has to find pairs from among the participants who meet the criteria; (b) sometimes potential participants have to be eliminated because there is not a matched participant from the comparison group; (c) the researcher needs to match on more than one variable as there can be numerous extraneous variables; (d) the researcher must be aware of all of the extraneous variables that can cause spurious relationships; (e) there is no guarantee that all of the extraneous variables have been eliminated; (f) matching based on different population group characteristics (e.g. achievement scores and ethnicity, etc…) can raise validity issues; and (g) generalizability is limited because matching can result in an "unrepresentative sample" since participants are chosen in order to be matched rather than be representative of a population (p. 357). Keeping these limitations in mind, the data set provided to the researcher represented a systematic approach to matching that included careful consideration of the extraneous variables and numerous checks and balances were employed to reduce error and oversight. Furthermore, the matching process was conducted numerous times to support the result findings, and each group was analyzed to verify that the matching process yielded a representative and comparison with similar make-up in regard to possible extraneous variables that included gender, ethnicity, Algebra II GPA, overall high school GPA, high school attended (geographical location), and community college attended.

Assumptions and key concepts of a causal-comparative design. Since this study involved studying two groups (AMR/no AMR) and had a categorical independent variable and dependent variables that included categorical and ordinal data, a causal-comparative design was a natural choice for a nonexperimental research method (Gall, et al., 2007; Johnson & Christensen, 2012; Suter, 2006). As Johnson (2001) explained, using a causal-comparative approach is more appropriate for comparing groups described by categorical data rather than correlational studies that rely on quantitative variables. In truth, the scaling of the independent and/or dependent data can make either approach an appropriate design (Johnson, 2001). Sometimes referred to as *ex-post-facto,* causal-comparative design focuses on group comparisons in which differences occurred prior to a researcher's observations as was the case with this study (Suter, 2006). As previously noted, causal-comparative design may focus on cause and effect but cannot determine causality because of the nature of nonexperimental methods. According to Suter (2006), with well-considered null and alternative hypotheses, causal-comparative research findings can have "strong inference" that is "one mark of a good research design" (p. 300). In causal-comparative design, groups are formed based on some variable (e.g. AMR/no AMR) and then compared based on specified outcome variables. For causal-comparative studies, using a matched grouped design is one way of selecting two groups that are similar based on extraneous variables yet dissimilar based on the independent variable tied to the hypotheses (Suter, 2006).

Research Procedures

The following are steps to conducting a causal-comparative study and applications to my research. (Creswell, 2008; Gall et al., 2007)

1. Determine if such a study is appropriate for research problem. Focus should be based on research questions rather than a hypothesis. Application: Based on the above mentioned philosophical view and research methods analysis, a causal-comparative study was the most appropriate design. Three research questions were also developed to guide the study.
2. Speculate about the cause or effects of the research problem and consider alternative hypothesis. Application: This study included a null and alternative hypothesis for each research question after careful consideration of the literature surrounding the research problem.
3. Identify participants in study and select comparison groups. Participants should be reasonably homogeneous and representative of population for which results will be generalized. Subgroups utilized should be homogeneous. Permission for involving participants needs to be granted by applicable authorities and the Institutional Review Board (IRB). Application: This study relied on de-identified and preexisting data provided to the researcher by the SBCTC. The data included a participant and comparison group member with techniques that matched a student who took the AMR course with a similar

student who did not take any mathematics during the senior year. Matching was based on the possible extraneous variables of gender, ethnicity, Algebra II grade, overall high school GPA, high school attended (geographical location), and community college attended to equate the representative and comparison groups. Because the data provided for this study were de-identified and preexisting, the IRB concluded that this project did not meet the definition for "research involving human subjects" and did not require an IRB review.

4. Identify what will be measured for each participant. This will include determining variables based on research questions and literature, developing a tool or instrument that is valid and reliable in which to measure the variables, and obtaining permission for any instrument not uniquely developed. Application: The independent variable (AMR course/no AMR course) and dependent variables (remediation credits, college level course taken, college level course grade earned, and college placement score) were determined based on the three proposed research questions that compared students who took the AMR course with students who took no mathematics during their senior year of high school. Because the independent variable involved a representative and comparison group (AMR course/no AMR course) that was at the nominal level and the dependent variables included both nominal and ordinal data, appropriate descriptive and inferential statistical analysis tools were utilized to measure the outcomes. All of the statistical tests were accepted data analysis

tools and carried out using SPSS, XLSTAT, and Excel; software packages commonly used for educational research.

5. Collect data (at least two data scores for each participant) and review for validity among the scores and gathering techniques. Scores were collected for each participant that included number of precollege math courses taken, college level courses taken with grade earned, and mathematics placement score. The de-identified and preexisting data set was reviewed for validity, and a number of checks and balances were employed to ensure an accurate data gathering process that would minimize error.
6. Analyze data using descriptive statistics and various inferential statistical tests. Application: This study first used descriptive statistics to explore the representative and comparison groups and check that both groups were homogeneous in regard to gender, ethnicity, Algebra II grade, and overall high school GPA. Chi-square and Fisher's Exact Test were utilized using cross-tabulation. A *t* test was also used to test the significance of the difference between the two sample means for each group in regard to Algebra II grade and high school GPA. For the dependent variables, this study determined the p value using chi-square, Fisher's exact test, *t* tests, and additional nonparametric tests (when appropriate) in order to reject or accept the null hypothesis. Effect size was also calculated using Cohen's d and *phi*.

Data needed. Participants for this study included students who completed the AMR course as seniors in high school during the 2008-2009 academic year and attended community college during the 2009-2010 academic year. According to Creswell (2008) there are two ways to categorize variables: as *dependent* or *independent*. Dependent variables are attributes or characteristics that are influenced by the independent variable. The outcome of a study often was described through the use of dependent variables. Independent variables, alternatively, are the attributes or characteristics that influence a particular outcome in a study. Words like "factors, treatments, predictors or determinants" are synonymous with independent variables (Creswell, 2008, p. 127). There are four particular types of independent variables: measured, control, treatment, and moderating (Creswell, 2008). For the purpose of this study, measured variables, categorical or continuous variables that are observed, and control variables, used for the matching process, were utilized (Creswell, 2008). Recommended by research conducted by the Social and Economic Sciences Research Center (P. Stern, personal communication, January 27, 2009), the following data were assembled by the SBCTC for each participant district high school and outlined in Table 3.1 and Table 3.2.

K-12 transcript data. (a) Service Set Identifier (SSID), (b) student name (c) district ID, (d) date of birth (e) high school (f) mathematics course(s) taken, (g) semester/year taken, (h) course grade(s) earned, (i) Algebra II grade, (j) overall GPA, (k) indicator for Running Start (excluded from participant list) and (l) graduation date.

Rationale. K-12 transcript data provided a list of students who took the AMR course and took no mathematics during their senior year at the participating high schools. The goal of this study was to compare students who completed the same level of mathematics their junior year and then either (a) enrolled in the AMR course or (b) decided to take no mathematics their last year of high school. Because Running Start characterizes a unique set of students, those participating in Running Start were not included in the study. Since there is no uniform data sharing system between the K-12 districts and the community college system, birthdates and names were provided to the SBCTC in order to track the students when they transitioned to the community college attended. SBCTC then removed the names prior to providing the data to the researcher.

K-12 demographic data. (a) SSID, (b) student name (c) district ID, (d) date of birth, (e) gender, (f) ethnicity, (g) eligible for free or reduced price lunch (if allowed), and (g) graduation date.

Rationale. K-12 demographic data were utilized to ensure that the two independent variable groups (those who took the AMR course and those who did not) had similar characteristics for a more effective statistical analysis. Furthermore, these characteristics were considered extraneous and could have been considered rival explanation for the result findings. The goal of matching the two groups using these demographic data was to minimize the impact of these variables on the outcomes. Again, the indentifying information was removed prior to giving the researcher access to the data for the purpose of this study.

Community /Technical College (CTC) enrollment/transcript data. (a) SSID, (b)community/technical college attended, (c) quarter/year enrolled (d) math course(s) taken and credits earned, (e) quarter taken, and (f) math course(s) grade(s) earned.

Rationale. CTC transcript data provided information regarding what community college the student attended and pertinent date regarding who needed remediation at the community college and degree/extent of persistence in those classes, both of which applied to research question one. These data also noted those students who took a college level mathematics course and grade earned which applied to research question two.

CTC placement test data. (a) SSID, (b) community/technical college, (c) student name, (d) date of birth, (e) quarter/year enrolled, (f) test name (COMPASS, ASSET/MPT), (f) test level, (g) score, (h) date of test, (i) recommended placement, and (j) alternate placement tool used (i.e. transcript or instructor permission).

Rationale. These data impacted research question one as to which participants in the study placed into college level mathematics courses versus precollege courses. Research question three was also addressed with the CTC Placement Test Data as they pertained to how high the participants scored on the placement tests at each participating community college.

Table 3.1: *Definition and Measurement of Variables*

Independent Variable(s) – Measured	Definition	Measurement
K-12 Transcript Data-Students who took the AMR course	Students who took this course their senior year of high school and completed Algebra II their junior year.	Service Set Identifier (SSID) Student name District ID Date of birth High school Mathematics course name Course grade earned Flag for Running Start Graduation date

K-12 Transcript Data- Students who took no mathematics	Students who took no mathematics during the senior year yet completed Algebra II their junior year.	Service Set Identifier (SSID) Student name District ID Date of birth High school Mathematics course name Course grade earned Flag for Running Start Graduation date
K-12 Demographic Data- Gender	Data was analyzed to compare female versus male students within the representative and comparison groups.	SSID Student name District ID Date of birth Gender
K-12 Demographic Data- Ethnicity/Race	For the purpose of this study and based on the data provided by the K-12 districts, students were categorized according to ethnicity/race with the following terms: White/Caucasian, non-Hispanic Black, non-Hispanic Hispanic American Indian/Alaska native Asian or Pacific Islander	SSID Student name District ID Date of birth Ethnicity
K-12 Demographic Data- Overall GPA	Overall high school Grade Point Averages (GPA's) were included in the analysis to indicate student overall high school performance.	SSID Student name District ID Date of birth Graduation date
K-12 Demographic Data- Grade in Algebra II	Student grades in Algebra II were analyzed to determine prerequisite knowledge for the AMR course and for those students who did not take mathematics during their senior year.	SSID Student name District ID Date of birth Algebra II grade earned
K-12 Demographic Data- Attended a Community or Technical College, Fall, 2009 or Winter, 2010	Students who attended community colleges within three quarters (summer excluded) of graduation of high school were the participants in this study.	CTC SSID Name of CTC Year/quarter enrolled

Dependent Variables	Definition	Measurement
CTC Enrollment Data-precollege mathematics courses	precollege mathematics courses below 100-level excluding courses taken for specific career and technical programs.	CTC SSID Name of CTC Year /quarter enrolled Math course(s) taken Math credits earned Quarter math taken Math grade(s) earned
CTC Enrollment Data-College-level mathematics course t	College-level mathematics course have a 100 or greater prefix and were deemed college-level by participating community college. The first college-level math course taken and grade earned were measured for the purpose of this study.	CTC SSID Name of CTC Year /quarter enrolled Math course(s) taken Math credits earned Quarter math taken Math grade(s) earned
CTC Placement Test Data- Mathematics scores	Placement tests utilized included COMPASS taken when students first enroll at the community college. Alternate placement tools (e.g. high school transcripts, instructor permission) were also considered and assigned an equivalent COMPASS score.	CTC SSID Name of CTC Year /quarter enrolled Math course(s) taken Quarter math taken Date of birth, Test name (COMPASS) Test level Score Date of Test Recommended placement Alternative placement tool if applicable

Table 3.2: *Data Needed for Research Questions*

Research Question	Data Needed
To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters compared to similar students who took no mathematics course their senior year?	The total number of courses enrolled and the number of credits per course at the community college for students who passed the AMR course and the comparison group who took no mathematics during their senior year of high school.
To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn credit compared to those students who did not take any mathematics during their senior year?	The name of the first college level mathematics course taken and grade earned in the course for students at the community college who passed the AMR course and the comparison group who took no mathematics during their senior year of high school.
To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?	The placement test results from COMPASS or equivalent COMPASS score based on alternate placement.

Data collection. Data were assembled by the SBCTC through transcript evaluations at the community college and high schools with input and guidance from the institutional research offices at participating community colleges and school districts; the Social and Economic Sciences Research Center (Stern & Pitman, 2009); the Transition Mathematics Project, and the Office of Research at the SBCTC. Placement test information (e.g COMPASS) was also analyzed. During the 2008-2009 academic year, 21 sections of the AMR course were offered at 14 different high schools representing 10 school districts in the south Puget Sound area. The total number of students who took the course during the 2008-2009 academic year was estimated at 550.

Site selection. Sites for the secondary schools included those high schools from the Auburn, Kent, Puyallup, Renton, and Sumner school districts that offered the AMR course. High schools included: Auburn Mountainview High School (Auburn), Auburn Senior High School (Kent), Kentridge High school (Kent), Kentlake High School (Kent), Kent-Meridian High School (Kent), Puyallup High School (Puyallup), Renton High School (Renton), and Bonney Lake High School (Sumner). Table 3.3 shows the demographics of the participating high schools which represented a variety of sites based on size, socioeconomic status, gender, and ethnicity.

Table 3.3: *High Schools' Demographics* (State of Washington, Office of Superintendent of Public Instruction, 2009)

School Districts-2009 Data	Student Enroll.-May 2009 Count	No. of High Schools (excl. alternative)	Free/ Reduced Lunch (SES)	Gender		Ethnicity	
				F	M	People of color[a]	White/non-Hispanic
Auburn	14,896	3	44.3%	48.7%	51.3%	40.1%	59.2%
Kent	27,319	4	41.9%	48.0%	52.0%	42.4%	48.6%
Puyallup	21,633	3	27.5%	49.0%	51.0%	22.3%	69.3%
Renton	14,021	3	47.6%	47.9%	52.1%	63.7%	36.3%
Sumner	8285	2	28.7%	48.5%	51.5%	14.5%	82.7%

[a]Includes American Indian/Alaskan native, Asian/Pacific Islander, Black, and Hispanic categories

These schools and districts were chosen based on the fact that they have offered the AMR course for both the 2007-2008 and 2008-2009 academic years, thus completing a pilot year, and all represent different student body populations. Though some high schools within these districts offered the same course number, only schools that had implemented the specific AMR course taught by instructors involved with Project TIME training and curriculum were included in the study.

Sites chosen for the community/technical colleges included: Bellevue Community College, Green River Community College, Highline Community College, Pierce College (both Ft. Steilacoom and Puyallup campuses) and Renton Technical College. These colleges were chosen as representative of the districts that contained the high school sites reflecting a range of colleges in regard to size (FTE's), financial aid eligibility (SES status), gender, and ethnicity of the student populations.

Table 3.4: *Community and Technical Colleges' Demographics* (SBCTC, 2010ab)

CTC's	FTE Count (Fall, 2010)	Financial Aid Eligible (2009-2010)	Gender (State Supported- Fall, 2010)		Ethnicity of Students Served (Fall, 2010)	
			F	M	People of color[a]	White/non-Hispanic
Bellevue	12,096	16.5%	56%	44%	38.6%	62.4%
Green River	8366	46.9%	55%	45%	35.4%	68.0%
Highline	7538	41.7%	59%	41%	68.6%	34.2%
Renton *2010 Data	4086	40.2%	41%	59%	53.8 %	47.7%
Pierce (Ft. Steilacoom/ Puyallup	9608	49.6/48.2%	61 /62%	39/38%	44.0/33.2%	61.9/71.9%

[a]Includes Native American, Asian/Pacific Islander, African American, Latino/ Hispanic, and *other* categories

Data pertaining to students who took the AMR course and enrolled at these community colleges were analyzed. The comparison group was composed of like students from the same high schools or school districts who also enrolled at the same selected community colleges. Those students who took the AMR course and transferred to other two-year colleges outside of the service areas or four year institutions were not included in the study. Tables 3.5 and 3.6 summarize the school districts and community and technical colleges that participated in the study along with placement diagnostics for each college.

Table 3.5: *High School Site Selection*

School District	High School	Number of AMR Sections (Number of Students-approx.)
Auburn	Auburn Mountain View	1 (31)
	Auburn Senior	1 (18)
Kent	Kentridge	2 (57)
	Kent-Meridian	1 (17)
	Kentlake	1 (26)
Puyallup	Puyallup	1 (40)
Renton	Renton	2 (45)
Sumner	Bonney Lake	2 (60)
Total		11 (294)

Table 3.6: *Community and Technical College Site Selection and Placement Diagnostics*

Community College	Placement Diagnostics
Bellevue College (BC)	COMPASS Instructor/advisor permission
Green River Community College (GRCC)	COMPASS High School Transcripts Entrance Exams- WAMAP Instructor/advisor permission
Highline Community College (HCC)	COMPASS Instructor/advisor permission
Pierce College (both Fort Steilacoom and Puyallup campuses) (PC)	COMPASS Instructor/advisor permission
Renton Technical College (RTC)	COMPASS Instructor/advisor permission

Participant selection. Participants were chosen based on the following criteria:

Representative group. Students who took the AMR course during their senior year of high school at the selected high school and enrolled at a local community college within three quarters (summer excluded) of graduating from high school in 2009. Students took the COMPASS placement test or an alternative test as part of the enrollment process at the community college.

Comparison group. Students from the same high schools that offered the AMR course but who took no mathematics during their senior year of high school and enrolled at a local community college within three quarters (summer excluded) of graduating from high school in 2009. These students took the same level of mathematics course (Algebra II) during their junior year of high school as those in the representative group. Students took the COMPASS placement test or an alternative test as part of the enrollment process at the community college. By comparing students within each high school offering the

AMR course, there was a similarity of experience among its student body and parallel environments and community variables. In addition, by examining data about students who enrolled directly at the community colleges, factors that affected mathematics performance based on time could be controlled. Results of the COMPASS or alternate placement test indicated if students (a) needed to take courses below college level (remediation), (b) placed directly into college level mathematics, and/or (c) tested out of the mathematics requirement for the desired degree. Students in both the representative and comparison groups reached the same mathematics level during their junior year of high school before taking the AMR course or opting out of mathematics during the senior year of mathematics. This requirement attempted to ensure that the students in the study had comparable mathematical background before the treatment (taking the AMR course or no mathematics) occurred.

Data analysis. After data were collected and coded for variable type and measurement level (Table 3.7), a spreadsheet was constructed that documented the above-mentioned data scores. College success in mathematics was defined in this study as (a) needing less remediation (b) enrolling in and passing a college-level mathematics course taken, and (c) scoring at the college level on mathematics placement tests. SPSS, cross-tabulation, chi-square test, and Fisher's exact test were used to determine if the representative and comparison groups were similar in regard to gender and ethnicity. A *t* test for both independent samples and pair samples was implemented to determine if the two groups were similar based on high school GPA and Algebra II grade. For the dependent variables, SPSS and XLSTAT were used to carry out cross-tabulation, chi-square, Fisher's Exact, Cochran's Q Test, *t* tests (both independent and paired sample), and other nonparametric tests (Mann-Whitney/Wilcoxon) to compare the mean scores of the group of students who took the AMR course to the group ofstudents who took no mathematics their senior year of high school and test the hypothesis for each research question.

Table 3.7: *Variable Types*

Variable	Dependent/ Independent	Measurement Level/Scale	Coding
Gender	Independent	Nominal	F:Female M:Male
Ethnicity/race	Independent	Nominal • Asian/Pacific Islander • Hispanic • African-American • Native American • White, Non-Hispanic • Multi	People of Color White/Non-Hispanic
Algebra II grade	Independent	Continuous	Range from 0.0-4.0
High school GPA	Independent	Continuous	Range from 0.0-4.0
High school senior year course	Independent	Nominal • Took AMR course • No math senior year	N: No AMR Y: Yes AMR
Remediation credits	Dependent	Ordinal	1.00: 0-5 credits taken 2.00: 10-15 credits taken
College level (CL) math course taken and passed with a 1.0.	Dependent	Nominal • Took a CL math course • No CL math course	N or 1: No CL math course Y or 2: Yes CL math course

Variable	Dependent/ Independent	Measurement Level/Scale	Coding
Grade earned in CL math course	Dependent	Continuous (all scores) Ordinal (for top five scores)	Range from 0.0-4.0
Mathematics placement scores	Dependent	Ordinal Placement "buckets" • Prealgebra/Numerical skills • Algebra/Elementary Algebra • College Algebra • Trigonometry	0-100 within each placement bucket

Choice of statistics. Both descriptive and inferential statistical analysis tools were used with the goal of testing the statistical significance of a null hypothesis being accepted or rejected. Gall et al. (2007) recommended that when comparing two groups, a researcher would want to employ a number of measures for the variables. Chi-square, *t* tests, and other nonparametric tests such as the Wilcoxon signed rank test and Mann-Whitney U are all considered common statistical tests for determining a *p* value that allows the researcher to accept or reject the null hypothesis in hopes of reducing the probability of Type I or Type II error (Gall et al., 2007; Suter, 2006). Furthermore, since the two groups being studied are matched (correlated), it is appropriate to use a paired sample approach when conducting a *t* test (Suter, 2006) or a nonparametric test which would require the Wilcoxon signed rank test for similar analysis. The Fisher exact test was also conducted in support of chi-square as it provided a more robust analysis required because of the small cell size in some cases. In order to increase the statistical power of the study (Gall et al., 2007), the effect size was also calculated when applicable. Based on the levels of measurement for each variable (see Table 3.7), appropriate statistical tests were chosen and the decision guided by research and recommendations of

Gall et al. (2007), Muijs (2011), and Suter (2006) (see Table 3.8). Sample size, directionality, effect size, the accuracy of *p* value s, and result interpretation were all carefully considered when analyzing the data for this study. In addition, the use of SPSS and XLSTAT helped guide the choice of statistics though help menus and information "pop-ups" inherent in the programs.

Table 3.8: *Statistical Tool by Research Question*

Research Question	Statistical Analysis Tool
To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters compared to similar students who took no mathematics course their senior year?	Cross-tabulation Chi-square + Phi Fisher's exact test
To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn credit compared to those students who did not take any mathematics during their senior year? Sub-analysis: If a CL math course was taken, to what extent did students who took the AMR course earn a higher grade in the CL math course compared to students who did not take mathematics during their senior year?	Cross-tabulation Chi-square + Phi Fisher's exact test Cochran's Q test Descriptive analysis *t* test (independent) Chi-square + Phi (for frequency of top five scores) Fisher's exact test (for frequency of top five scores)
To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?	Descriptive analysis *t* test (paired sample) + Cohen's D Wilcoxon signed rank test/Mann-Whitney U

Strategies to ensure soundness. The State Board of Community and Technical Colleges provided support for this study by assembling and de-identifying the data. The data assembly by the SBCTC was carried out with cooperation from institutional researchers at each participant K-12 school district and community and technical college. As institutional researchers, they have expertise in gathering data using sound research techniques (Creswell, 2008). When collecting data for quantitative research, validity (internal and external), reliability, and generalization are important factors when considering research soundness (Muijs, 2011).

Validity. Though all types of validity (content, criterion, and construct) were considered for this study, efforts to ensure criterion validity were more purposeful in an attempt to determine if transcript data and test scores gathered accurately analyzed a relationship between students taking the AMR course and college success in mathematics as defined by the study. As Muijs (2011) advocated, there are two things needed to establish criterion validity: "…a good knowledge of theory relating to the concept, so that we can decide what variables we can expect to be predicted by, and related to it, and a measure of the relationship between our measure and those factors" (p. 59). For this study, the literature review extensively examined the theoretical base behind the research questions and hypothesis development. Furthermore, the use of descriptive and inferential statistics provided a valid measure for examining the relationship between the AMR course and college success in mathematics as determined by the specified outcomes. Schutt (2009, pp. 90-92) maintained that the following positivist research guidelines should be followed in order to achieve validity:

Tests ideas against empirical reality while maintaining subjectivity. A study in which conclusions are accurately represented and bias is minimized is dependent on minimizing threats to validity. According to Creswell (2008), threats to *internal* validity involve issues around the procedures and participant experiences that prevent questions as to the results of a study and inferences made by the researcher. History, maturation, regression, selection, mortality, and interactions with the selections are all categories that address threats to internal validity relating to the participants. Testing and instrumentation are categories related to the procedures of a nonexperimental study. (Creswell, 2008). Threats to *external* validity (or generalizabilty) include how the selection of participants interact with factors associated with the environment in which the study takes place such as the inability to generalize the findings due to (a) the selection of the participants, (b) the selection of the setting where the study takes place, and (c) the timeline of the study (Creswell, 2008). Because this study was a causal-comparative design, descriptive and inferential statistics were used to control or “partial out” uncontrolled variables that may influence the outcome (Suter, 2006). The use of matching when selecting the participant groups also aided in minimizing bias (See Table 3.9 for response to threats to validity).

Multiple measures of college success were examined thus improving validity (Schutt, 2009) including course-taking behavior and placement test scores. In addition, existing transcript and placement test data were used for all of the students when forming the representative and comparison group and de-identified by the SBCTC for the study. This ensured that the researcher received similar data for all participants and worked with de-identified data when carrying out the statistical analysis phase of the study using

SBSS and XLSTAT software. Because the placement and transcript data were obtained through institutional research offices at the community colleges and high schools, the scores themselves were considered valid (Creswell, 2008). Having preset hypotheses coupled with an extensive literature review also contributed to the validity of the study.

Table 3.9: *Response to Threats to Internal and External Validity*

External Threat	Causal-Comparative Study	Response
Interaction of participant selection and treatment	Potential threat	Assumption exists that the results of this study can be generalized to other groups from varying social, geographical, age, gender, or personality groups. The participants were clearly identified and results carefully analyzed to minimize this threat.
Interaction of setting and treatment	Potential threat	Assumption exists that results of this study apply to colleges other than two-year colleges and to community colleges in other states or regions. The setting was be clearly identified and results carefully analyzed to minimize this threat.
Interaction of history and treatment (timeline)	Potential threat	Assumption exists that similar results could occur during subsequent quarters or years in college. The results of this study avoided making generalizations to other times and the study itself was designed such that it can be easily replicated for future participant groups.
History	No threat	Both representative and comparison group have the same history context. All participants were enrolled at the community college within three quarters of graduating from high school (summer excluded).
Maturation	No threat	It is assumed that both the representative and comparison groups progressed through the study at similar educational development rates indicative of their age groups.
Regression	No threat	Both the representative and comparison

		groups were not specifically selected based on extreme scores.
Selection	Potential threat	Though the representative and comparison groups were not randomly selected, the participants attended the same high schools in the same geographical location and will be community college students. These factors, along with the use of statistics to control for confounding variables, minimized the potential threat to the selection process.
Mortality	Potential threat	Participants who stopped attending the community college may have impacted the ability to draw conclusions for some of the research questions. By including a high number of community colleges in the areas that service the high schools that offer the AMR course, the n-value will be as large as possible and will help minimize this threat.
Interactions with selection	Potential threat	Confounding variables such as socioeconomic status and previous mathematics performance in high school may threaten results. As stated above for selection, analyzing only those students who attend community colleges will help to control for these factors, as community college students often represent similar backgrounds and academic performance. In addition to matching the independent variable groups, descriptive and inferential statistics were utilized to control for confounding variables.

Plan and implement a systematic investigation. Part of the process of a systematic investigation is to plan carefully before carrying out a proposed study as evident in this dissertation proposal which was scrutinized through the Oregon State University Graduate School. Much of the design of this study was based on the work of Creswell (2008) who outlined the steps: (a) determine if chosen study best addresses the research questions, (b) identify the study participants, (c) identify two or more variables to measure for each participant, (d) collect data and monitor potential threats, (e) analyze the data, and (f) interpret the results.

Document all procedures and make available to the public. In the research design chapter of this study, the methods on which any findings were based were clearly outlined and disclosed. In addition, a personal disclosure section was included that clarifies any bias or subjectivity that would have compromised the study's validity.

Clarify assumptions. Based on the postpositivist perspective, no investigation is without some background assumptions. According to Schutt (2009), "By taking the time to think about and disclose their assumptions, researchers provide important information for those who seek to evaluate research conclusions" (p. 91). The assumptions for this study were as follows: (a) students desire to transition to postsecondary education; (b) all students can learn mathematics; (c) different courses that are considered entry into the college level are similar in scope and rigor; (d) there is a uniformity among community college mathematics instructions when determining passing grades; and (d) determination for placement into precollege math courses among the community colleges and mathematics instructors is similar enough for the purpose of this study.

Define all terms and key concepts. Words can often have duplicate meanings that can be interpreted differently depending on the audience. Creswell (2008) emphasized the use of defining key terms when conducting the review of literature in particular. For the purpose of this study, key works were defined in the Review of Literature section for guiding the review of applicable research as well as clarifying key concepts that impacted the study.

Be critical and skeptical towards current research. Guidelines provided by Pyrczak (2008) and Glatthorn and Joyner (2005) provided the structure by which the literature was reviewed in this study. Maintaining a good research record; conducting a comprehensive search; and critiquing retrieved sources by understanding each study's research methods, strengths, and limitations were effective ways to be critical and skeptical towards the current research (Glatthorn & Joyner, 2005). Pyrezak's (2008) work was designed for students first learning how to evaluate research published in journals and reports and included a step by step evaluation rubric for critiquing literature. For the purpose of this study, a précis was constructed that included the author, date, research focus, research method, findings, and limitations to the study.

Replicate research and build upon social theory. Because this study was conducted from a postpositivist worldview perspective, the importance of replicating research to approximate universal truth more closely was maintained throughout. As Schutt (2009) noted, "We can't fully understand a single study's results apart from the larger body of knowledge to which it is related, and we can't place much confidence in these results until the study has been replicated" (p. 91). As a nonexperimental research design, cause and effect was not determined by the outcome of this study; only a relationship among variables will be examined. Therefore, a future experimental design study is warranted to gain a better understanding of how specific courses taken during the senior year of high school directly impact college success. Even though this study did not replicate another study, the research can contribute to a community of knowledge around the area of K-16 transitions and encourage future research work.

Search for regularities or patterns. Since postpositivists maintain that there is an underlying order to the scientific world, research should examine any similarities and carry out a study that could allow for repeating behavior to surface. Using participants from a variety of K-12 school districts and community and technical colleges and employing matching techniques to form the representative and comparison groups allowed any patterns of course-taking behavior and placement testing results to emerge despite extraneous variables. Furthermore, working with a data set that was de-identified and provided to the researcher in a spreadsheet format for the purposes of this study, enabled the participants to be viewed from a quantitative, non-biased perspective that would help validate any patterns that surfaced.

Reliability. Whereas validity refers to accuracy, Creswell (2008) defined reliability as characterizing scores that are consistent and stable. In other words, a reliable measure should yield the same result when a test is implemented numerous times (Suter, 2006). Researchers need to consider the following when determining if data are unreliable: (a) the questions on the instrument are unclear or ambiguous, (b) procedures of test administration are not standardized, (c) participants are fatigued, nervous, etc… when completing a testing instrument (Creswell, 2008, p. 169). Since most of the data analyzed involved transcript data from reliable college and high school sources, reliability issues around data were minimized. For placement score data, students were taking placement tests at community colleges where these tests have been studied for internal consistency and standardized to a national average with a minimum margin of error in testing results. Because different community colleges have varying cutoff scores for mathematics course placement, the scores were utilized for this study, not the placed course. In a few cases when a student was placed using alternate means (high school transcript, instructor permission), the median score of the appropriate placement test "bucket" was assigned to the student to maintain integrity during the statistical testing. Because participants may have varied in their performance on the placement test due to nervousness or lack of test-taking skills, this study considered the number of precollege courses taken and grades earned in mathematics courses as a basis for the methods employed, thus providing additional data for analysis.

Generalization. As mentioned earlier, a key component of external validity is generalization, or "how well the findings apply to the people and settings beyond the borders of the sample and research conditions…" (Suter, 2006, pp. 178-179). Planning a carefully designed causal-comparative study, determining a null and alternate hypothesis for each research question, using statistics to calculate a *p* value in order to accept or reject the null hypothesis, calculating the effect size, and maximizing the sample size in order to minimize making Type I or Type II error were all carried out in this study to estimate the probability that any findings found in the sample could be generalized to the population. Furthermore, students included in the study represented multiple high school and community college sites with varied demographics that increased the overall diversity of the sample. No definitive statements, however, were made that would generalize the findings with certainty to the population but rather, the research could signify a likelihood that the results had meaning for a specific population.

Strategies to protect human subjects. Anonymity was maintained throughout the study. Participant data were collected, coded, and de-identified by the SBCTC before being analyzed for this study. This dissertation proposal was also submitted to the Oregon State University Institutional Review Board (IRB) for review consideration and to ensure that ethical policies were being followed in regard to human subjects. It was concluded that the study did not require IRB review because the preexisting and de-identified dataset eliminated the definition of research work involving human subjects. The researcher also completed the Human Participants Protection Education for Research Teams online course, sponsored by the National Institute of Health (NIH).

Summary of Research Design

Numerous students who graduate from high school are unprepared for college level mathematics. The purpose of this research was to design a study that examined the relationship between completing a rigorous mathematics course, titled Applications of Mathematical Reasoning, during the senior year of high school and preparation for and success in college mathematics. Methodology behind this quantitative study represented a postpositivist philosophy and was the catalyst behind designing nonexperimental, causal-comparative study involving students who graduated from high school and attended community colleges in the state of Washington during the 2009-2010 academic year. Transcript and placement test data were analyzed comparing recent high school graduates who took the AMR course to those students who took no mathematics during their senior year of high school. Using SPSS and XLSTAT, descriptive and inferential statistical methods were employed to determine strength of the relationship between the independent and dependent variables. Research-based methods to address threats to internal and external validity, create a reliable study, avoid making erroneous generalization statements, and protect the rights of the participants were also incorporated into the study.

CHAPTER 4

Results

The purpose of this study was to explore a possible relationship between taking the AMR course as a high school senior and preparation for college level mathematics. This chapter provides results from data analysis performed using descriptive and inferential statistical methods on a data set with transcript and placement test information for students who either took the AMR course or took no mathematics during their senior year of high school and then attended one of the participating community and technical colleges. As outlined in Chapter One, the three research questions guiding the study were as follows:

- To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters compared to similar students who took no mathematics course their senior year?
- To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a passing grade (1.0) compared to those students who did not take any mathematics during their senior year?
- To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college

earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

First, this chapter will describe the data collected in terms of the independent, dependent, and confounding variables. Second, data analysis results are organized by the research questions and address the null hypothesis for each question as established in Chapter One. Last, a summary of findings concludes the chapter.

Data Collection

The data assembly work was performed by the State Board of Community and Technical Colleges (SBCTC), de-identified and provided to the researcher for this study. Institutional researchers from the participating K-12 school districts, community and technical colleges, and the SBCTC played an integral part in collecting a sound data set that maximized the participants in the representative and comparison groups. After collecting the data from the K-12 school districts, the SBCTC (a) determined if the students were attending community college and if so, which college in particular, (b) collected information on student mathematics course-taking behavior at the applicable community and technical colleges, and (c) contacted the institutional researchers at the CTC's to retrieve mathematics placement test data. Next, the SBCTC employed matching techniques to minimize any extraneous variables that could cause spurious relationships impacting the study outcomes. Finally, the SBCTC organized the data into an Excel spreadsheet format and provided it to the researcher for the purpose of this study.

Independent variables. Data provided to the SBCTC from the participating high schools contained approximately 190 students who took the AMR course and 228 who did not take any mathematics during their senior year of high school from the participating sites. Before arriving at the 190/228 sample size, students who had not completed Algebra II or had completed an alternate course during their junior year were eliminated from the study. Students were also removed from the original data set from the high schools for the following reasons: (a) took a math course during their senior year of high school other than the AMR course (e.g. precalculus, statistics, etc…), (b) entered the Running Start program at a neighboring community or technical college, (c) transferred into the high school from another school, (d) transferred out of the school before graduation, and/or (e) earned a failing grade for the Algebra II prerequisite course and/or the AMR course. All participants in the study graduated from high school June, 2009 and then attended community college within three quarters (summer excluded). After eliminating students who did not attend one of the participating community colleges or only attended for one quarter, the data set consisted of approximately 50 students who took the AMR course and 70 who did not. The matching process then produced 35 paired sets for the data analysis phase of the study. Table 4.1 illustrates the progression by which the sample size was reduced to the eventual 35 pairs.

Table 4.1: *Sample Size Progression*

2008-2009 High School Graduates	No AMR	Yes AMR
Sample from participating high school provided to SBCTC after elimination for senior year course-taking, lack of prerequisites, Running Start, and transfer status.	228	190
Sample from SBCTC after eliminating those students who neither attended a participating community college within three quarters nor completed more than one quarter.	70	50
Final sample size after matching process	35	35

The school districts provided SBCTC with the requested independent variables that included gender, ethnicity, Algebra II grade, and overall high school GPA. Though initially requested, not all of the schools were able to provide free or reduced lunch status so that variable was unable to be consistently used in the matching process. Using a nearest neighbor matching process, the SBCTC sorted the data by high school, K-12 school district, and AMR course (took AMR course/did not take AMR course). Upon receiving the database, the SBCTC then matched students in the AMR course group (representative) with the students in the non-AMR course group (comparison) based in order of the following: Algebra II grade, high school GPA, K-12 school district, high school attended. The students were then matched by gender and ethnicity. Each participant was assigned a random color coding and number along with and “a” or “b” indicating if the student completed or did not complete the AMR course as shown in Table 4.2.

Table 4.2: *Excel Files Produced by SBCTC for Independent Variables*

Excel File	Field Names	Field Definitions	Number of Records	
			Yes AMR	No AMR
AMR Data Set	Match	Match code (e.g. Blue 1a-Blue 1b pairing)	35a	35b
	AMR	Took AMR course (Y-yes, N-no,)	35Y	35N
	QTR at CTC	Quarter first enrolled at CTC (Su-summer, F-fall, W-winter)	1Su/ 31F/ 4W	0Su/ 29F/ 5W
	Gender	F-female/ M-male	16 F/ 19M	20 F/ 15M
	Ethnicity/ Race	Asian or Pacific Islander (A); Black, non-Hispanic (B); Hispanic (H); Multi (districts had this designation for undecided) (M); White, non-Hispanic (W).	3A/ 2B/ 1H/ 2M/ 27W	4A/ 3B/ 2H/ 0M/ 26W
	Free or Reduced Lunch	F-free or reduced/ P-pass	3F/ 10P/ 22 missing	4F/ 10P/ 21 missing

Group characteristics. The sample was comprised of 70 participants who graduated from high school in 2009 so were of similar age. As seen in Table 4.2, 45.7% of the students in the AMR course-taking group were female and 54.2% were male. In contrast, over 57.1 % of the students who did not take the AMR course were female and 42.9 % were male. For the purpose of the data analysis in terms of ethnicity, all of the groups identified other than White, non-Hispanic, were classified as *people of color* (see Table 4.3). Overall, 24.2 % of the entire sample population was considered people of color. More specifically, 22.9 % of the students who took the AMR course were considered people of color whereas 25.7 % of the students who did not take the AMR course were people of color as seen in Table 4.2. In terms of mathematics and grade performance, Algebra II grade was included in the data since completion of this course is strong indicator of success in mathematics as noted in the literature review in Chapter Two. The range in the sample for Algebra II grade was from a minimum value of 1.00 to a maximum of 3.60. Overall high school GPA for the participants in the sample ranged from 2.19 to 3.88. As seen in Table 4.3, the mean value (*M*) for Algebra II grade was 1.88 (*SD*=.57) for students who did not take the AMR course compared to 1.81 (*SD*=.61) for those students who did take AMR. The mean value for high school GPA was 2.85 (*SD*=.42) for those students who did not take AMR compared to 2.84 (*SD*=.39) for those who did complete the AMR course. These data, along with student identifiers (SID), student names, graduating year (to verify that they met the qualifications of the sample), and birthdates were also supplied to the SBCTC. The SBCTC used the identifying information to track the students to see if they were attending community college and if so, which one. Students attending baccalaureate institutions, and community and technical colleges not participating in the study were eliminated along with students who did not attend college after graduating from high school.

After receiving all of the independent variables data, the SBCTC matched students from the population who took no AMR course to the population of students who completed the AMR course. The matching process was conducted in a way to maximize the sample size for the study and was carried out a minimum of three times to support the final matching outcomes. Only the resulting matches were included in the final data sheet. Data for the dependent variables were then gathered only for the matched representative (yes AMR) and comparison (no AMR) groups.

Table 4.3: *Group Characteristics: Gender*

		AMR Course		
		No	Yes	Total
Gender				
	Female	20	16	36
	Male	15	19	34
Total		35	35	70
Ethnicity				
	People of Color	9	8	17
	White, Non-Hispanic	26	27	53
Total		35	35	70

Table 4.4: *Group Characteristics: Algebra II Grade and High School GPA*

	No AMR Course (*n*=35)			Yes AMR Course (*n*=35)		
	M	*SD*	*SEM*	*M*	*SD*	*SEM*
Algebra II Grade	1.88	.57	.10	1.81	.61	.10
High School GPA	2.85	.42	.07	2.84	.39	.07

Dependent variables. In addition to collecting the independent variable data, the SBCTC provided data from their own system-wide databases and collected placement test results from the community and technical colleges where the sample participants attended. These data included (a) number of precollege math credits taken, (b) first college level mathematics course completed, (c) grade earned in college level course if applicable, and (d) mathematics placement test results (see Table 4.4). When gathering these data, a college level mathematics course was required to have a MATH prefix and a course number 100 or greater. A 1.0 was considered a passing grade for the college level course recorded based on the significant number of community and technical colleges that consider 1.0 (D) as the minimum grade for earning credit. Some colleges like Green River Community College, consider 0.7 for that purpose, so choosing 1.0 as the passing grade was a more conservative choice.

All of the participating community and technical colleges utilized COMPASS as their main math placement test. For placement test results, there were a few cases where students were placed into a mathematics course by instructor permission, high school transcript evaluation, or an alternate placement tool. In these cases, the student was assigned the median value of the bucket representing the course level (e.g. prealgebra, algebra, college algebra, trigonometry). Based on the bucket distributions for COMPASS placement each score was added to 100, 200, 300, or 400 to allow for a ranked test statistic. For example, a student may earn a score of 60, but based upon question responses, it was determined the student is operating at the college algebra level or bucket. Another student may have the same score but be placed into the lower Numerical Skills bucket. To distinguish the two scores and levels, the above-mentioned ranks were added to each bucket. For this study, placement score data ranged from115.0 to 347.0 for those students who completed the AMR course, whereas the scores for students who did not take the AMR course ranged from 117.0 to 418.0. After receiving all of the dependent variables data from the community and technical colleges, both the dependent and independent variables data were merged onto a single spreadsheet for analysis. All identifying information for the students was removed from the file by SBCTC and provided to the researcher for the purpose of the study.

Table 4.5: *Excel Files Produced by SBCTC for Dependent Variables*

Excel file	Field Names	Field Definitions	Number of Records
AMR Data Set	Q1: Remediation Credits	# of credits taken at the precollege level at the CTC	8- n/a (placed into CL) 19-zero credits 23- five credits 18-ten credits 2-fifteen credits
	Q2a: Took CL course	N-no/Y-yes	49-no/21-yes
	Q2b: CL course grade	Grade earned in college level course from 1.0-4.0	3/1.00-1.99 7/2.00-2.99 8/3.00-3.99 2/4.00
Excel file	Field Names	Field Definitions	Number of Records
	Q3: Placement score	100-199/prealgebra bucket 200-299/algebra bucket 300-399/college algebra bucket 400-499/trigonometry bucket	18-prealgebra 41-algebra 10-college algebra 1-trigonometry

Data Analysis

After collecting the data and matching the representative and comparison groups, the SBCTC de-identified the data and provided the final data set in a spreadsheet for analysis. SPSS, XLSTAT, and Excel were all utilized for conducting statistical tests with SPSS the primary software. First, the analysis process began with the use of descriptive and inferential statistics to analyze any differences between the representative and comparison groups in order to verify the matching process. Second, statistical tests were performed to test the null hypothesis for each research questions. Finally, tests were rerun numerous times in order to confirm the results.

Confounding variables. Based on the research conducted for the literature review, gender, ethnicity, socioeconomic status, Algebra II grade, and overall high school GPA are confounding variables that may have caused a spurious relationship between the independent and dependent variables. Socioeconomic status was similar between the matched groups, because students were matched with other students who attended high school in the same geographic area. Out of 35 pairs, 28 (80%) attended the same high school, whereas the remaining pairs attended a high school in close proximity to the other high school and within the same district. For the other potential confounding variables, cross-tabulation, chi-square, Fisher's exact test, and *t* tests were used to determine if the two groups differed significantly and therefore, the impact made by the confounding variables was measurable. The following were the results of the analysis:

***Gender*.** To determine if the representative and comparison groups were significantly dissimilar in regard to the gender variable, cross-tabulation and a chi-square test were applied. Statistical significance was measured based on the following null and alternate hypotheses and significant at the alpha level of .05:

H_0: there is no significant difference between the representative and comparison groups in regard to gender.

H_a: there is significant difference between the representative and comparison groups in regard to gender.

Since the sample size (*n*=35) for both groups was adequate but small, a Fisher's exact test, applied to the chi-square test, was also performed which can be a robust measure for smaller sample sizes and can be useful when the expected frequency in any cell is less than five (Gall, Gall, & Borg, 2007). Both tests (chi-square and Fisher's exact) showed no significant differences ($p>.05$). This suggests that any gender differences between the representative and comparison groups were due to chance fluctuations, given the null hypothesis is true. In addition, the cross-tabulation results as shown in Table 4.5 also produced hypothetical data illustrating similarity in regard to gender when comparing the expected to the actual counts for the two groups.

Table 4.6: *Gender Comparison Between no AMR/ yes AMR Groups.*

	No AMR Course		Yes AMR Course		Total
	Count	Expected Count	Count	Expected Count	
Female	20	18.0	16	18.0	36
Male	15	17.0	19	17.0	34
Total Count	35	35.0	35	35.0	70

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.92[a]	1	.34	.47	.24
Phi/Cramer's V	.11		.34		
Fisher's Exact Test				.47	.24
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 17.00.

Ethnicity. To determine if the representative and comparison groups were significantly dissimilar in regard to the ethnicity, cross-tabulation and a chi-square test (including Fisher's exact) were applied:

H_0: there is no significant difference between the representative and comparison groups in regard to ethnicity.

H_a: there is significant difference between the representative and comparison groups in regard to ethnicity.

Both tests (chi-square and Fisher's exact) showed no statistically significant differences (χ^2 [1, N=70] = .08, p >.05. For Fisher's exact, p=1.00). In addition, the cross-tabulation results as shown in Table 4.6, also produced hypothetical data illustrating some similarity in regard to ethnicity when comparing the expected to the actual counts for the two groups. Table 4.7: *Ethnicity Comparison Between no AMR/yes AMR Groups.*

	No AMR Course		Yes AMR Course		Total Count
	Count	Expected Count	Count	Expected Count	
People of color	9	8.5	8	8.5	17
White, non-Hispanic	26	26.5	27	26.5	53
Total Count	35	35.0	35	35.0	70

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.08[a]	1	.78	1.00	.50
Phi/Cramer's V	.03		.78		
Fisher's Exact Test				1.00	.50
N of Valid Cases	70				

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.08[a]	1	.78	1.00	.50
Phi/Cramer's V	.03		.78		
Fisher's Exact Test				1.00	.50
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.50.

Algebra II grade. A paired sample *t* test (2-tailed) was performed to determine if the representative and comparison groups had statistically significant mean differences for the grade earned when taking Algebra II during the participants' junior year of high school. Since the groups were matched or correlated, a paired sample *t* test would be more appropriate than an independent sample *t* test (Suter, 2006). Statistical significance was measured based on the following null and alternate hypotheses and significant at the alpha level of .05:

H_0: there is no significant difference between the representative and comparison groups in regard to Algebra II grade mean. (H_0: $\mu_{no\ AMR} = \mu_{2yes\ AMR}$)

H_a: there is significant difference between the representative and comparison groups in regard to Algebra II grade mean. (H_a: $\mu_{no\ AMR} \neq \mu_{2yes\ AMR}$)

Findings from the *t* test indicated that the comparison group (*M*=1.88, SD = .57) did not score significantly higher than the representative group (*M*=1.81, SD = .61) in terms of Algebra II grade, t (34) = 1.68, p >.05. Therefore, the findings failed to reject the null hypothesis as the *p* value was greater than the alpha level of .05. Based on this *p* value calculation, we could determine that the probability is more likely than not that any variations in the mean score values for Algebra II grade are due to chance fluctuations given the null hypothesis is true. In addition, the 95% confidence interval [-.02, .16] indicated that one could be 95% confident that the actual mean value difference of the population for both groups lay somewhere between the lower and upper limit values as shown in Table 4.7.

Table 4.8: *Algebra II grade Comparison-Paired Samples t Test (2-tailed)*

Algebra II grade- Pair 1	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% *CI* of the Difference *LL*	*UL*			
No AMR Yes AMR	.07	.26	.04	-.02	.16	1.68	34	.10

High school GPA. A paired sample *t* test (2-tailed) was also performed to determine if the representative and comparison groups had statistically significant mean differences for the overall high school GPA, a significant indicator of academic performance as noted in the literature review. Statistical significance was measured based on the following null and alternate hypotheses and significant at the alpha level of .05:

H_0: there is no significant difference between the representative and comparison groups in regard to high school GPA mean. (H_0: $\mu_{no\ AMR} = \mu_{2yes\ AMR}$)

H_a: there is significant difference between the representative and comparison groups in regard to high school GPA mean. (H_a: $\mu_{no\ AMR} \neq \mu_{2yes\ AMR}$)

Findings from the *t* test performed indicated that the comparison group (*M*=2.85, SD = .42) did not score significantly higher than the representative group (*M*=2.84, SD = .39) in terms of high school GPA, t (34) = .29, p >.05. Therefore, the findings failed to reject the null hypothesis as indicated by the p value. Based on this p value calculation, we could determine that the probability is more likely than not that any variations in the mean score values for high school GPA are due to chance fluctuations given the null hypothesis is true. In addition, the 95% confidence interval [.08, .10] indicated that one could be 95% confident that the actual mean value of the population for both groups lay somewhere between the lower and upper limit values as shown in Table 4.8.

Table 4.9: *High School GPA Comparison-Paired Samples t Test (2-tailed)*

	Paired Differences							
				95% *CI* of the Difference				
High School GPA- Pair 1	Mean	Std. Dev.	Std. Error Mean	*LL*	*UL*	*t*	*df*	Sig. (2-tailed)
No AMR Yes AMR	.01	.26	.04	-.08	.10	.29	34	.78

Research Question One. Research Question One stated the following:

- To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters (summer excluded) compared to similar students who took no mathematics course their senior year of high school?

The purpose of this question was to determine to what degree students were prepared or not prepared for college level mathematics. The dependent variable used to address this question was the number of credits taken in precollege courses for the students who took the AMR courses compared to those students who did not take the AMR course or any other mathematics course during their senior year of high school. Participants were assigned an "1" if they sought to take zero or five credits of precollege mathematics or a "2" for 10 or 15 credits of precollege mathematics. All of the community colleges utilized for this study offered five credits for their typical precollege courses. For the purpose of the analysis of the dependent variable, statistical significance was measured based on the following null and alternate hypotheses with a significance determined at the alpha level of .05:

> H_0: there is no difference between the representative (yes AMR) and the comparison groups (no AMR) in terms of precollege credits taken during the first three quarters.(H_0: *# of* precollege credits $_{no\ AMR}$= # of precollege credits $_{yes\ AMR}$)
>
> H_a: Those representative students who took the AMR course will seek to take fewer precollege math credits than the comparison group who did not take the AMR course. (H_0: *# of* precollege credits $_{no\ AMR}$≠ # of precollege credits $_{yes\ AMR}$)

The initial descriptive statistics calculated (Table 4.9) indicated that the comparison group (*M*=1.31, SD = .47) had a slightly higher mean and standard deviation than the representative (or AMR) group (*M*=1.26, SD = .44). However, since the dependent variable was ordinal rather than continuous, chi-square and Fisher's exact test were performed to see if these differences were significant at the alpha level of .05, χ^2 (1, N=70) = .28, p >.05. The effect size or *phi* was calculated to be .06 which indicated a weak relationship.

As shown in Table 4.10, the chi-square/Fisher's exact test findings indicated that there was not enough evidence to support rejecting the null hypothesis so there is a strong probability that any differences in precollege math credits sought between the representative and comparison groups were due to chance fluctuations. Furthermore, there was not enough evidence to support the variances between the expected and actual counts for the two groups based on the cross-tabulation results. To analyze further any relationship between the rows and columns in the contingency table particularly with the sample size indicated, a Cochran-Armitage trend test was performed with significance established at the alpha level of .05. The resulting *p* value of .74 indicated that we failed to reject the null hypothesis and strengthened the chi-square test results.

Table 4.10: *Precollege Descriptive Statistics*

	No AMR Course (*n*=35)			Yes AMR Course (*n*=35)		
	M	*SD*	*SEM*	*M*	*SD*	*SEM*
Precollege Credits$_a$	1.31	.47	.08	1.26	.44	.08

[a] For those students who would not take a precollege math class because they tested into college-level, they earned a "0."

Table 4.11: *Precollege Courses Significance Tests*

	No AMR Course		Yes AMR Course		Total Count
Value assigned	Count	Expected Count	Count	Expected Count	
1.0 (0-5 credits)	24	25.0	26	25.0	50
2.0 (10-15 credits)	11	10.0	9	10.0	20
Total	35	35.0	35	35.0	70

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.28[a]	1	.60	.79	.40
Phi/Cramer's V	.06		.60		
Fisher's Exact Test				.79	.40
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 8.50.

	|z| (Observed value)	|z| (Critical value)	Asymp. Sig. (2-sided)
Cochran-Armitage trend test [ab]	.33	1.96	0.74

a. Asymptotic *p* value /two-tailed test
b. Significance level alpha=0.05

Research Question Two. Research Question Two stated the following:

- To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a minimum passing grade of a 1.0 compared to those students who did not take any mathematics during their senior year?

The purpose of this question was to determine the likelihood of students reaching the college level in mathematics, a significant "tipping point" as outlined in Chapters One and Two. The dependent variable addressing this question was determine by a "yes" if the student completed a college level (CL) math course, or a "no" if the student did not enroll in a CL math course or failed to complete the course with a passing grade of 1.0. For the purpose of the analysis of the dependent variable, statistical significance was measured based on the following null and alternate hypotheses with a significance determined at the alpha level of .05:

> *H_0:* there is no difference between the representative (yes AMR) and the comparison groups (no AMR) in terms of enrolling and passing a college level mathematics course. (*H_0:* CL math course $_{no\ AMR}$= CL math course $_{yes\ AMR}$*)*
>
> *H_a:* Those representative students who took the AMR course will be more likely to enroll in and pass a college level mathematics course than the comparison group who did not take the AMR course. (*H_0:* CL math course $_{no\ AMR}$≠ CL math course $_{yes\ AMR}$*)*

As shown in Table 4.11, cross-tabulation was performed, and hypothetical data indicate that those students who took the AMR course enrolled more frequently in a college level course. However, chi-square and Fisher's exact test were performed to see if the differences between the two groups was significant at the alpha level of .05, χ^2 (1, N=70) = .61, *p* >.05. For Fisher's exact test, p=.60.The effect size or *phi* was calculated to be .09 which indicated a weak relationship.

The chi-square/Fisher's exact test findings as shown in Table 4.11 indicated that there was not enough evidence to support rejecting the null hypothesis so there is a strong probability that any differences in enrolling in and passing a college level mathematics course between the representative and comparison groups were due to chance fluctuations. Furthermore, there was not enough evidence to support the variances between the expected and actual counts for the two groups based on the cross-tabulation results. To analyze further any relationship between the rows and columns in the contingency table and strengthen the chi-square test results, a Cochran-Q test was performed with significance established at the alpha level of .05 (Table 4.12). The resulting *p* value of .37 indicated that we failed to reject the null hypothesis.

Table 4.12: *College Level Courses Cross-tabulation*

College Level Math Course Taken	No AMR Course		Yes AMR Course		Total Count
	Count	Expected Count	Count	Expected Count	
No CL Course	26	24.5	23	24.5	49
Yes CL Course	9	10.5	12	10.5	21
Total	35	35.0	35	35.0	70

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.61[a]	1	.43	.60	.30
Phi/Cramer's V	.09		.43		
Fisher's Exact Test				.60	.30
N of Valid Cases	70				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 10.50.

Table 4.13: *Cochran's Q Test Results*

	df	Q (Observed value)	Q (Critical value)	Asymp. Sig. (2-sided)
Cochran's Q Test[ab]	1	.82	3.84	0.37

a. Asymptotic *p* value /two-tailed test
b. Significance level alpha=0.05

After analyzing the college level mathematics course-taking patterns of the representative and comparison groups, the grades earned in the completed college level courses were then considered. The values for the representative group (yes AMR) ranged from 1.5 to a grade of 4.0. The values for the comparison group (no AMR) ranged from 1.0 to a grade of 3.8. As shown in Table 4.13, the initial descriptive statistics calculated for college level math course grades earned indicated that the representative group (*M* =2.84, SD =.81) had a slightly higher mean than the comparison group (*M* =2.72, SD = 1.04) though the distribution curves (Figure 4.1) and sample sizes varied.

Table 4.14: *CL Math Course Grades Descriptive Statistics*

	No AMR Course (*n*=9)			Yes AMR Course (*n*=11)		
	M	*SD*	*SEM*	*M*	*SD*	*SEM*
CL Course Grades	2.72	1.04	.35	2.84	.81	.24

[a] For those students who would not take a precollege math class because they tested into college-level, they earned a "0."

To determine if the means were significantly different, statistical analysis using and independent *t* test was implemented based on the following null and alternate hypotheses with a significance determined at the alpha level of .05:

H_0: there is no significant difference for those students who enrolled in a college level mathematic course between the representative and comparison groups in regard to CL course grades. (H_0: *CL course grades* $_{no\ AMR}$ = *CL course grades* $_{yes\ AMR}$)

H_a: there is significant difference between the representative and comparison groups in regard to CL course grades. (H_a: *CL course grades* $_{no\ AMR} \neq$ *CL course grades* $_{yes\ AMR}$)

As shown in Table 4.14, The independent samples *t* test performed in terms of college level mathematics course grade had the following result: *t* (14.96) = -.27, *p* >.05. The measure of effect size (Cohen's *d*) was calculated to be 0.13 which represented a weak effect, understandable with such a small sample size. Overall findings do not support rejecting the null hypothesis as differences in the means between the two groups could be attributed to chance fluctuations. The 90% confidence interval for a 1-tailed test [-.86, .63] indicated that one could be 90% confident that the actual mean value difference of the population for both groups lay somewhere between the lower and upper limit values but the analysis did no support determining that that mean difference was significant.

Table 4.15: *CL Math Course Grades -Independent Samples t Test (1-tailed)*

Grades Earned in CL Math Courses	*t* Test for Equality of Means						
	Mean Difference	Std. Error Difference	90% *CI* of the Difference		t	df	Sig. (1-tailed)
			LL	*UL*			
Equal Variances not Assumed	-.11	.42	-.86	.63	-.27	14.96	.40

Based on the distribution curves for the two groups, there appeared a similarity in the top spread of each curve. For further examination, the top five scores above a 3.0 grade were analyzed for the representative and comparison groups. Statistical significance was measured based on the following null and alternate hypotheses with a significance determined at the alpha level of .05:

H_0: there is no significant difference for those students who enrolled in a college level mathematic course between the representative and comparison groups in regard to CL course grades higher than a 3.0. (H_0*: Top five CL course grades* $_{no\ AMR}$ = *Top five CL course grades* $_{yes\ AMR}$)

H_a: there is significant difference between the representative and comparison groups in regard to CL course grades higher than a 3.0. (H_a*: Top five CL course grades* $_{no\ AMR} \neq$ *Top five CL course grades* $_{yes\ AMR}$)

As shown in Table 4.16, a cross-tabulation with chi-square and Fisher's exact test were performed to determine if the null hypothesis could be rejected. Fisher's exact was performed because of the small sample size and low expected values and considered more robust than chi-square. The significant level was set at the alpha level of .05 with the results: χ^2 (1, N=10) = .40, p >.05. The Fisher's exact test results found that p=1.00. The effect size of *phi* was calculated to be .20 which indicated a modest relationship. The Fisher's exact test findings showed that there was not enough evidence to support rejecting the null hypothesis. The resulting *p* value of 1.00 indicated that we failed to reject the null hypothesis.

Table 4.16: *College Level Math Course Grades Top Five Scores Cross-tabulation*

	No AMR Course		Yes AMR Course		Total Count
Top Five Scores above a 3.00	Count	Expected Count	Count	Expected Count	
3.00-3.50 Grade Point	2	2.5	3	2.5	5
3.50-4.00 Grade Point	3	2.5	2	2.5	5
Total	5	5.0	5	5.0	10

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.40[a]	1	.53		
Phi/Cramer's V	.20		.53		
Fisher's Exact Test				1.00	.50
N of Valid Cases	10				

a. 4 cells (100%) have expected count less than 5. The minimum expected count is 2.50.

Research Question Three. Research Question Three stated the following:

- To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

Since the students in this study took a mathematics placement test upon entering the community college or earned an equivalent placement score based on alternate assessments (e.g. instructor permission, high school transcript, etc…), this dependent variable provided a baseline by which to measure preparation for community college mathematics courses.

For the purpose of the analysis of the dependent variable, statistical significance was measured based on the following null and alternate hypotheses with a significance determined at the alpha level of .05:

H_0: There is no difference between the representative (yes AMR) and the comparison groups (no AMR) in terms of earning a higher score on the mathematics placement test. H_0: (placement score $_{no\ AMR}$ = placement score $_{yes\ AMR}$)

H_a: Those representative students who took the AMR course will score higher on the mathematics placement test than the comparison group who did not take the AMR course. (H_0: placement score $_{no\ AMR} \neq$ placement score $_{yes\ AMR}$)

The initial descriptive statistics calculated indicated that the representative group (M =248.89, SD = 58.18) had a higher mean than the comparison group (M =219.93, SD = 70.84) as shown in Table 4.15 though different standard deviations and box plot data showed a wider spread for the comparison group (Table 4.16, Figure 4.1). To determine if the difference in the means for both groups was significant at the alpha level of .05, a paired sample *t* test was performed in terms of mathematics placement test results, t (34) = -2.56, $p < .05$ as shown in Table 4.18. The measure of effect (Cohen's *d*) was calculated to be 0.45 which represented a modest effect.

Overall findings supported rejecting the null hypothesis as indicated by the *p* value and we could conjecture that the probability is more likely than not that any variations in the mean score values were significant and not due to chance fluctuations. In addition, the 90% confidence interval for the 1-tailed *t* test [-48.05, -9.86] indicated that one could be 90% confident that the actual mean value difference of the population for both groups lay somewhere between the lower and upper limit values as shown in Table 4.18. With the mean difference between the representative and comparison group calculated to be: $M_1 - M_2 = -28.96$, the confidence interval provided additional support that this difference in the means for the sample is in a range comparable to what we can expect for the difference between the means for the actual population.

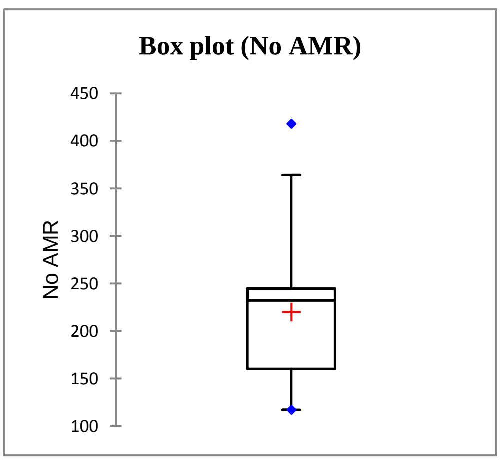
Table 4.17: *Mathematics Placement Test Scores-Mean Median, SD*

	No AMR Course (*n* =35)			Yes AMR Course (*n* =35)		
	M	*Mdn*	*SD*	*M*	*Mdn*	*SD*
Placement Test	219.93	232.00	70.84	248.89	242.00	58.18

Table 4.18: *Mathematics Placement Test Scores-Minimum, Maximum, Quartiles.*

	No AMR Course (*n* =35)				Yes AMR Course (*n* =35)			
	Min	Max	1st Quart.	3rd Quart.	Min	Max	1st Quart.	3rd Quart.
Placement Test	117.0	418.0	160.0	244.5	115.0	347.0	231.5	268.5

Figure 4.1: *Mathematics Placement Test Scores*



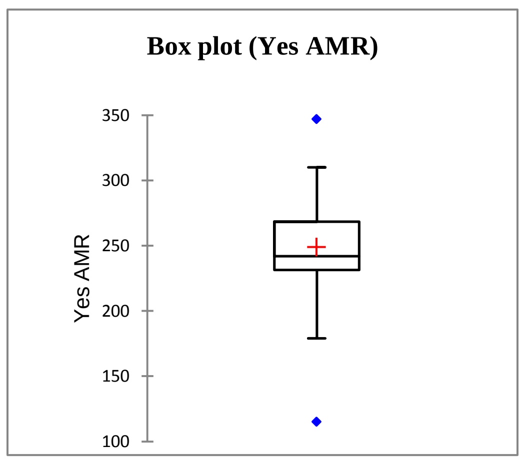


Table 4.19: *Placement Test -Paired Samples t Test (1-tailed)*

Math Placement Test Pair 1	Paired Differences					t	df	Sig. (1-tailed)
	Mean	Std. Dev.	Std. Error Mean	90% *CI* of the Difference				
				LL	*UL*			
No AMR Yes AMR	-28.96	66.91	11.29	-48.05	-9.86	-2.56	34	.007

Since the mathematics placement test scores were ordinal rather than continuous due to the nature of the “bucket” placements for each mathematics course level that brought into question the shape or variance of the population scores, the Wilcoxon signed rank test was conducted as a nonparametric counterpart for the *t* test. The Wilcoxon signed rank test was more appropriate than the Mann-Whitney *U* Test due to correlated nature of the matched representative and comparison groups (Gall, et al., 2007). The calculations using XLSTAT software showed a *p* value of .02 with the significant level at the alpha level of .05 as shown in Table 4.18.Therefore, the results indicated that the null hypothesis could be rejected in favor of the alternative hypothesis and support the conjecture that the difference in the mean rank scores between the representative and comparison groups was significant and not due to chance fluctuations.

Table 4.20: *Results From XLSTAT/SPSS Calculation of the Wilcoxon Signed Rank Test*

	No AMR Course (*n*=35)		Yes AMR Course (*n*=35)	
	Mean Rank	Sum of Ranks	Mean Rank	Sum of Ranks
Placement Score	29.99	1049.50	41.01	1435.50

	V	Expected value	Variance (V)	*p* value (1-tailed)
Wilcoxon signed rank test/ 1-tailed test (paired samples)[ab]	183.50	315.00	3726.13	.02

a. An approximation has been used to compute the *p* value.
b. Significance level alpha=0.05.

Summary of Findings

The purpose of this section was to summarize the results from the data analysis comparing those students who took the AMR course during their senior year of high school with those students who took no mathematics during their senior year of high school. Participants were selected from predetermined high school and college sites that represented a variety of student populations. The representative (yes AMR) and the comparison (no AMR) groups were carefully matched by the SBCTC based on demographic characteristics and geographical location. The first step in the data analysis process was to determine if the representative and comparison groups regarding the independent variables were well matched using descriptive and inferential statistical methods. Using similar methods, the dependent variables were then analyzed based on the three research questions. The three major findings of this study were as follows:

1. Significant testing showed that representative and comparison groups were well matched and similar based on (a) gender, (b) ethnicity, (c) Algebra II grade, and (d) high school GPA. Since free or reduced lunch status for all the participants was not available, similar socio-economic status between the groups was not determined though students were matched from the same districts, and in most cases, the same high school for geographic similarity. Due to the matching process, the impact of the independent variables other than taking the AMR course was greatly reduced.
2. The dependent variables to determine preparation for college level mathematics were (a) precollege math courses sought, (b) completion of a college level mathematics course, and (c) grade earned in the college level mathematics course (when applicable). The descriptive and inferential statistical tests showed no significant relationship between the students who took the AMR course and those who took no mathematics during the senior year of high school.
3. The dependent variable that was found to be significantly different between the representative and comparison groups was mathematics placement test scores. The Wilcoxon signed rank test showed the mean rank for those who took the AMR course to be significantly higher than the mean rank for those who did not take the course which supported initial *t test* findings.

CHAPTER 5

Discussion

The following section will detail the findings of the current study in light of national and statewide issues around transitions in mathematics. In addition to study findings, implications for practicebased on research and personal insight will be examined, followed by study limitations that are inherent with causal-comparative study designs and implemented statistical research methods. Based on the study limitations and additional gaps in the research involving the significant area of high school to college transitions in mathematics, recommendations for future research will be considered and outlined.

Overview/Findings

Nationwide there is concern that students are not adequately prepared for college level work at a time when success in college can impact the ability to earn a living wage and sustain employment (Bailey, et al., 2004, Prince & Jenkins, 2005). With technological innovation and globalization impacting the economy, skills for the jobs of the future will require more advanced skills in mathematics (Bailey, et al., 2004; Kirst & Bracco, 2004; Venezia et al., 2008; U.S. Department of Education, 2008), yet research shows that students are finding it increasingly difficult to succeed in college. This is most apparent at the community college, where over 50% of students enroll in at least one developmental course during their years at the two-year college (Bailey et al., 2010), and that percentage is higher (60%) for first-time community college students (Levin & Calcagno, 2008). In Washington State, of recent high school graduates enrolled in a community college in 2008-2009, 48% required remediation and once enrolled in precollege courses, struggled to progress through the sequence and reach a “tipping point” of completing a college level mathematics course (Bailey, et al., 2010; Jenkins, 2008). With the cost of remediation high (Carnevale, 2007; Strong American Schools, 2008; U.S. Department of Education, 2008), significant effort is underway to focus on the transition from high school to postsecondary education (Achieve, 2007, Bailey & Morest, 2006; Conley 2007ab). This transition is becoming more paramount as an increasing number of high school students are aspiring to go to college (Kirst & Bracco, 2004), taking more rigorous high school mathematics courses, and performing slightly better on national exams (Nord, et al., 2011).

At the center stage of the transition from high school to post-secondary education is the senior year of high school often referred to as the “senior slump” (Conley, 2005b, Charles A. Dana Center, 2006; Newton, 2010) as many students stop taking mathematics during their senior year after meeting minimal high school graduation requirements. The purpose of this study was to explore the offering of a mathematics course during the senior year of high school titled Applications in Mathematical Reasoning (AMR) that was deemed rigorous by requiring Algebra II as a prerequisite course (ACT 2005, 2007; Cavanagh, 2008; Charles A Dana Center, 2006; Zelkowski, 2011), based on well established College Readiness Mathematics Standards, and focused on conceptual development though real-world, problem solving activities.

Matching. The members of the representative group who took the AMR course during the senior year of high school were matched with like participants in the comparison group who took no mathematics during the senior year. The matching variables were (a) gender, (b) ethnicity, (c) Algebra II grade during junior year, and (d) high school GPA. Socio-economic status, mostly measured by students qualifying for free or reduced lunch, was not able to be provided for all the participants and therefore, not included in the matching. Since free or reduced lunch qualification is not always an accurate representation of socio-economic status because it is self-reported, matching students who attended the same high school or district and transitioning to the same community college within a like geographical region was utilized in an attempt to control for socio-economic status. Overall GPA in mathematics courses in high school was also not provided for the purpose of this study which might have provided additional insight into mathematics performance. Matching was carried out based on a "nearest neighbor" approach that matched students first by Algebra II grade and high school GPA with the other variables matched next. The process was carried out numerous times in order to confirm the matching results. During the analysis phase of this study, descriptive and inferential statistical tests showed that the representative and comparison groups were significantly similar based on the matching variables and confirming the matching process.

Mathematics preparation. The goal of this study was to examine the effectiveness of the AMR course in terms of preparation for mathematics at the college level. Based on the literature reviewed in Chapter Two, students could be considered prepared for college level mathematics if they (a) need less remediation as evident in the number of precollege courses taken; (b) persist in mathematics by seeking remediation classes, progressing through a precollege sequence and eventually completing a college-level course; (c) earn higher grades in their first college level mathematics course taken; and (d) place into a higher level of mathematics course.

Less need for remediation. Determining the need for remediation for students who took the AMR course compared to students who took no mathematics during their senior year of high school was analyzed with data mainly based on Research Question One which stated the following:

- To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters (summer excluded) compared to similar students who took no mathematics course their senior year of high school?

The examination of this question considered the number of credits of precollege mathematics courses taken during the first three quarters while enrolled at the community college. All precollege courses for the participating sites were five quarter credits with the assumption that fewer credits may indicate less of a need for remediation.

Findings: Remediation. The mean score of the number of precollege mathematics courses taken was slightly higher (M = 1.31) for the comparison group of students who took no mathematics during their senior year of high school compared to the representative group who completed the AMR course (M = 1.26). However, the analyses findings determined that this difference was not significant based on cross-tabulation, chi-square, and Fisher’s exact test. A Cochran-Armitage trend test was also performed to support the findings. In some cases, having no remedial credits indicated that a student placed out of precollege mathematic courses and directly into college level, a factor that would be included in the analysis of the placement test scores and Research Question Three. In other instances, students may have chosen not to take a precollege course, waiting until their second year before enrolling in mathematics courses. Even though there was no significance in terms of mean value between the representative and comparison groups, the standard deviation for both groups was similar (SD= .47, no AMR; SD= .44, yes AMR), indicating a comparable spread. Overall, there were 65 courses taken (325 credits) for both groups combined which could support the concept that many students do enroll in precollege mathematics courses.

Discussion: Remediation. Related research indicated that remediation trends are a significant problem for students transitioning from high school to college (Achieve, 2004; Bahr, 2008; Bailey, 2009; Bailey & Morest, 2006; Bettinger & Long, 2005, Conley, 2005b; Kirst & Bracco, 2004; Levin & Calcagno, 2008).When students are placed into precollege courses, their ability to complete degrees when aspiring to do so is compromised (Bailey & Morest, 2006; Kane & Rouse, 1999; National Commission on the High School Senior Year, 2001, Newton, 2010) and the cost to individuals and institutions is skyrocketing (Bailey, 2009; Levin & Calcagno, 2008; Strong American Schools, 2008) further challenging our nation's ability to prepare workers for careers in the 21st Century.

Even though researchers attribute increased remediation rates to a lack of an interconnected K-16 system, problems with accurate and standardized placement exams, and overall curriculum standards alignment (e.g., Achieve, 2007; ACT 2005, 2007; Conley, 2005b; Kirst 1998, 2008), there was little to no research found that could connect specific mathematics courses taken during the senior year of high school with remediation. Furthermore, though there was minimal research about successful solutions for addressing the growing need for taking precollege courses (Attewell et al., 2006; Bahr, 2008; Levin & Calcagno, 2008; Long, et al., 2009), the studies that did exist relied on survey responses (e.g. Strong American Schools, 2008) by participants who may not have accurately represented their educational experiences; analyzed data from the National Education Longitudinal Study of 1988 with follow-up studies that are at least ten years old (Attewell et al., 2006; Bailey et al., 2009, 2010); or only involved four-year institutions that may not be applicable to community college students (Bettinger & Long, 2005). Since the AMR course was comprised of rigorous curriculum aligned to a well-developed set of college-readiness standards and resulted from a partnership between high school and community college mathematics faculty, it was expected that the findings would show that these students needed less remediation. That was not the case with this study's results, yet further analysis may lead to the discovery of other confounding variables. Future research with a true experimental or possibly regression discontinuity design, may clarify the relationship between senior year mathematics course-taking and college performance in terms of remediation and may provide some additional insight into this study's findings.

College persistence in mathematics. Determining persistence for students who took the AMR course compared to students who took no mathematics during their senior year of high school was analyzed with data mainly based on Research Question Two which stated the following:

- To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a minimum passing grade of a 1.0 compared to those students who did not take any mathematics during their senior year?

Persistence can be defined as students moving from one level to the next in terms of reaching their educational goals. Therefore, enrolling in a college mathematics course would be considered a significant level for degree or credential obtainment (Prince et al., 2010) whether progressing through precollege courses or demonstrating proficiency that enabled a student to directly enroll at the college level. Since the study found no evidence to support a significant difference in precollege course-taking between the representative and comparison groups, the data addressing persistence involved enrolling in and passing a college level mathematics course. Data were gathered and analyzed in terms of a "yes" for a participant taking a college level mathematics course, and "no" for a participant not taking such a course. All of the students who took a college level course earned at least a 1.0, deemed passing for the purposes of this study.

Findings: Persistence. Based on the utilization of chi-square and Fisher's exact test, the difference between the number of college level math courses taken for the representative group (yes AMR) and the comparison group (no AMR) was found to be insignificant even though the cross-tabulation count for taking such a course was slightly higher for those students who took AMR. A Cochran-Q test was also performed to support the result findings due to the fact that the sample size was relatively small (*n*=70). Neither group had many students who enrolled in a college level math course (*n* =12, yes AMR; *n*=9, no AMR) which is not unusual for community college students, many of whom avoid taking mathematics courses until later in their college experiences (Conley, 2007a). Furthermore, the representative and comparison groups were matched based on variables including high school GPA and Algebra II grades. The representative group had a mean high school GPA of 2.84 and a mean Algebra II grade of 1.81 whereas the comparison group had a mean high school GPA of 2.85 and a mean Algebra II grade of 1.88. Statistical analysis concluded that the two groups were not significantly different in terms of these means. Having means below 3.0 for high school GPA and below a 2.0 for Algebra II grade indicates that the participants for this study were typically “B” or “C” students which can be a factor in college performance as noted in research by Conley (2007b), Levin and Calcagno (2008), and Rose and Betts (2004). Additionally, some community college students do not seek degrees or credentials but only take courses for training or transfer to another institution. This may have been a factor affecting the outcome of analyzing college-level course-taking.

Discussion: Persistence. There are numerous national research studies that support taking a rigorous mathematics course beyond Algebra II and persistence as measured by degree completion (Achieve, 2005; Adelman, 1999, 2006; Kirst & Bracco, 2004; National Commission on the High School Senior Year, 2001; Nord et al., 2011) with some studies emphasizing the importance of taking a rigorous course during the senior year (Adelman, 2006; Bailey, et al., 2002; Conley, 2005b; Hudson-Hull & Seeley, 2010; Newton, 2010). The findings of this study for Research Question Two in regard to persistence did not support the premise of this research.

Persistence, however, is a complicated concept to measure as there are numerous factors that influence results. Though the representative and comparison groups were matched based on demographic factors (gender, race/ethnicity, geographic location) and high school grades (Algebra II grade, overall high school GPA), factors such as motivation, attitudes toward mathematics, social-economic status, family/work obligations, and parental education were not included and controlled and could be affecting postsecondary outcomes in mathematics (Jenkins, 2008; Levin & Calcagno, 2008: National Center for Education Statistics, 2007b). In addition, degree completion may not be the only indicator of persistance in mathematics. Since many two-year degrees and four-year degrees only require passing one college level mathematics course, earning a degree in certain areas would not necessarily demonstrate positive mathematics performance if the students passed their math course requirements with a minimal grade. The following section, however, will examine the findings in regard to math grades for college level course taken.

Grades in college level mathematics. Grades were analyzed for those students who enrolled in a college level math course and earned "at least a minimum passing grade of a 1.0" as referenced in the second part of Research Question Two. Transcript data from the participating community and technical colleges were analyzed with the students who took the AMR course being compared to students who took no mathematics during their senior year of high school. As mentioned in the previous section, enrolling in and completing a college level mathematics course can be a reflection of college persistence as defined by the study. In addition, grades earned in a college level mathematics course can indicate higher mathematical performance (Rose & Betts, 2004). Reaching the college level in mathematics is significant enough to be considered an indicator for college readiness and one that is being carefully scrutinized in Washington State's Student Achievement Initiative program (Prince et al., 2010).

Findings: Grades in college level mathematics. After analyzing transcript data, there were 11 students from the representative group (yes AMR) who enrolled in and completed a college level math course within the first year of school with at least a 1.0 passing grade. Only nine students from the comparison group (no AMR) enrolled and completed a college level math course. For both the representative and comparison groups, the actual grades earned in the college level math course were contrasted (M=2.84, yes AMR; M=2.72, no AMR). Though the mean for the representative group was slightly higher than the comparison group and due to the unbalanced sample size, a subsequent independent t test was performed with results confirming that the difference between the means was insignificant. Instead, the descriptive analysis and graph showed that the distribution curves for both groups shared a similar shape for the top grade scores (SD= .81, yes AMR; SD=1.04, no AMR). Based on this observation, a cross-tabulation, chi-square, and Fisher's exact test were performed. Findings showed no significant difference between the two groups for the top five scores in the college level mathematics course.

Discussion: Grades in college level mathematics. There was some research that drew a parallel between taking a higher level mathematics course in high school and obtaining higher grades in college (Adelman, 2006; Berry, 2003; Conley, 2005b; Kirst & Bracco, 2004; Lundin et al., 2004). This present study, however, was focused more specifically on college-level mathematics grades similar to the work of Hoyles, Newman, and Noss (2001) and Sadler and Tai (2007), who determined that grades in college science were being impacted by high school mathematics course-taking. Overall, the findings of this study for Research Question Two in regard to passing a college level mathematics course and grades earned did not support the premise of research connecting high school mathematics to either math course grades or overall GPA in college.

More research, however, is warranted, around the dependent variable of grades earned in college level mathematics courses as the number of studies examining this topic was minimal. In addition, as Lundin et al, (2004) maintained in their study, students in high school get conflicting messages about college requirements and what it takes to be a college student, factors that should be examined. Achieve (2004, 2007), Bailey, et al.(2002), Conley (2005a, 2007a), Karp and Hughes (2008), and Kirst (2008) are some of the researchers who have recommended more uniform standards across the high school and postsecondary sectors to address a disconnect between college level mathematics performance and expectations based on high school experiences. With more standardized outcomes for courses and communicated college readiness skills for high school graduates, additional research that was based on transcript analysis (Adelman, 2006, Hoyles et al., 2001; Lundin et al, 2004, Sadler & Tai, 2007) could be updated to explore further the connection between senior year mathematics courses and college grade performance.

Placement. Determining the placement test results for students who completed the AMR course compared to students who took no mathematics during their senior year of high school was analyzed with data based on Research Question Three which stated the following:

- To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

Students who enroll in community colleges in Washington State are placed into mathematics courses using a placement test. For the purposes of this study, the participants were mainly placed using COMPASS with a few (six total) assigned to math courses by instructor determination, high school transcript placement, or a local placement test. For those few cases in which the COMPASS scores were unavailable, an equivalent COMPASS score was assigned based on the course to which students were placed. Since students are assigned to course levels or "buckets" based on their responses to the computer adaptive questions, students could earn the same numerical score but considered at different levels. Assigning a 100, 200, 300, or 400 in front of the score indicated in which bucket the student was placed. The ranked scores were than analyzed using a nonparametric statistical test.

Findings: Placement. Initial descriptive calculations showed that the representative group (yes AMR) had a higher mean score (*M*= 248.89, SD=58.18) than the comparison (no AMR) group (*M*= 219.93, SD=70.84). An initial paired sample *t* test showed that the mean differences were significant. However, to conduct a more rigorous analysis of the data, a Wilcoxon signed rank test, a nonparametric counterpart to the *t* test, was performed, This test also showed that the mean values were significantly different and not due to chance fluctuations in the sample.

Discussion: Placement. Research indicates that students who take mathematics courses beyond the Algebra II level are more likely to place higher into college-level mathematics courses (ACT, 2005; Berry, 2003; Hoyt & Sorensen, 2001; Roth et al., 2001). Work by Conley (2005b, 2007a), The Charles A. Dana Center (2006), Hudson-Hull and Seeley (2010), Long, et al (2009) and the National Commission on the High School Senior Year (2001) has linked placement with rigorous course-taking during the senior year of high school. Hoyt and Sorensen (2001) did not find a time gap between high school and college to have a significant impact on placement scores. Furthermore, Stern and Pitman (2009) were unable to connect the AMR course to increased placement test scores when assessing the course during its 2007-2008 pilot year. Overall, the findings of this study for Research Question Three in regard to higher placement into mathematics courses at the community college support the majority of the current research. The literature is not as strong in regard to the timing of taking a mathematics course, particularly a rigorous course, and its relationship to college placement. Hopefully, the findings for Research Question Three will contribute to that body of knowledge by showing an association between mathematics course-taking during the senior year of high school and improved placement. Limitations to the findings exist due to the validity issues with placement exams, inconsistent standards across the K-16 pipeline, lack of consistency though the use of alternate placement tests, and varying cut scores within placement tests across the community college sector. Even so, the study design that matched students from the representative with the comparison group who attended the same colleges from the same school districts can mitigate some of these limitations. Additional research may also be needed to explore further high school mathematics course-taking and placement test scores, particularly in light of the development of alternate methods of placing students into mathematics courses.

Implications for Practice

The epistemological lens through which this research was conducted was postpositivism in which the researcher must remain objective and detached from the study proceedings (Manning & Stage, 2003). However, postpositivism acknowledges that, though limited, bias cannot be totally eliminated as research evaluation and observations are imperfect (Schutt, 2009). What contributed to bias for this study and disclosed in Chapter Three was the fact that as the researcher, I had also been involved as a community college faculty member and administrator in the grant work that developed and implemented the AMR course. With a master's degree in mathematics education, developmental mathematics teaching experience at the community college, and former work as a K-12 teacher, my background may have produced bias but also provided insights into the issues facing students who transition from high school to the community college in mathematics. While the research was carried out in a scientific and systematic way in order to minimize the impact of bias on study results, Schutt (2009) also recognized that though reducing bias is paramount, replicating research and searching for regularities or patterns in order to build upon social theory should be emphasized. Conducting additional work around a similar theme can contribute to the social theory and help achieve “intersubjective agreement” or “an agreement by different observers on what is happening in the natural or social world” (p. 89). With this goal in mind, based on the results of this study, and guided by my own educational and employment background, the following section provides recommendations for future practice that can improve the college-readiness math skills for students transitioning from high school to college while contributing to the scholarly field of knowledge.

Alternate rigorous mathematics courses. Because of the current study’s findings that there is a significant relationship between taking a mathematics course during the senior year of high school other than precalculus and higher placement into community college mathematics courses, it would be worth exploring the development of alternate courses and consider expansion of the AMR course to other districts. By design, the AMR course was considered less traditional in terms of its hands-on professional development training for teachers, conceptually based curriculum, problem-solving emphasis, and group activities so the study findings bring some credibility to the development of alternate courses that are less focused on “skill and drill.” The professional development piece to the AMR course could have been a factor in its impact on student’s success in college. Therefore, continuing professional development training for teachers to implement a course like AMR in ways that engage students and explore real-world topics should be emphasized, similar to the professional development recommendations by the senior capstone course in Texas (Charles A. Dana Center, 2006, 2008, 2009). The fact that the AMR course was deemed rigorous because it was beyond the Algebra II level may have influenced the study findings and should encourage the development of rigorous courses rather than just the number of math credits (Adelman, 2006; Dougherty, 2008; Dougherty, Mellor, & Jian, 2006; Hudson-Hull & Seeley, 2010; Jago, 2000). In addition, it is possible that the placement results were impacted by the taking of a rigorous course during the senior year as advocated by researchers in Chapter Two (ACT, 2005; Adelman, 2006; Conley, 2005b; Hoyt & Sorensen, 2001; Hudson-Hull & Seeley, 2010; Karp & Hughes, 2008; Ma & Wilkins, 2007; Zelkowski, 2011), therefore, continuing to explore senior year math course offerings is warranted.

Mandatory placement in basic skills classes. Though the findings for this study did not show a direct connection between taking the AMR course and seeking and completing precollege courses, the research did support continually taking mathematics courses (Hudson-Hull & Seeley, 2010; Newton, 2010, Zelkowski, 2011). Researchers like Conley (2005b) have advocated that students should take mathematics during their first year of college after taking mathematics during the senior year of high school. Prince et al. (2010) also recognized that the importance of reaching the college level in mathematics, as completing a college level math course has college readiness and achievement implications. Enrolling in and completing remediation courses could also be more successful for students than just placing directly into college-level courses as maintained by Bettinger and Long (2009), In addition, Sanders (2007), in her dissertation findings, recommended that mandatory placement be practiced as her study found a positive relationship between students taking remedial courses and persistence rates. Some of the criticisms for such a practice would be the limitations to students in terms of accessing courses and would have implications for course offerings and schedules. However, mandatory placement into basic skills courses like mathematics would be worth examining based on personal experience, since students who stop taking mathematics courses within a sequence can lose momentum and struggle to catch up with the material when they eventually take a math course for a degree or program requirement.

Four years of high school mathematics. The Charles A. Dana Center at the University of Texas has spearheaded the development of standards in high school mathematics that require four years of mathematics including one course at the precalculus/beyond Algebra II level (Charles A. Dana Center, 2006, 2009). Additional work by Conley (2007b), Newton (2010), Charles A. Dana Center (2006), and Zelkowski (2010) recognized the importance of taking mathematics courses all four years of high school including the senior year. Findings from this study examined a course offered to students during the senior year of high school after completing Algebra II during their junior year of high school, and these students ended up enrolling in mathematics courses all four years of high school. With the findings showing a positive relationship between taking the AMR course and higher placement into mathematics courses at the community college, it would appear worthwhile to consider the feasibility of a four-year mathematics requirement for high school graduation in the state of Washington, similar to Texas, and research student college readiness in mathematics based on that requirement.

Improvements in math placement. Even though the findings from this study showed a significant difference between the representative and comparison groups in terms of math placement test scores at the community college, one of the limitations to the findings is that community colleges are not consistent with how they utilize and implement the COMPASS placement test in regard to placing students into classes. Colleges within those states that use COMPASS vary as to whether they: (a) require placement tests; (b) enforce a common placement cut score; (c) require mandatory placement into developmental education courses; (d) allow for retakes and challenges; and (e) utilize COMPASS in conjunction with alternate placement tools (Collins, 2008). Though Washington State is implementing the College Readiness Math Test with a recommended cut score for entry into college-level mathematics and advocating for utilization of alternate multiple measures when placing students (Washington State Board of Community and Technical Colleges [SBCTC], 2011) the communication of transparent placement policies based on consistent expectations for success in college is at the forefront of placement issues (Collins, 2008). Since the AMR course was based on the College Readiness Mathematics Standards (CRMS), developed through K-16 collaborative efforts orchestrated by the Transition Mathematics Project (TMP), this study on the feasibility of the course would support further exploration of math placement refinement. In addition, one of the multiple measures being recommended is the use of high school transcripts when placing students into community college math classes, a policy currently in practice at Green River Community College. Since such a policy emphasizes highest *level* of math course taken in high school and most recent *year* taken, this research that examines senior year math course-taking would parallel efforts to research transcript placement. (SBCTC, 2011)

K-16 transitions improvement. This study, examining the relationship between taking the AMR course during the senior year of high school and college-preparedness, relied on high school transcript data provided by the K-12 school districts, transcript data assembled by the Washington State Board of Community and Technical Colleges (SBCTC), and placement test scores provided by community college institutional research offices. Since student identifiers differed between the K-12 and community college system, personal identifiers had to be shared in order to track students from one system to the other. Though the identifiers were coded and eliminated for this study in order to protect the privacy of the participants, the process was still considered arduous and time-consuming for those K-12 and college staff who collected the data and the SBCTC staff who were required to de-identify the data for analysis purposes. Furthermore, transcript data themselves contain inherent challenges as most high school and college transcripts are based on varying sets of standards. This study contributes to the field of research that calls for a more seamless transition among K-16 educational levels (Achieve, 2007; Collins, 2008; Conley, 2007a; Kirst & Usddan, 2007; Kirst, 2008; Tell & Cohen, 2007). The National Governors Association Center for Best Practices et al. (2008) advocated for (a) linking K-12 and postsecondary data; (b) connecting high school and college curriculum in terms of curriculum and assessment based on college and career readiness standards; and (c) forming P-16 councils to monitor transitions among the various educational sectors. Improved K-16 data sharing would also help minimize validity issues inherent in research relying on high school and college transcripts that are neither linked nor aligned, an issue that may have impacted the findings from this study. Another hope for improved K-16 communication and transitions would be to award dual credit for courses like AMR, which is similar in scope and rigor to some college-level math courses. From personal experience, providing college credit would increase the efficiency of students progressing through college as well as help reduce the overall college costs that are of major concern in the political and academic arenas today.

Limitations of Study

As with any approach to research, postpositivism and the current research design have inherent limitations that can impact study findings. Though the postpositivism approach attempts to reduce bias by employing systematic and statistically-based data analysis strategies, the greatest limitation lies in an inherent risk of making causal determinations. Furthermore, a causal-comparative, non-experimental design based on postpositivism cannot support the same cause and effect findings that results from a well-designed experimental study (Creswell, 2008; Gall, et al., 2007; Johnson & Christensen, 2012). The current study found that there was a statistically significant relationship between taking the AMR course during the senior year and math placement at the community college compared to matched students who took no mathematics courses. Because of the causal-comparative design, no conclusions as to the “cause” for this difference can be drawn, but rather, the study findings can be utilized as a basis for future research, hopefully quasi-experimental or experimental design studies.

A second limitation to the study was its reliance on transcript data that were not standardized between the high schools and postsecondary institutions and did not contain non-academic variables that may have impacted college readiness. Some of these non-academic variables could include highest level of parent's education, attitude toward math, motivation, living conditions, language proficiency, socio-economic status, and family/work obligation utilized in other research studies (Jenkins, 2008, Levin & Calcagno, 2008; National Center for Education Statistics, 2007b; Rose & Betts, 2004). Though this study matched the representative and comparison group participants based on non-academic variables such as gender, race/ethnicity, and age as advocated by Bailey et al. (2009) and Jenkins (2008), socio-economic status was unable to be consistently gathered for the participants. It was hoped that by matching participants from like high schools and K-12 districts who attend the same community college within similar geographical regions that the impact of socio-economic factors would be minimized. However, it would be prudent for future researchers to gather socio-economic status data and control for that specific variable through the study design.

In addition to addressing socio-economic factors, incorporating a survey design study would be advantageous in terms of gathering data from the participants that may contribute to factors associated with motivation and perception around mathematics courses and curriculum, which were unable to be analyzed in this study. This qualitative information may have also addressed the parental involvement of the participants, as students who took the AMR course may have done so because of stronger parental support compared to students who took no mathematics courses during the senior year of high school. In terms of academic variables, matching the participants by Algebra II grades and overall high school GPA scores seemed adequate and representative of academic performance in high school. Motivational factors would have likely influenced remedial and college-level course-taking behavior addressed in Research Questions One and Two. Unfortunately, high school math GPA was not provided with the high school data and may have been an additional factor in mathematics performance that could have strengthened the use of the Algebra II/high school GPA variables.

A third limitation to the study was the number of participants and subsequent process that matched the representative participants with the comparison group. Because the study focused only on students who transitioned to the community college rather than the four-year universities and colleges, the number of students in the original sample was rather small. This low *n* value then impacted the overall number of matched pairs (*n*= 35) that could be obtained while still meeting the qualifications of participants in both groups completing Algebra II during the junior year of high school and either taking the AMR course or no mathematics during the senior year of high school. In addition, the small number of community colleges and high schools participating in the study limited the overall sample size. Because of the small *n* value, matching had to take place using the "nearest neighbor" method beginning with Algebra II grade points and high school GPA. This may have been less scientific than using propensity score matching, a technique utilized in other studies that match participants but requires a greater *n* value to substantiate. Furthermore, because four-year institutions were not included and the *n* value was limited, the Algebra II grades and high school GPA for the majority of participants fell in the B or C range, which would indicate that better performing students were not adequately represented in the study and therefore impacting generalizability of the study findings. The lower *n* value also impacted Research Questions One and Two as many students who attend community colleges do not always immediately enroll in mathematics courses during their first year of attendance (Bailey, 2009).

A final limitation to this study was the reliance on placement scores for analyzing Research Question Three. Placement testing among the community colleges has significant inconsistencies as addressed earlier in this chapter, and though COMPASS is a widely accepted placement test, results do not always place students into the appropriate course. There are also inconsistent scoring procedures among the community colleges as colleges locally determine their own cut scores for placement into classes based on expert judgment, course offerings, and curricular knowledge. Furthermore, most community colleges provide advising, offer opportunities to challenge the result findings, and may consider high school transcripts or individual interviews to place students accordingly that can affect placement decisions (SBCTC 2011). In addition, three participants from the representative group (yes AMR) and three from the comparison group (no AMR) did not have placement scores so were assigned scores based on the enrolled math course and the median value for that particular ranked bucket. These students did not subsequently have to experience issues associated with taking a computer-adaptive test for placement, but since the number of cases was quite low and median value used, the impact would have been minimal. Regardless of these limitations, research values the use of a variety of placement tools and expert judgment of college faculty and staff regarding placement decisions (SBCTC, 2011), factors that needed to be acknowledged and respected for the purpose of this study.

Recommendations for Future Research

Based on the findings from this study, recommendations that a study conducted within the worldview of postpositivism replicate research findings in order to build on social theory, and my own experiences as a community college administer and educator, the following are some suggestions for future research that can improve the knowledge base regarding high school to college transitions in mathematics.

Teacher/student perceptions. When the AMR course was analyzed during its pilot year, one of the recommendations for future research was to gather data from teachers who were teaching the course and obtain their reflections and recommendations as to its effectiveness (Stern & Pittman, 2009). This research could be carried out through the use of focus groups and survey research that are effective tools for gathering opinions and perceptions (Creswell, 2008; Gall, et al., 2007; Johnson & Christensen, 2012). The effectiveness of the professional development for training teachers to teach the AMR course and gleaning the understanding these teachers have regarding college-readiness skills could also be examined through interviews. Designing a study that incorporates math teacher perceptions from both the high schools and community colleges may also provide some insight into barriers to successful K-16 transitions.

Affective data pertaining to the students in the course would also be useful as to whether the AMR course's design and focus contributed to an increase in the enjoyment of and confidence in learning mathematics. Such a study would be particularly useful, since many of the students who took the AMR course were "B" or "C" students based on Algebra II grades and overall high school GPA. Survey data may also provide insight into the decision of taking the AMR course and implications for required parental involvement, motivation, and other non-academic variables.

Alternate senior year math courses. The AMR course is just one course that is being offered at high schools during the senior year. Precalculus, statistics, and business mathematics are just some of the examples of alternate courses that go beyond the Algebra II threshold. Including these courses and even AP math courses in a longitudinal study may help answer the questions, "Is it the timing of taking the course (senior year) or the rigor of the curriculum that matters more regarding college-readiness?" An analysis that examines students who take one of these options with those who take the AMR course and with those who take no mathematics in the senior year may discover whether the AMR course impacts student success in college or if any math course taken during the senior year, regardless of design, would yield similar results. Furthermore, additional studies that consider the Algebra II prerequisite may confirm other researchers' theories (and this study's assertion) that Algebra II, in its current common format and containing the present curriculum, is a significant gateway course that is a required prerequisite for rigorous math courses. Studies that examine alternate senior math courses should also include the preparation of students for the world of work as opposed to just college-readiness skills.

Remediation. This study was unable to determine significance differences regarding the remediation course-taking patterns in college as they relate to high school mathematics courses taken during the senior year. This study could be replicated but should include (a) increasing the number of participating high schools and colleges; (b) focusing on colleges that require mandatory placement so students immediately enroll in remedial courses; (c) including colleges that have similar precollege math sequences; and (d) incorporating grades earned in remedial classes to consider successful completion and persistence (Sanders, 2007). The literature examined for this study revealed the growing focus on remediation and the problem that exists for students who have to take precollege courses after successfully completing similar courses during their high school experiences. Future research is warranted as much of the current research recognized the drastic increased need for remediation but often does not clearly recommend effective solutions to this national problem.

Chapter Summary

The findings of the current study based on the research questions showed that taking the AMR course during the senior year of high school, a course deemed rigorous because of its Algebra II prerequisite, had a statistically significant relationship with improved placement into mathematics courses at the community college. Participants in the representative group were matched with the comparison group from the same high school or school district and attending the same community college, a process that was supported by the statistical analysis comparing the two groups on the variables of gender, ethnicity, Algebra II grade, and overall high school GPA. The placement findings have implications for math preparation and college-readiness skills that can contribute to the field of study around K-16 transitions. A relationship, however, could not be significantly determined between the AMR course and seeking to enroll in precollege math courses, which may have impacted persistence, a concept supported by research on taking rigorous coursework during the senior year of high school. In addition, the connection between the AMR course and completing a college level math course with higher grades could not be established through the research findings. Limitations to the study may have impacted the results and suggest factors to be considered for future research.

Even though the research questions for this study could not be answered resolutely, these questions and methods could lay the foundation for follow-up studies. Such studies, if well controlled, may find a positive relationship between senior year course-taking behavior and a reduced need for remediation and greater success for students progressing toward their goal of a degree or credential when attending college. Based on the research examined, personal experiences, and the study findings, there is support for considering the following policies: (a) create alternate math courses offered during the senior year; (b) enact a mandatory placement particularly for students who place into precollege courses; (c) consider four years of mathematics, including the precalculus level, as a requirement for high school graduation, and (d) continue fostering K-16 communication and reduce the barriers to a successful transition between the high school and post-secondary sectors. Additional research is also warranted in determining the perceptions of the teachers and students involved in the AMR course and college mathematics courses to understand their unique situations and insights into what it takes to be truly prepared for college.

CHAPTER 6

Conclusion

According to study findings regarding the 2007 Trends in International Mathematics and Science Study (TIMSS) (Gonzales, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2008), the U.S. is still scoring lower than other developed nations in mathematics for students in K-12. As a result, more rigor is being emphasized in high school requirements, and more students are enrolling in additional rigorous mathematics courses than previously in our history (Bailey & Morest, 2006; National Center for Education Statistics, 2007a, Nord, et al., 2011). In addition, 70 percent of high school students attend college immediately after graduating from high school (NCES, 2011) as they understand that technological innovation and globalization will require advanced skills in mathematics and science and that college degrees and credentials can pave the way for increased earnings and job security (Carnevale, 2007, Strong American Schools, 2008, U.S. Department of Education, 2008). The question to be asked, however, is: “Can postsecondary institutions meet the challenge of this upcoming surge and demand for college mathematics?” The answer may lie with the community colleges as they try to prepare students for degree or credential completion while facing the reality that more students are requiring remediation, particularly in mathematics (Bailey, et al, 2010, Bailey & Morest, 2006). These underprepared and often underrepresented students struggle to reach the success threshold or “tipping point” of attending college for at least one year to obtain a credential and solidify their achievement by completing a college-level mathematics course (Prince & Jenkins, 2005; Prince, et al., 2010). The subsequent “train wreck” between K-12 college seekers and community college students struggling with college readiness will likely happen at the historically significantly senior year of high school, a time that many students stop taking mathematics and engage in a “senior slump” that results in avoidance of rigorous coursework.

With this problem facing our educational system in mind, this study focused on the implementation of a senior math course, Applications in Mathematical Reasoning (AMR), which was developed by the Transition Mathematics Project (TMP) in order to provide a rigorous alternate to precalculus for students who are likely to take no mathematics during their senior year of high school. Students taking the course were required to complete Algebra II during their junior year of high school and experienced a rigorous, real-world curriculum that engaged them with problem-solving and group activities. To examine the relationship of the AMR course and student success in college as defined by (a) mathematics preparation, (b) less need for remediation, (c) college persistence in mathematics, and (d) improved placement, this study addressed the following research questions:

- To what extent did high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college seek remediation in their first three quarters (summer excluded) compared to similar students who took no mathematics course their senior year of high school?

- To what extent are students who took the AMR course during their senior year of high school and transitioned directly to a community college more likely to enroll in college level mathematics and earn at least a minimum passing grade of a 1.0 compared to those students who did not take any mathematics during their senior year?
- To what extent do high school graduates who took the AMR course during their senior year of high school and transitioned directly to community college earn higher scores on mathematics placement tests than those who did not take mathematics during their senior year?

In order to answer these questions, a causal-comparative study was designed that matched participants from the representative group (yes AMR) with the comparison (no AMR) group based on K-12 transcript data and resulted in 35 pairs of students attending the same community colleges from participating sites. Data were also gathered on the matched pairs from community college transcript data and placement score results from COMPASS. Analysis of the data involved descriptive and inferential statistical tests utilized to determine if there was a significant relationship between taking the course and selected dependent variables as outlined in this study.

Findings. The major findings of the study were as follows:

- Significance testing showed that the representative and comparison groups were well-matched and similar based on (a) gender, (b) ethnicity, (c) Algebra II grade, and (d) high school GPA.

- The descriptive and inferential statistical tests showed no significant relationship between taking the AMR course and preparation for college level mathematics in terms of (a) precollege math courses sought, (b) completion of a college level math course, or (c) grade earned in first college level course for those participants who reached the college level.
- Math placement test scores were found to be significantly higher for those students who took the AMR course compared to students who took no mathematics during their senior year of high school. This finding supported other research that linked high school mathematics course-taking and improved college placement into mathematics courses and subsequently, an improvement in student retention and academic achievement.

Final thoughts. The postpositivist worldview recognizes that reality can only be obtained through many research studies that will eventually point the way toward scientific truth. This study supports this view as it is only a small piece in a very complex puzzle addressing K-16 transitions as they pertain to mathematics course offerings during the senior year of high school. Hopefully, community college leaders can use this study information as additional support to continue to work with K-12 partners and reinvent our high school/postsecondary pipeline. As educators, we all need to continue the journey to fine-tune an educational system rich in history and with a consistent goal that has stood the test of time: help *all* students reach their educational potential for a prosperous future and thriving democracy.

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