EXPLORING STUDENT SUCCESS FACTORS IN A REMEDIAL MATHEMATICS COURSE: A QUALITATIVE STUDY OF MEDICAL IMAGING AND NURSING STUDENTS AT A SMALL, PRIVATE COLLEGE

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Carl David Gilmore

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Abstract

The purpose of this qualitative study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course at small private college. A case study method was used to answer the one research question: what factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course? The case study included eleven student participants, three faculty who taught remedial mathematics, and supporting documents. The student participant sample included both medical imaging and nursing students. Data was gathered primarily through individual interviews with the student participants. There was one focus group that included all three of the faculty. Other documents that were related to the case were gathered and analyzed. Data was analyzed using an inductive and deductive approach, coding, and constant comparison.

Findings show that students had a self-awareness that they needed to seek help in order to pass the course. Once they made the decision to seek help, they obtained help from a variety of academic support services and resources available at the college. Students in this study had motivation that was career-driven. Students also believed that there was a commitment from their faculty to help them be successful in the course. The required math lab was described by all eleven of the student participants as beneficial to understanding the material. All student participants talked about some level of support they received from their peers. Finally, the amount of time that each student participant put into practicing the math problems so that they could understand the material was described as critical for their success. Four conclusions were drawn from the findings of this study: 1) having a career goal and rigorous program entrance requirements served as strong motivators for students to pass the remedial mathematics course;
2) self-direction (manifested as seeking one-on-one support) was integral to success; 3) perceived faculty commitment contributed to student success; and 4) learner-centered curricular design of remedial mathematics benefited students.
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CHAPTER ONE: STATEMENT OF THE PROBLEM

Introduction

The number of first-time students entering college in the United States who lack the quantitative skills required for the rigor of college-level mathematics courses (Attewell, Lavin, Domina, & Levey, 2006; Dasinger, 2013; Medhanie, Dupuis, LeBeau, Harwell, and Post, 2011; Melguizo, Kosiewicz, Prather, & Bos 2014) continues to grow, and represents a significant problem for both colleges and students. For colleges, a solution to the growing number is continued administration of placement examinations in mathematics and the addition of more remedial mathematics courses (Dasinger, 2013; Melguizo et al., 2014). For first-time college students, it often means being placed in a remedial mathematics course their first semester and a potential delay in starting prerequisite and core courses. For those who do not pass the remedial mathematics course, the lack of quantitative skills is of even greater significance if it results in not being accepted into the major of their choice (Hackett, 1985; Hackett & Betz, 1989). It is this latter category of students that poses the most serious problem; in that, among these first-time students who don’t pass remedial mathematics are individuals with aspirations of entering the health professions, in particular, the medical imaging and nursing professions. These professions require strong quantitative skills as mandated by their accrediting and professional organizations (American Association of Colleges of Nursing [AACN], 2008; Joint Review Committee on Educational Programs in Nuclear Medicine Technology [JRCNMT], 2014). Given that some of these students will leave college never having achieved their goal, it would seem in a college’s best interest to do what it can to assist these students in passing remedial mathematics, allowing them to move forward with the prerequisites for their major.
Given the need for medical imaging and nursing professions to have strong quantitative skills amid an increasing number of students requiring remedial mathematics, there is a need to understand what factors that help students succeed in remedial mathematics and matriculate into one of these health professions. This study explored the research topic within an institution that has a large percentage of incoming students needing remedial mathematics. At the same time, many of the incoming first-year class wish to enter one of these professions. The study site is described in detail in the following section.

Study Site Overview

This study site was a small, private Catholic college in New England with an enrollment of approximately 2,000 students. The college offers associate, baccalaureate, masters, and doctoral degrees. At the time of the study, the undergraduate population was approximately 1,000 students, with the incoming first-year class of 2015 comprising approximately 290 students. The student body was a diverse mix of students from 26 states and 30 countries. Thirty percent were minority and international students. Over 90% received some form of financial aid and over 40% of this undergraduate population was considered first-generation students. The college prides itself on being a diverse community and providing opportunities to all students who may or may not have similar opportunities elsewhere. The mission of the institution is supported by the admission practice of creating an inclusive environment where all students can be prepared for work and life. The focus of the undergraduate population is centered on being a small, four-year, residential college.

The college has established a reputation around the health professions with a strong emphasis on the liberal arts. More than 50% of the degrees conferred each year are in the health professions. While the number of students admitted directly into the nursing program as
freshman (because they do have the prerequisite math and science skills) is most often more than sufficient to fill the nursing class, the college remains committed to its mission of inclusivity. Thus remedial math remains an important course. The site was chosen because the administration and faculty at the institution were particularly concerned regarding the relevance of the remedial mathematics that they offered, the number of students in their freshman classes needing remedial mathematics in order to enter into the medical imaging and nursing programs, and the number of students who did not successfully pass the course.

Some of the students in the remedial mathematics course at the site for this study were able to pass the course. By doing so, they demonstrated the mathematical competency required to progress towards their intended major. The outcome for these students was consistent with the literature that supports the value of remedial education in terms of progression and graduation (Attewell et al., 2006; Bahr, 2012; Bahr, 2010a, 2010b; Hall & Ponton, 2005). Bahr (2010b) suggested that students who “remediate successfully” (p. 232) in mathematical skills, experience similar academic outcomes related to persistence and graduation rates as do students who did not require remediation. On the other hand, some students are simply unable to progress into their intended majors because they are not successful in demonstrating the mathematics competency necessary to pass the remedial mathematics course.

Remedial mathematics education had been a concern for several years at this institution given the fact that the number of students who needed remedial mathematics had doubled over the last decade. Multiple attempts had been made to address the lack of mathematical skills the students had when entering this research site for their first year of college. All students entering the research site took the Accuplacer test administered by the College Board, which is the college-level course placement examination to assist colleges and universities in determining the
best course in which to place first year students to help students be successful in passing courses their first year (Mattern & Packman, 2009; Scott-Clayton, 2012). The College Board does not set the score that the individual college or university should use to place students; however, they provide guidelines based on correlation data of the placement test scores and the course grades in colleges and universities. Accuplacer is a computer-adaptive placement examination and “in 2008, more than 1,300 institutions used Accuplacer tests and nearly seven million exams were administered” (Mattern & Packman, 2009, p. 2). The scores range from 20-120 and for the mathematics portion, there are 17 multiple choice questions on arithmetic and 12 on elementary algebra. The site in this research study used 100 as minimum score to move into pre-calculus or statistics. Those who scored between 70-100 were required to take a remedial mathematics course that is credit bearing, but not applied toward a major for graduation; those who scored below 70 are required to take a remedial course in mathematics that is non-credit bearing.

Prior to fall 2014, the site offered two remedial courses in beginning algebra, which were non-credit bearing, and intermediate algebra, which was a 3-credit course that did not count toward any major. In the fall 2014 semester, the first-year mathematics sequence was revised to include a quantitative reasoning course for all first-year students who scored below 100 on the Accuplacer exam, replacing the previous remedial mathematics courses. As in the older model, students who scored 100 or above were placed into a college-level mathematics course, such as calculus or statistics (based on the students intended major). Quantitative Reasoning (QR 101) was designated as the foundation course in mathematics for all students who scored below 100. In order to address the students who would need additional remedial mathematics, a co-requisite model would be provided. This meant that these students would take the 3-credit Quantitative Reasoning course (QR 101), along with an additional 1-credit remedial course that consisted of a
lab. This course was designated as a comprehensive Quantitative Reasoning course with remedial mathematics education (QR 101A). It is this course and the students that were of interest in this study. Students who scored below a 70 on the Accuplacer exam were placed in QR 101A, which included the co-requisite remedial course.

In fall 2015, 171 students (69%) of the entering first year class scored below 100 and were required to take one of the quantitative reasoning sequences (foundation mathematics course) before moving into a higher-level college mathematics course. Of these 171 students, 96 (56%) had to take the remedial co-requisite course (QR 101A). Among these students who had to take the remedial co-requisite course (QR 101A), only 45 (47%) achieved a passing grade of a “C-” or better in order to move into a higher college-level mathematics course. Only 42% of the 56% that were required to take the remedial co-requisite course (QR 101A) achieved a “C” or better. A “C” or better was the minimum grade for programs in medical imaging and nursing prerequisite courses in order to be accepted into the major. While quantitative reasoning was not a specific required prerequisite course for medical imaging or nursing, it did determine who was eligible to move into the prerequisite mathematics and science courses.

The students in either the QR 101 or QR 101A course took the courses based on their schedules and were not placed in the courses based on their majors or programs or interest. There was a cap of 20 students per each class and there were a variety of faculty members that taught the course including full-time professors in mathematics and part-time and adjunct faculty members. There was one coordinator of all of the quantitative reasoning courses. This individual, with consultation from all faculty members in the mathematics department, determined the course placements for the incoming first-year students after the Accuplacer placement examination had been administered. The college had also increased its tutoring
resources, developed a Quantitative Learning Center, and offered academic coaching through the Academic Center for Excellence, now called the Learning Commons, specifically for the students in the health professions.

The two programs of study at the site under investigation represented two of the largest undergraduate populations. Combined, the two programs made up more than 50% of the total health professions at the college. The medical imaging program in nuclear medicine at the research site was accredited via the JRCNMT, which used the standards mentioned in the sections above. Similarly, the nursing program met the requirements set forth by the AACN (also mentioned above). Even after these multiple new resources and a change in the remedial mathematics courses, many of the students who actually sought acceptance into the medical imaging or nursing programs did not matriculate because they lacked the mathematical skills necessary to move into the prerequisite mathematics and science courses. Despite the course redesign based on literature and best practices at other institutions, some students were still not successful. Therefore, exploring the factors that contributed to the success of students who did successfully complete the remedial mathematics course and were eventually accepted into the program of their choice was justified. The successful student in this study is defined as one who passed the remedial mathematics course with a grade of a “C” or better.

In order to help the large percentage of students hoping to be in the medical imaging and nursing programs, it was important to this site to understand the factors that these students report as helping them to be successful in the remedial mathematics course. Thus, the population of focus in this study was students who were accepted into the medical imaging or nursing program (second or third year of college) after successfully completing a required remedial mathematics course their first semester of college. Given this population focus, the study was by nature,
retrospective. Students who were successful in passing the remedial mathematics course, but were unable to pass the remaining prerequisite courses and were not accepted into the medical imaging or nursing programs, were not examined in this study. The focus was to understand the factors that did help potential medical imaging and nursing students in the remedial mathematics course achieve success, so that future students might be helped. Given that 50% of the incoming class typically has intentions of majoring in medical imaging or nursing and the fact that 69% of the first-year class in 2015 was required to take the remedial course, it was, and remains important to help support these students.

The next section is the problem statement. Within the problem statement will be subsections that will further describe the trends of remedial education in mathematics, the mathematics skills needed for medical imaging and nursing professionals, and factors of student success identified in the literature to date.

**Problem Statement**

As mentioned above, in 2015 at the institution under analysis in this project, 171 (69%) of the incoming first-time first-year students were not prepared to take a traditional college-level mathematics course, such as pre-calculus or statistics, based on their performance on a mathematics placement exam, Accuplacer, and therefore were required to take a remedial mathematics course. Of this incoming first-time class, more than 50% had intentions of majoring in either the medical imaging or nursing program. Those who successfully passed the remedial mathematics course were eligible to be accepted into the medical imaging and nursing programs after taking the prerequisite mathematics and science courses. Those that did not pass were not eligible. Thus, the passing of the remedial mathematics course was considered high stakes (Benken, Ramirez, Li, & Wetendorf, 2015). Unfortunately, at the institution under study,
there was only a 39% matriculation rate into the medical imaging and nursing majors from the first year of college to the second year of college (their first year in the professional program), a fact that only further supported the gravity of the situation for both the college and the students. Because of the college’s commitment to its mission (as previously mentioned), the college wants to see all students from a variety of different backgrounds (including first-generation students) be successful in their education as related to the chosen careers. If this is to occur, the quality and implementation of the remedial math course remains a top priority. As is presented in the following sections, the lack of adequate quantitative skills among college freshmen has only continued to escalate, as has the number of colleges offering remedial mathematics (Attewell et al., 2006; Dasinger, 2013; Medhane et al., 2011; Melguizo et al., 2014) and the number of students wishing to enter medical imaging or nursing programs (American Association of Colleges of Nursing [AACN], 2015; American Society of Radiologic Technologists [ASRT], 2015). In light of the above, it seemed that gaining a better understanding of why some students pass the remedial mathematics course and others do not would be most prudent. One might ask, “Are there specific factors at play among students wanting a career in medical imaging or nursing (for whom the stakes are so high) that contribute to their success in remedial mathematics?”

In fact, the literature on factors contributing to student success in remedial education and in remedial mathematics is limited, at both the macro and micro levels, and there was no literature that specifically focused on medical imaging and nursing students for whom the stakes are so high (Brown, 2002; Harvey et al., 2010; Noone et al., 2007). The concept of self-efficacy in educational success had been explored as a factor (Bandura & Cervone, 1983; Bandura & Schunk, 1981; Trigwell, Ashwin, & Millan, 2013; Zimmerman, 2000; Zimmerman, Bandura, &
Martinez-Pons, 1992), but again, not specifically among medical imaging and nursing students. Thus, the purpose of this study was to explore the factors at the micro level as they contributed to the successful passing of a remedial mathematics course by a very specific population of medical imaging and nursing students. Knowledge of these factors might assist colleges in providing this specific population of students the best remedial mathematics experience possible. The following sections elaborate on the trends in remedial education, the well documented need for quantitative skills in medical imaging and nursing, and the research on factors contributing to educational success.

**Trends in Remedial Education**

The number of students needing remedial education across the United States is growing in colleges and universities (Attewell et al., 2006; Benken et al., 2015; Li, Zelenda, Buonaguidi, Beckman, Casillas, Couse, Allen, Hanson, Acton, & Robbins, 2013; Melguizo, Bos, & Prather, 2011); by 1995, 75% of all 4-year institutions offered remedial courses (Melguizo, Bos, & Prather, 2011). In a 2000 survey, Attewell, Lavin, Domina and Levey (2006) found that 28% of first-time, full-time students were enrolled in remedial mathematics courses. Since then, others have found that 30%-40% of first-time college students, despite meeting admissions criteria and gaining acceptance into college, lack the quantitative skills required for the rigor of college-level courses and are required to take a remedial mathematics course based on placement tests (Benken et al., 2015; Martorell & McFarlin, 2011; Medhanie et al., 2011; Tierney & Garcia, 2011). The latest data from the United States Department of Education’s National Center for Education Statistics (2016) revealed that 33% of students who entered 4-year institutions in 2003-2004 were required to take a remedial mathematics course.
The Mandate for Quantitative Skills in Medical Imaging and Nursing

At the same time, enrollment in medical imaging and nursing programs at colleges and universities in the United States continues to thrive as growing numbers of students seek to obtain a bachelor’s degree in either of the two fields (AACN, 2015; American Society of Radiologic Technologist [ASRT], 2015). These programs have rigorous curricula, which draw on strong mathematical skills that are fundamental to each profession (AACN, 2008; JRCNMT, 2014). Examples of these mathematical skills are patient medication calculations (Brown, 2002) and calculations related to the manipulation of equipment for patient diagnoses and treatments. Professional and regional accreditation standards also require that institutions adequately prepare students in mathematical skills. The New England Association of Schools and Colleges (NEASC) Commission on Institutions of Higher Education (CIHE) states that baccalaureate degree programs must provide “adequate breadth” of the sciences including mathematics focused on “subject matter and methodologies of the primary domain” (New England Association of Schools and Colleges [NEASC], 2011, para. 4.17). Professional organizations and accreditors including the American Association of Colleges of Nursing ([AACN], 2008) and the Joint Review Committee on Educational Programs in Nuclear Medicine Technology ([JRCNMT], 2014) require that mathematical skills be embedded into the curriculum in order for students to demonstrate competency in the clinical setting. For example, the standards of the JRCNMT (an accreditor for medical imaging) include the requirements of students’ demonstrating “competency” in “science and mathematics core courses” and ensuring “learning experiences, curriculum sequencing, and the integration of clinical assignments to develop the necessary competencies for graduation” (JRCNMT, 2014, pp. 6-7). Similarly, the AACN (one of nursing’s professional bodies) requires a solid base in mathematical sciences, which is seen as essential in
order to solve complex health problems and challenges. Even discipline specific research by
Brown (2002), Noone, J. Carmichael, R. Carmichael, and Chiba (2007), Prescott, Wilson, and
Wan (2014), and Revell and McCurry (2012) has indicated that students who enter the nursing or
pharmacy field (though pharmacy is not relevant to this study) need mathematical skills because
these skills are important for healthcare professionals in order to demonstrate competency in
their fields. Thus, the evidence of the need for strong quantitative skills among this specific
population of students was irrefutable. Given this documented need, the rise in the number of
students who lack quantitative skills upon entering college, and the increase in remedial
mathematics courses, the following section reviews the factors affecting student success in
education and remedial mathematics.

Factors Related to Student Success in Education

While the term student success may have multiple meanings, Kim, Newton, Downey, &
Benton (2010) defined success as:

Acceptable grade averages, retention toward a degree, and attainment of
productive life skills. College success is important to students because it
demonstrates that they are meeting the expectations to achieve desired leaning
goals and, thereby, improve their chances of meeting long-term personal and
career goals (p. 112).

The literature reports that factors related to student success in general include: connections
between students and faculty, active learning, prompt feedback, and communication
(Brackenbury, 2012; Chickering & Gamson, 1987; Trigwell et al., 2013; Poon, 2013). There is
also research that provides support for a direct connection between the student’s prior history,
knowledge, or experiences with the subject and the level at which the student learns the material
(Brackenbury, 2012). Studies also show that students learn better and have greater success when there is a learner-centered approach (Brackenbury, 2012; Chickering & Gamson, 1987; Wingert et al., 2014) with an involved instructor (Dolmans, Wolfhagen, Heineman, & Scherpbier, 2008; Folkard, 2004; Fuller et al., 2000; King, 2014), timely feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014), and clearly outlined outcomes and expectations for the course (Prescott et al., 2014; Trigwell et al., 2013). Additional factors can include motivation, self-efficacy, critical thinking skills, and personal values (Kim, Newton, Downey, & Benton, 2010). Lopez and Lent (1992) reported that mathematics self-efficacy could also serve as a filter for career choices. To date, these factors have emerged from research that focused on what or how students described their learning experience and success in various courses (not necessarily in remedial mathematics) and not among medical imaging and nursing students.

In summary, the number of students needing remedial mathematics at the college level continues to increase and at the same time, so does the interest from students to enter either medical imaging or nursing professions. There are virtually no studies that examine what factors do support these specific students in passing the remedial mathematics course and eventually entering one of the majors. This study addressed the research problem and will add to the literature regarding remedial mathematics education and student success factors. Therefore, the following section is the purpose statement and research question.

**Purpose Statement and Research Question**

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. A qualitative case study addressed the following research question:
1. What factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course?

**Significance of the Study**

This problem is significant not only for the study site, but also on a national level. Remedial education in mathematics has grown nationally (Attewell et al., 2006; Benken et al., 2015; Li et al., 2013; Melguizo, Bos, & Prather, 2011) and at the research site. The results of this study could enable the institution and some colleges nationwide to better support students who desire to enter medical imaging or nursing, but who lack the required mathematical skills and are required to take a remedial mathematics course. Given the high stakes of passing the remedial mathematics course at the institution in this study, an understanding of the factors among those students passing the remedial mathematics course offered insights into what contributed to their success. In turn, the college faculty and staff can now use these factors to assist other students in successfully passing the remedial mathematics course. Doing so might augment student persistence, progression, retention, and program completion at the study site that is more comparable to the literature regarding remedial mathematics statistics at the macro level. This becomes even more important, given that often nearly half of the college’s incoming first year class has interest in one of the health careers. Further, to the extent that colleges nationally mirror the college in this study, faculty might be able to use the results to support students who are similar to the population studied in this project.

Nationally, it is also important that students in the medical imaging and nursing professions have strong skills in mathematics (Brown, 2002, Noone et al., 2007; Prescott et al., 2014; Revell and McCurry, 2012). To this end, the findings of this study might, in fact, generate additional questions and concepts that might enable researchers nationally to further study the
factors that these students describe as affecting their success in remedial mathematics. These studies would generate additional findings that might or might not support the results of this qualitative study.

To date, several quantitative research studies report the positive relationship between remedial education and student progression, retention, and graduation rates (Bahr, 2012; Bahr, 2010a; Benken et al., 2015; Deil-Amen & Rosenbaum, 2002; Goldrick-Rab, 2010; Martorell & McFarlin, 2011; Melguizo, Kienzl, & Alfonso, 2011). The factors related to student success specifically in mathematics have also been of interest to researchers for years (Lent, Lopez, & Bieschke, 1991). In fact, it has been documented that when students achieve success early in remedial mathematics, they gain “early momentum” that contributes to future success with quantitative skills (Benken et al., 2015, p. 14; Dasinger, 2013).

As already mentioned, the research over the past several decades have reported numerous factors that may contribute to success in mathematics (Benken et al., 2015; Dasinger, 2013; Kim, et al., 2010). However, the research has generally been at a macro level, focusing on the outcomes of remedial courses for large populations of college or university students, and not at the micro level, focusing specifically on remedial math for individuals within medical imaging or nursing who must rely heavily on strong mathematical skills. Currently no studies explore the factors driving medical imaging and nursing student success in passing a required remedial mathematics course. Again, given the trending decline in quantitative skills among first time, first year college students across the country, the associated costs of remedial mathematics courses for an increasing number of institutions, and the number of students wishing to enter the health professions, the need for this study was justified. A strong argument has been made relevant to the significance of this study for colleges nationwide, for students wishing to enter
medical imaging or nursing, and for the medical imaging and nursing professions which rely so heavily on strong mathematical skills.

**Theoretical Framework**

The theoretical framework selected for this study was Bandura’s (1977) self-efficacy theory. Self-efficacy is the belief in one’s ability to produce the required behaviors or actions needed to achieve specific outcomes (Bandura, 1977, 1989, 1993). Albert Bandura has long been associated with social learning theory ideas. While working in the 1970s with the various social learning theories, Bandura began to realize an important component was missing (Pajares, 1996), self-belief, which led to the self-efficacy theory. Similar to other expectancy theories, the self-efficacy theory relates to beliefs about one’s perceived capability; however, “they differ in that self-efficacy is defined in terms of individuals’ perceived capabilities to attain designated types of performances and achieve specific results” (Pajares, 1996, p. 546).

“Students’ beliefs in their efficacy to regulate their own learning and to master academic activities determine their aspirations, level of motivation, and academic accomplishments” (Bandura, 1993, p. 117); thus, students’ success and skills are important in developing their self-efficacy. Further, Bandura (1977) stated, “People fear and tend to avoid threatening situations they believe exceed their coping skills, whereas they get involved in activities and behave assuredly when they judge themselves capable of handling situations that would otherwise be intimidating” (p. 194). Bandura’s self-efficacy framework has extensive support to the “validity and utility” of the theory (Iroegbu, 2015, p. 170). To build on Bandura’s theory, Zimmerman (2000) conducted a review of key studies that demonstrated self-efficacy was the key factor that motivated students to learn and achieve goals. In fact, he concluded “self-efficacy has proven to
be responsive to improvements in students’ methods of learning and predictive of achievement outcomes” (p. 89).

Student experiences with academic material may be the pivotal point in which the students’ perceptions become a reality for them (Howard & Whitaker, 2011). Howard and Whitaker (2011) discussed that those successful experiences, such as with faculty, grades, and problem solving had an impact on students and a change in mindset. Successful students believed “that their abilities could be expanded if they made the effort to learn (Howard & Whitaker, 2011, p. 12). They further state, “when students develop increased levels of motivation and learn to use strategies for successful learning, they experience a positive turning point that marks a shift in their beliefs, attitudes, and patterns of achievement” (p. 14). Bandura refers to this as self-efficacy.

The use of this framework was supported by the results of a meta-analysis conducted by Multon, Brown, and Lent (1991), which demonstrated the correlation between self-efficacy and student outcomes. The results of their meta-analysis “revealed positive and statistically significant relationships between self-efficacy beliefs and academic performance and persistence outcomes across a wide variety of subjects, experimental designs and assessment methods” (Multon, Brown, & Lent, 1991, p. 30).

Bandura’s work is supported by a more recent study conducted by Trigwell, Ashwin, and Millan (2013), which indicated that self-efficacy is “directly related to academic achievement” (p. 376). The meta-analysis conducted by Robbins et al. (2004) of 109 studies demonstrated that self-efficacy and motivation were the strongest predictors for grades. In addition, the study also found that goals, academic skills, and self-efficacy were the “strongest predictors of college retention” (Robbins et al., 2004, p. 274). Studies have also shown that students who feel they are
supported and have an understanding of deep learning approaches have higher levels of academic achievement (Hazel, Prosser, & Trigwell, 2002; Prosser, Trigwell, Hazel, & Waterhouse, 2000; Trigwell et al. 2013). Furthermore, Hall and Ponton (2005) suggested that enhancing self-efficacy could contribute to an increase in students’ achievement in mathematics.

Bandura (1993) also described goal setting as an important factor related to cognitive processes. Students with a higher sense of self-efficacy tend to set more challenging goals and are more committed to them. Bandura (1993) further explained that individuals who have a higher sense of self-efficacy tend to achieve the goals they have established for themselves. Conversely, students who doubt their self-efficacy tend to visualize more failed scenarios and tend to not reach their educational goals (Bandura, 1977). The four sources of self-efficacy that Bandura (1977) describes are performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal.

Performance Accomplishments. Academic performance is one source of self-efficacy. When students perform successfully on varying academic tasks, their self-efficacy is heightened. When failure happens, especially early on, there is a lowered sense of belief in one’s self (Bandura, 1977). However, after multiple successes and a heightened self-efficacy, occasional failures can be overcome by a determination to succeed (Bandura, 1977). Students’ sense of accomplishment can also come from learning experiences in which timely feedback is provided on their submitted work (Dolmans et al., 2008; Fuller, Rawlinson, & Bevan, 2000; Wang, 2014). When students see that they are capable of getting the correct answer or that they are able to master the material in a timely fashion, the learning experience is more positive, a factor that can lead to an increase in self-efficacy (Hall & Ponton, 2005).
Pajares and Miller (1994) explored this relationship between self-efficacy and mathematics in 350 students at a large public university in the South. Their findings showed that performance accomplishments were the major influence on a student’s self-efficacy. Part of this was related to their perceptions about solving mathematics problems and prior experiences. When students received higher scores on their assignments, they gained more confidence in their ability.

Lopez and Lent (1992) found that “remedial programs that provide students with genuine mastery experiences and reduce excessive math fears may enhance students’ math self-efficacy and, ultimately, expand their range of perceived career and academic options” (p. 11). Their study supported Hackett and Betz (1989), which found self-efficacy in mathematics was a key indicator in math-related career and major selections. However, performance accomplishments alone were not the deciding factor in self-efficacy. Three other sources contribute to self-efficacy.

**Vicarious Experiences.** According to Bandura (1977), vicarious experiences also have a correlation to self-efficacy in that “seeing others perform threatening activities without adverse consequences can generate expectations in observers that they too will improve if they intensify and persist in their efforts” (p. 197). When a student sees other students with different characteristics succeeding, his or her belief in his- or herself can increase (Bandura, 1977). Interventions, such as peer mentoring, can also be a vicarious experience that is effective for students engaged in college remediation. Interventions such as this can lead to student success and improve graduation rates, especially if the peer mentor is someone who has had similar experiences in remedial education (Di Tommaso, 2012).
**Verbal Persuasion.** The third source of self-efficacy as described by Bandura (1977) is verbal persuasion. When students are “persuaded that they possess the capabilities to master a difficult situation and are provided with provisional aids for effective action, they are likely to mobilize greater effort” (Bandura, 1977, p. 198). In many classrooms, this comes from direct feedback from the teacher or from tools that students use on their own, such as information/communication technology-enhanced devices. Students have better learning experiences with timely and supportive feedback, similar to the “performance accomplishments” mentioned earlier (Dolmans et al., 2008; Fuller et al., 2000; Wang, 2014).

Dolmans et al. (2008) reported that evaluations from 350 undergraduate medical students demonstrated higher engagement faculty scores when faculty gave timely feedback and when the students believed that the faculty was vested in their learning. Similarly, Wang’s (2014) mixed method study of 52 students in a one-semester course showed that students claimed to have a better learning experience and better graduates when there was timely feedback and persuasion from their faculty members. Students believed they knew the material better based on the faculty’s involvement.

**Emotional Arousal.** The final source of self-efficacy in Bandura’s (1977) framework is emotional arousal. Stressful encounters can increase emotional distress and lower one’s belief in her or his ability; finding coping strategies to reduce this level of emotional arousal can “reduce avoidance behavior” (Bandura, 1977, p. 199). Students not only do better academically regarding grades, but they also feel they have better comprehension when they perceive that the teacher is an engaging, caring, and passionate instructor and that there are clear expectations of course outcomes (Finnigan, 2009; Manning, McKinley, & Chipamaunga, 2010).
Hackett and Betz (1989) reported there is a correlation between self-efficacy, particularly in mathematics, and career selection. According to Schunk and Gunn (2001), self-efficacy does have an effect on a students’ “choice of activities, effort expended, persistence, and task accomplishments” (p. 238). It is this researcher’s belief that the various factors that have been identified as contributing to student success can be aligned to one of the four sources of self-efficacy that Bandura (1977) describes, as is depicted in the model below (Figure 1.1).

Efficacy expectations determine how much effort people will expend and how long they will persist in the face of obstacles and aversive experiences. The stronger the perceived self-efficacy, the more active the efforts (p. 194).

Figure 1.2 demonstrates how the self-efficacy model may contribute to the student success factors that have been identified above.
Figure 1.1

Self-efficacy Model

Efficacy Expectations

<table>
<thead>
<tr>
<th>Source</th>
<th>Mode of Induction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Accomplishments</td>
<td>Participant Modeling, Performance Desensitization, Performance Exposure, Self-Instructed Performance</td>
</tr>
<tr>
<td>Vicarious Experience</td>
<td>Live Modeling, Symbolic Modeling</td>
</tr>
<tr>
<td>Verbal Persuasion</td>
<td>Suggestion, Exhortation, Self-Instruction, Interpretive Treatments</td>
</tr>
<tr>
<td>Emotional Arousal</td>
<td>Attribution, Relaxation, Biofeedback, Symbolic Desensitization, Symbolic Exposure</td>
</tr>
</tbody>
</table>

Figure 1.2

*Self-efficacy Model with Factors from Literature Cited*

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>MODE OF INDUCTION</th>
<th>POTENTIAL SUCCESS FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Accomplishments</td>
<td>Performance, Performance Exposure, Self-Instructed Performance</td>
<td>Prior Academic Achievement (Trigwell et al., 2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timely Feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong &amp; Alexander, 2014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Learner-Centered Approach (Chickering &amp; Gamson, 1987; Wingert et al., 2014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Active learning (Brackenbury, 2012)</td>
</tr>
<tr>
<td>Vicarious Experience</td>
<td>Live Modeling, Symbolic Modeling</td>
<td>Peer Mentoring (Di Tommaso, 2012)</td>
</tr>
<tr>
<td>Verbal Persuasion</td>
<td>Suggestion, Exhortation, Self-Instruction, Interpretive Treatments</td>
<td>Timely Feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong &amp; Alexander, 2014)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Involved Instructor (Dolmans et al., 2008)</td>
</tr>
<tr>
<td>Emotional Arousal</td>
<td>Attribution, Relaxation, Biofeedback, Symbolic Desensitization, Symbolic Exposure</td>
<td>Clear Expectations (Prescott et al., 2014; Trigwell et al., 2013)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Involved Instructor (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; King, 2014)</td>
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<tr>
<td></td>
<td></td>
<td>Learner-Centered Approach (Chickering &amp; Gamson, 1987; Wingert et al., 2014)</td>
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<td></td>
<td></td>
<td>Active learning (Brackenbury, 2012)</td>
</tr>
</tbody>
</table>

Koch, Slate, and Moore (2012) completed a study exploring students’ experience and perceptions in a remedial mathematics course. They found that self-efficacy was the contributing factor to the change in students’ behavior regarding mathematics. Relating the study to Bandura’s (1977) theory and four sources, the students described positive experiences related general positive experiences academically (performance accomplishments), faculty support (verbal persuasion), resources such as labs and tutors (emotional arousal), and goal setting, a key component to Bandura’s theory. Given that there are various factors related to student success and ultimately self-efficacy, the framework guided the research problem by exploring the factors described by first year medical imaging and nursing students as having contributed to their successful completion of a remedial mathematics course.

**Positionality Statement**

I am the first person in my immediate family to go to college and earn a degree. I am also the first to enter the healthcare field and the first to move hundreds of miles away from home. Yet, my road to success in college and in my career, was not easily traversed. College was always my goal and my parents assured me that I would attend. My father was a coal miner and my mother was a waitress. They worked hard and sacrificed much for me to attend college.

Once I entered college, I was notified that I needed to be placed in a remedial writing course before I could progress into the required college composition course. I really did not know what that meant at the time other than I was working extremely hard to take additional courses to be on track with the curriculum and the other students in my major. I remember going to some of the information sessions about radiology and realizing that I still had more classes to take before my application into the program would be reviewed. In the end, everything worked out and I was successful in radiology and made a great career out of it. At that time, I am not
sure if I fully understood the value of remedial education or what it took to overcome some of
the challenges I had with taking extra courses. Over time I saw the value of that education and
how it prepared me to succeed in my major.

Currently, I have held a position as a faculty member for ten years, teaching in the highly
technical healthcare field of medical imaging at the baccalaureate and master’s levels. As a
novice medical imaging faculty member, I had limited experience with students who were
required to take remedial courses or who were behind in college credits and struggling to catch
up. The students who were selected into the first-year medical imaging program were at least at
the sophomore level, had competitive grade point averages (GPA) of a 3.0 or better, and had
completed prerequisites in courses such as chemistry, statistics, physics, and advanced biology.
Therefore, if a student entered college needing a remedial course, the student would have to
succeed in his or her remedial course in order to meet the minimum requirements for entering
into the medical imaging program. After ten years, I now appreciate what these students have
gone through.

Additionally, I have taught in the first-year experience program working with students
who are in remedial courses and seen how this impacts their learning. I also have seen the
financial impact these non-credit courses place on the college and the students, and the negative
effects on the students who don’t pass the remedial mathematics course and are unable to
matriculate into college level courses. However, I also witnessed the tremendous value of the
remedial mathematics course when I see students who enter the college with poor scores on the
Accuplacer exam, placed in a remedial mathematics course, who then succeed in the medical
imaging or nursing programs, which require strong quantitative skills. As someone who also had
to take a remedial course, I see the value of it and believe that remedial education is a benefit for some students.

Biases and positionalities are critical for any researcher to recognize so that they may be controlled (Machi & McEvoy, 2012). Machi and McEvoy (2012) pointed out that there are advantages when there is a personal connection or passion for the topic; however, it must be controlled. I recognized my bias for remedial education given my personal involvement with remedial courses as a student and now as an educator and I needed to control for that bias in my research. Miles, Huberman, and Saldana (2014) stated that personal bias includes the “researcher’s personal agenda” which can “skew the ability to represent and present fieldwork and data analysis in a trustworthy manner” (p. 294). My goal in this study was not a personal goal but rather, to explore the factors that contributed to students successfully completing a remedial mathematics course. Other ways by which I limited my biases included making clear the intentions to the participants around the purpose of the study, having a diverse group of participants both from medical imaging and nursing, and keeping true to the research question (Miles, Huberman, & Saldana, 2014).

I crafted the interview questions that were open-ended in order to obtain detailed responses students discuss concerning what contributed to their success in remedial mathematics. These open-ended questions allowed me to resist asking questions that could be answered as a yes or no, which could have been perceived as showing bias. While I have stated that I have a bias, I believe that many of the open-ended questions generated descriptions of the factors that the students perceived made them successful. At the same time, I was careful in not “leading them” in a particular direction with my questions. Finally, in order to reduce the potential bias in
the data analysis I presented my preliminary data and findings to two informed colleagues who provided critical feedback during the data collections and analysis phases (Yin, 2014).

**Summary**

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. The topic of remedial education is extremely important given the number of students needing remedial education today. At this research study site, a majority of the 2015 incoming first year class needed remedial mathematics. Of this incoming class, approximately half of the students were interested in medical imaging or nursing when entering the college of interest, yet only 39% matriculated into one of these majors. An understanding of the factors that medical imaging and nursing students described as contributing to their successful completion of a required remedial mathematics course might provide information that allows the development of new support strategies to help increase the percentage of students who succeed in remediation and then progress into the major of their choice.

Students’ success is associated with a wide variety of factors (Hall & Ponton, 2005; Multon et al., 1991; Trigwell et al., 2013) and research has shown there is a connection between these factors and self-efficacy, and self-efficacy and the attainment of goals. Bandura (1977) introduced the four sources contributing to self-efficacy. The four sources were performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal. Research exists (Calcagno, Crosta, Bailey, & Jenkins, 2007; Deil-Amen & Rosenbaum, 2002; Di Tommaso, 2012; Hall & Ponton, 2005) regarding the topics of remedial education, students’ success, and self-efficacy; however, there is little literature on what factors contribute to the successful completion of a remedial mathematics course, especially for medical imaging and
nursing students. Thus, the findings of this study add to the body of knowledge concerning the completion of remedial education in mathematics in a subset of the health education field for whom succeeding in a remedial mathematics course is of great importance.

**Definition of Terms**

**Accuplacer:** A placement test that is computer based used to test knowledge of students in various subjects, primarily in mathematics, writing, and reading (Levin & Calcagno, 2008). A test used to determine which first year course (i.e. mathematics, writing, reading) to place entering college students into.

**First-generation:** Student who is the first in their immediate family to go to college.

**First-time student:** The first-time a student attends a college. This does not include transfer students or students who earned credits at college during another period in their lifetime.

**First-year student:** Students who have received less than 30 credits hours.

**Learner-centered:** The student learns at his or her own pace and in a format that is best for that student.

**Medical Imaging:** The overarching term used to describe the field of imaging. Specific areas include Breast Imaging, Computed Tomography, Interventional Vascular and Cardiac Technology, Magnetic Resonance Imaging (MRI), Nuclear Medicine, Radiography, and Sonography. Similar terms include Radiology.

**Quantitative Skills:** Skills and knowledge related to mathematics.

**Remedial Education:** Courses that provide the skills and knowledge necessary for college-level courses. These courses are considered developmental in nature to provide the skills that a student(s) does not already possess.
**Remedial Mathematics:** Course(s) in mathematics that provides the skills students lack in mathematics in order to be successful for college-level courses in mathematics.

**Self-efficacy:** The belief in one’s self to produce the required behaviors or actions needed to achieve specific outcomes (Bandura, 1977, 1989, 1993).

**Student Success Factors:** A technique, fact, or influence a student perceives that contributed to their success.

**Successful Student:** A student who achieves a “C” or better in the remedial mathematics course.
CHAPTER TWO: LITERATURE REVIEW

Purpose Statement and Research Question

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. A qualitative case study will address the following research question:

1. What factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course?

Introduction

Enrollment in the medical imaging and nursing professions is growing, particularly at the baccalaureate level (American Association of Colleges of Nursing [AACN], 2015; American Society of Radiologic Technologist [ASRT], 2015). At the same time, the number of students entering college for the first time who lack the mathematical skills required for the college-level entry mathematics course is also growing (Attewell et al., 2006; Dasinger, 2013; Howard & Whitaker, 2011; Medhanie et al., 2011; Melguizo, Kosiewicz, Pather, Bos, 2014). Many of the students who are not prepared for the college-level mathematics course are required to take at least one remedial mathematics course prior to enrolling in the college-level course (Howard & Whitaker, 2011). There is overwhelming support in the literature for remedial education. Much of this literature is at the macro level, focusing on outcomes of remedial courses at larger college or universities, and not necessarily at the individual student level or even for students in the medical imaging or nursing programs. This chapter presents a review of the literature specific to mathematical skills needed in the medical imaging and nursing professions, remedial education, factors related to students’ success, and self-efficacy.
**Scope of Review**

This review of the literature explored the mathematical skills that are required for the medical imaging and nursing professions. The professional societies and various research studies demonstrate those needs and the lack of skills in some. Next, a discussion around remedial education in higher education, the impact of remediation, and specifically remedial work in mathematics is provided. Given that this research study attempted to explore the factors related to students’ success in a remedial mathematics course, it was imperative to review the literature related to those factors identified in student success. This section will explore those student factors and success in general college-level courses, in mathematical skill development, and in remedial mathematics courses. Self-efficacy in the literature was also reviewed given that this study is to be guided by the theoretical framework of self-efficacy. The four sources identified by Bandura (1977) are explored in the academic setting, as is self-efficacy in mathematics, career or major selection, and in remedial mathematics courses. Finally, a summary of the literature review and a discussion related to this study concludes this chapter.

Three conditions indicate that this study is timely:

- More students than ever are unprepared for college level mathematics courses (Li et al., 2013; Medhanie et al., 2011)
- Mathematical skills are critical to professions in healthcare, specifically related to patient care (Brown, 2002; Noone et al., 2007; Revell & McCurry, 2013)
- There is a lack of published literature on students’ self-described success factors or experiences in remedial mathematics courses (Bahr, 2010b), specifically in the fields of medical imaging and nursing.
The literature reviewed consisted of an extensive search of articles related to various topics including mathematics skills required in medical imaging and nursing, remedial mathematics, student success factors, and the students’ learning experiences. The topics and terms used for included remedial education, developmental education, student learning experiences, student success factors, quantitative skill development, mathematics and nursing, and mathematics and medical imaging or radiology. A variety of databases were used to access the literature, which included Northeastern University Library databases, Scholar OneSearch tools, and Google Scholar. Databases searched were EBSCO Host Search, ERIC (EBSCO), JSTOR, CINAHL, Medline (EBSCO), ProQuest for dissertations and theses, and others as needed. Reference lists from relevant articles were also reviewed to identify any additional resources that would potentially be useful in this review of the literature.

There is a wealth of literature on self-efficacy. The review consisted of focusing on self-efficacy used in academic settings, self-efficacy in mathematics, and self-efficacy in remedial education. The terms used in the searches were self-efficacy, self-efficacy theory, mathematics self-efficacy, students’ perceived self-efficacy, and students’ academic self-efficacy. The search consisted of the use of databases and tools as noted in the last search. As with the other search, the reference lists from self-efficacy articles that were found to be beneficial to this review were used to identify any additional possible resources.

This review of literature as noted above starts with understanding the need for mathematical skills in the medical imaging or nursing fields. This provides an overview of the professions’ professional organizations and accreditors that require the mathematics skills, along with literature from the disciplines specifically.
Mathematics Skills in Medical Imaging and Nursing

The need and requirement for mathematical skills in medical imaging and nursing professions comes from several different perspectives. Accreditation organizations, professional organizations or associations, and literature from the discipline all have an impact on the mathematical skills that are viewed as necessary for the professions mentioned. Accreditation in higher education is seen as the mechanism to ensure quality of education at the various college and universities. There are two types of accreditation that are important in this review, because most of the health professions’ programs in the United States tend to have both the regional accrediting bodies (recognized by the United Stated Department of Education [USDOE]) and the professional or programmatic accrediting organizations (recognized by either the USDOE and/or the Council for Higher Education Accreditation [CHEA]) examining their programs. The regional accreditation is focused on the standards that are required for the college or university to be accredited at the macro level and not necessarily at the specifics in the programs or majors level, such as professional curriculum or clinical requirements. The programmatic accreditation has the responsibility of developing and overseeing the standards within the professional program, usually with input from the professional organizations and associations required for that profession. The Commission on Institutions of Higher Education (CIHE) of the NEASC demands that baccalaureate degree programs must provide “adequate breadth” of the sciences including mathematics focused on “subject matter and methodologies of the primary domain” (NEASC, 2011, para. 4.17). The CIHE is less specific about the actual skills for the professions, but does mention mathematics skills as part of the baccalaureate degree. Professional accreditors like the AACN and the Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRCNMT) have established the standard that quantitative skills be embedded into
the curriculum and that students demonstrate having acquired the competency as applied to the clinical setting. The Joint Review Committee on Educational Programs in Nuclear Medicine Technology, one of the medical imaging accreditors, requires demonstration of “competency” in “science and mathematics core courses” to ensure “learning experiences, curriculum sequencing, and the integration of clinical assignments to develop the necessary competencies for graduation” (JRCNMT, 2014, pp. 6-7). As well, the AACN (2008) requires a solid base in mathematical sciences in order to solve complex problems and challenges. While there are not specific courses listed by the professions’ accreditors, the skills are to be embedded into the program to relate to the duties of that profession. The literature from researchers within the fields provides more details on the mathematics skills needed for the professions.

Researchers including Brown (2002), Noone et al. (2007), Revell and McCurry (2013), and Prescott et al. (2014) have also suggested that mathematics or quantitative skills are important for healthcare professionals in order for them to be competent in their chosen professions. Harvey et al. (2010) further explained that the mathematical skills are “essential in nursing as it underpins a number of key skills including nutritional assessments, fluid balance and body mass index calculations” (p. 19), not to exclude the obvious skill of calculations and administration of medications. Brown (2002), Noone et al., (2007), Revell and McCurry (2013), and Prescott et al. (2014) all note the critical importance of dose calculations for the nursing profession. While there is no specific literature regarding medication administration in medical imaging, the professional society, the Society of Nuclear Medicine and Molecular Imaging (SNMMI), states in its scope of practice for the profession, makes clear the role of calculation and administration of imaging medications, contrast agents, and radiopharmaceuticals in medical imaging (SNMMI, 2016). Revell and McCurry (2013) expanded on this critical need for
mathematics skills to include the “conceptual understanding of how to solve math problems” (p. 1354) to avoid patient errors within the clinical arena. However, while there is a demonstrated need for the mathematical skills for the professions, there is a lack of the skills among students in these professions.

**Students Lack of Mathematical Skills**

Brown (2002) related that the majority of students in a study of 39 nursing schools were “mathematically underprepared” (p. 134). Regardless of what math courses students took prior to entering nursing, the majority of the students were unable to complete basic math problems. In particular, the skills necessary for medication calculations were especially problematic since students lacked the ability to convert fractions to decimals, change mixed numbers, calculate percentages, and make simple ratio conversions.

Harvey et al. (2010) conducted a study of 304 first year nursing students in one large university and found that only 17% of the students could pass the entry-level mathematics test. The biggest challenge for students who could not pass the exam was in the area of basic mathematics such as fractions, decimals, and formulas. They also concluded that there appeared to be a lack of understanding with overall problem solving. This level of knowledge is considered critical to duties such as dose calculations (Brown, 2002; Noone et al., 2007; Revell and McCurry, 2013). The results from Harvey et al. (2010) are staggering, yet are consistent with the literature demonstrating the lack of mathematical skills among students, yet critical to the profession. This study highlights the challenges that students had with mathematical skills; however, it does not provide insights to the challenges the students themselves describe as a challenge.
Revell and McCurry (2013) conducted a literature review of 51 studies that focused on challenges that undergraduate nursing students identified with mathematics concepts and effective teaching methods for mathematical skills. The results reported by this study demonstrated that there were a number of researchers that found students’ “inability to comprehend basic calculations and problem-solving approaches” (Revell and McCurry, 2013, p. 1353). In fact, there were themes identified among the literature that is consistent with this literature review. The themes identified included “pre-college math preparation, inability to comprehend problem-solving approaches, test anxiety, and lack of contextual understanding” (Revell and McCurry, 2013, p. 1353).

Summary

Mathematical skills are essential not only to the medical imaging and nursing professions, but also they are critical components to patient care. Professional accreditation bodies imply that mathematical skills are to be embedded into the curriculum, as related to the duties and responsibilities of the profession (AACN, 2008; JRCNMT, 2014; & SNMMI, 2016). While the specifics of the mathematical skills that educational programs in these professions must minimally meet are not stated, the expectations are. It’s the literature that provides the level and attention to mathematical skills that is relevant to the professions (Brown, 2002; Harvey et al., 2010; Noone et al., 2007; Prescott et al., 2014; Revell & McCurry, 2013). The most noted skills are ones of calculations and administration of medications or other agents administered to patients such as contrast agents and radiopharmaceuticals. However, there are other critical duties identified within the profession that require mathematical skills and problem solving such as patient assessments and fluid intake and output levels (Harvey et al., 2010).
While there is the common knowledge of the mathematical skills required, the challenge remains with students having that knowledge and skills.

One well documented challenge with students entering the medical imaging or nursing fields is the lack of mathematics skills for the professions (Brown, 2002; Harvey et al., 2010; Noone et al., 2007; Revell & McCurry, 2013). Studies have shown that as much as 80% of first year nursing students do not have the skills for basic mathematics operations such as fractions and decimals (Harvey et al., 2010). In addition to the lack of basic skills, students struggle with problem solving skills that are critical to complex critical thinking situations (Harvey et al., 2010). Given this need for remedial education, the next section explores remedial education.

**Remedial Education at the College Level**

Remedial education continues to be a topic of discussion in higher education, in part due to the increasing number of students required to take remedial courses (Benken et al., 2015; Goldrick-Rab, 2010; Howell, 2011; Howell et al., 2010; Melguizo, Bos, & Prather, 2011; Tierney & Garcia, 2011). There are proponents and opponents of remedial education. Critics argue that the courses are non-credit and incur extra costs, while others argue that remedial education affects rate of progression, causes delays in graduation, and may even lead to stigma (Calcagno et al., 2007; Martorell & McFarlin, 2011). However, the vast majority of literature supports remedial education by demonstrating a correlation between the completion of a remedial course and positive student outcomes, particularly with regard to retention, progression and graduation rates (Attewell et al., 2006; Bahr, 2010a, 2010b; Benken et al., 2015; Bettinger & Long, 2004; Li et al., 2013).

The number of students needing remedial education has been growing over the past few decades (Attewell et al., 2006; Benken et al., 2015; Li et al., 2013; Melguizo, Bos, & Prather,
Remedial education, often referred to as developmental education, has long been a part of higher education (Tierney & Garcia, 2011). However, it was not until the 1970s that national discussions regarding remedial education began to take place in higher education with the first issue of the *Journal of Developmental Education* published in 1978 (Tierney & Garcia, 2011). At that time, the “federal government and some states expanded their roles in higher education, with the goal of increasing access for a larger segment of the population” (Scott, Bailey, & Kienzl, 2006, p. 249). There was a new focus and a push to increase financial aid, which started the “need-blind admissions policies at many colleges” (Scott et al., 2006, p. 249). By the 1980s roughly 64% of students who entered a community college needed at least one remedial course (Melguizo, Bos & Prather, 2011). At this point, post-secondary remedial education became a topic of national conversation and the desire to want to know more about the purpose and value of remediation became significant.

By the early 1990s remedial education had become a topic of political discussion because of the increasing number of entry level college students enrolled in remedial courses offered at all colleges and universities (Attewell et al., 2006). Melguizo, Bos, and Prather (2011) also reported that by 1995 nearly all of the community colleges in the United States offered remedial courses, as did almost 75% of all 4-year institutions. Toward the end of the 1990s, almost 78% of the students enrolled in college were attending a state college or university; graduation rates were continuing to decline; and the “public support for financing higher education had waned” (Scott et al., 2006, p. 250). Today, the majority of remedial courses are in writing and mathematics (Li et al., 2013).

Critics of remedial education tend to focus on the students who are unable to pass remedial courses. While these critics are limited in number, their findings are worth mentioning.
Martorell and McFarlin (2011) stated that there is virtually no evidence that supports improved outcomes for students who were required to take remediation. Their study explored data of 255,878 freshmen that enrolled in public two-year institutions and 197,502 that entered four-year institutions of higher education in Texas between 1991-1992 and 1999-2000. The students were followed for six years with colleges submitting reports to the Texas Higher Education Coordinating Board (THECB). Martorell and McFarlin claimed that students’ graduations are delayed (if they graduate), because of taking non-credit bearing courses and the costs associated with these non-credit bearing courses. Calcagno et al. (2007) found similar data from 42,641 first time, degree-seeking students in Florida’s 28 community colleges in the fall of 1998-1999 and stated that being enrolled in a remedial course decreased their odds of graduation. While these studies demonstrated non-favorable results for students in remedial education, they are in the minority.

The wealth of literature supports remedial education as a means of improving student outcomes. Attewell et al. (2006) examined the National Educational Longitudinal Study (referred to as the NELS: 88), a project of the United States Department of Education, which followed a sample of students from 1988 when they were in eighth grade to the year 2000. The sample does represent a national cohort of students who graduated high school and went to college over an eight-year period, and included a sample size of 6,879 students that had complete records to study. Within this sample, 40% of the students took at least one remedial course while in college with mathematics being the largest area of remediation, followed by writing. The data demonstrated that taking a remedial education course did not decrease the chances of graduation and did not have an effect on overall academic success. The study actually showed the opposite, that remediation courses actually helped students be successful. Students who completed and
passed a remedial course had higher rates of graduation versus the students who needed remediation but did not take a remedial course in college. Similarly, Bettinger and Long (2004) examined first-time college students at public institutions in Ohio who were required to take a remedial course. Their findings posited that students who successfully completed the remedial courses were more likely to persist in college. Di Tommaso (2012) conducted a qualitative study of 20 students and three faculty members from one community college in New York City. She reported that despite some of the challenges that some students in remedial education experience, there are other factors that if understood could assist students in being successful in remedial education. Her findings also showed that students value their education; and when they perceive support from faculty, administration, and/or their peers, they had an increase in self-belief, which will be discussed in more detail in sections that follow. A large number of these remedial courses are in mathematics (Attewell et al., 2006; Bahr, 2010a), which is important to understand for the purposes of this study.

**Remedial Education in Mathematics**

As already mentioned, the Attewell et al. (2006) study, is one of the largest, most diverse studies that focused on students in eighth grade and followed them up to eight years after graduating from high school. Beyond the staggering 40% of students that were required to take at least one remedial education course in college, the study found that 28% of first-time, full-time traditional freshmen had enrolled in a remedial mathematics course, more than any other remedial course. Furthermore, Li et al. (2013) reported that between 2000 and 2008, the percentage of students who took a remedial course rose to 44%, with approximately 70% of this percentage in mathematics. Likewise, Medhanie, Dupuis, LeBeau, Harwell, and Post (2011) indicated that “the number of students enrolling in college in the United States taking
developmental coursework is staggering… more than 3,000,000 students completed at least one
developmental mathematics course… the impact on students is substantial” (p. 333). In
comparison, 69% of the students who entered college at this study’s site in the fall of 2015 were
required to take the Quantitative Reasoning course before take a college-level course and of
these students, 39% needed even more remedial coursework in mathematics before moving into
a college-level mathematics course. Despite this growing number of students needing
remediation in mathematics, the literature does support the value of remediation in mathematics
for the students in general.

How students are placed in remedial mathematics is still very much dependent on the
individual college or university. Some schools use the ACT or SAT scores, along with high
school records to make the determination. Some schools use national placement examinations
such as Accuplacer (published by the College Board) or Compass (published by ACT, Inc)
(Scott-Clayton, 2012). Still some schools use a combination of methods. For the purposes of
this review, Accuplacer will be the focus since that is the placement examination used at this
research site in this study. The College Board is a membership association of more than 5,600
schools, colleges, and universities that assists students and parents through a variety of programs
and services such as college readiness, admissions processes, financial aid and learning (Mattern
& Packman, 2009). The College Board publishes and administers a variety of examinations such
as the SAT, Advanced Placement examinations, and Accuplacer. Accuplacer is the college-level
course placement examination to assist colleges and universities in determining the best course
to place first year students to help students be successful in passing courses their first year
(Mattern & Packman, 2009; Scott-Clayton, 2012). Typically, the subjects that are of most
interest to colleges and universities for accurate placements are reading, writing, and
mathematics. The College Board does not set the score that the individual college or university should use to place students; however, they provide guidelines based on correlation data of the placement test scores and the course grades in colleges and universities. Accuplacer is a computer-adaptive placement examination and “in 2008, more than 1,300 institutions used Accuplacer tests and nearly seven million exams were administered” (Mattern & Packman, 2009, p. 2). The scores range from 20-120 and for the mathematics portion, there are 17 multiple choice questions on arithmetic and 12 on elementary algebra. Mattern and Packman (2009) completed a meta-analysis study between 2001-2004 and forty-seven studies were examined at 17 institutions. The data showed a 58-84% correct course placement rate and the results indicated a “moderate to strong relationship between Accuplacer scores and course success, demonstrating that Accuplacer test scores provide utility in terms of placing students into courses in which they are likely to succeed” (Mattern & Packman, 2009, p. 1). Accuplacer does publish a guide for schools to use, but again, schools should make their own decisions based on the student demographic and their own analysis of passing rates in various courses and the placement test scores (Mattern & Packman, 2009). The suggest the following placement courses in mathematics based on the scores:

- Below 40  Take the Elementary Algebra test prior to placement decisions
- 40-62   Placement into intermediate algebra
- 63-85   Placement into college algebra
- 86-102  Placement into pre-calculus or non-rigorous beginning calculus
- 103-120  Placement into calculus

Again, this is a guide to help colleges and universities. Decisions by each school should be made on their own analysis of student success in college-level courses, the make-up of the
student demographic, along with the type of college or university such as a community college or 4-year non-selective school or 4-year selective school (Mattern & Packman, 2009). To demonstrate the comparison, the site in this research study uses 100 as minimum score to move into pre-calculus or statistics. Scores between 70-100 are required to take Quantitative Reasoning (non-remedial course, credit-bearing) and scores below 70 are required to take a remedial course and lab in mathematics. Understanding who these students are is important in understanding the success of remedial education in mathematics.

The findings of the Di Tommaso (2012) study previously mentioned supported the findings of Weinstein’s 2004 study that demonstrated students in remedial mathematics view mathematics very differently from faculty and from students who are strong in quantitative skills. According to Weinstein (2004), when students believed they were acquiring the skills on their own with support and positive feedback from faculty or peers, their self-belief in learning the material increased. Weinstein followed 32 students in a remedial mathematics course for one semester at a large Midwestern university. What was known at the university was that students who completed and successfully passed the remedial mathematics course were better prepared for college mathematics versus the students who did not take the course. As a result, he conducted surveys, interviews, and would observe classes and tutoring sessions with staff and with peers. The results were an engaged group of students who expressed their confidence had increased in mathematics by being involved in the learning process and having immediate positive feedback on what was perceived to be challenging problems. These factors such as feedback, will be discussed later in this chapter.

Bahr (2010b) examined over 63,000 first-time community college students in California over a six-year period, starting in 1998 and ending in 2001. The database used to obtain a wealth
of information was directly from the California Community College Chancellor’s Office. The study examined the progression and achievement of students in college-level mathematics courses. The results showed that the students with extremely low mathematical skills based on placement examinations and secondary school scores have a low rate of success in college-level mathematics; however, the students who “remediate successfully in math, experience favorable long-term academic outcomes” (Bahr, 2010b, p. 232). The outcomes were measured by graduation with a degree or certificate or transfer to a 4-year state school. Additional results in Bahr’s study showed the racial gap in remediation. “More than one-quarter of [Caucasians] and Asians attain college-level math skill within six years”, while “only one-fifth of Hispanic and one-ninth of Black students do so” (Bahr, 2010b, p. 232). Bahr further highlighted the need for additional studies to focus on a few of the key findings. Two important suggestions focused on the need to identify students at risk in order to increase the success of remediation for more students and the second was the successful role of academic advising expansion opportunities for students. Bahr stated the need for more qualitative studies to explore students’ perspectives in order to explore these findings in greater detail.

In another similar study, but more recent study, Benken et al. (2015) described “initial success” in mathematics as “early momentum” which can increase the students’ “overall success in college” (p. 14). Benken et al. collected data from 376 students in a semester-long remedial mathematics course in 2008 using pre- and post-course evaluations, open-ended surveys, and course grades. Exploring the other factors contributing to students’ success in remedial education (as described by Di Tommaso, 2012, and Weinstein, 2004), questions focused on students’ anxiety, attitudes, and confidence related to the learning of mathematics, their faculty member, and their skill level. The results demonstrated that when factors such as attitude and
self-belief increased by the end of the semester-long remedial mathematics course, students had a higher success rate of passing remedial mathematics.

**Summary**

Remedial education has been a component of higher education for decades; however, over this period of time the number of students needing remediation has increased (Benken et al., 2015; Goldrick-Rab, 2010; Howell, 2011; Howell et al., 2010; Melguizo, Bos, & Prather, 2011; Tierney & Garcia, 2011). Latest data suggest that approximately 40% of students entering college for the first-time require some sort of remediation (Li et al., 2013) and mathematics accounts for the majority of remedial courses offered (Li et al.; Medhanie et al., 2011). There are critics of remedial education (Calcagno et al., 2007; Martorell & McFarlin, 2011); however, the vast majority of literature supports remedial education (Bahr, 2010b, Benken et al., 2015; Li et al., 2013; Medhanie et al., 2011). It is important to mention that the majority of this literature is focused at the macro level exploring the success of students as a whole as measured by progression and graduation rates.

Student placement into a remedial mathematics course vary from institution to institution; however, national placement examinations have the potential to guide placement of students into courses to help ensure the development of competencies that are lacking (Scott-Clayton, 2012; Mattern & Packman, 2009). Remedial education results in success for some students, but for others it does not. Understanding the factors that students identify as helping them be successful is of importance (Bahr, 2010b). A better understanding of the factors that students wishing to enter medical imaging or nursing professions describe as contributing to their success in remedial mathematics has the potential to inform future strategies for improving student support
programs and offerings. The next section of this review is centered on the factors that relate to students’ success.

**Factors Related to Students’ Success in the Academic Setting**

Students view their success differently from educators and often refer to it in terms of their experiences, whereas faculty and administrators tend to use the term outcomes (Weinstein, 2004). The learning experiences described by students in the literature presented in this section are associated with factors that are identified with academic success. While there is sufficient literature focusing on students’ success through their learning experiences in a variety of settings and disciplines (Brackenbury, 2012; Dolmans et al., 2008; Fuller, Rawlinson, & Bevan, 2000; King, 2014; Poon, 2013), very few studies address these experiences in remedial education. The following review of the literature will begin with an examination of the factors that relate to students’ success from a variety of college-level courses in different disciplines and then followed by subsections related specifically to mathematics and then those factors identified in the literature in remedial mathematics. The final subsection is related to those factors identified in the health professions.

**Student Factors and Success in General College-Level Courses**

Chickering and Gamson (1987) wrote the *Seven Principles for Good Practice in Undergraduate Education*, which served as an early work in understanding students’ learning experiences and the factors related to student success including connections between students and faculty, active learning, prompt feedback, and communication. Research also provides evidence supporting the student’s prior history, knowledge, or experiences as having a direct correlation to the level at which the student learns the material (Brackenbury, 2012). In fact, over the past three decades, studies reporting students’ descriptions of their learning experiences
have generated common themes as contributing to their success. Studies show that students learn better when there is a learner-centered approach (Chickering & Gamson, 1987; Rufatto et al., 2016; Wingert et al., 2014) with an involved instructor (Folkard, 2004; Fuller et al., 2000), timely feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014), and with clear outcomes and expectations for the course (Prescott et al., 2014; Trigwell et al., 2013). Additional factors reported by Trigwell et al. (2013) that affect students’ academic success (which they report as characteristics) include prior academic achievements, motivation, critical thinking skills, self-efficacy, self-image, and the availability of resources. These factors, while not all-inclusive, can be connected with the components of self-efficacy theory as espoused by Bandura (1977, 1989, 1993), and are presented in the section on Self-Efficacy.

One factor is student’s prior learning experiences. According to the literature, one must consider the students and the characteristics that would affect their learning, including their prior learning experiences (Brackenbury, 2012; Trigwell et al., 2013). In a mixed methods study, Trigwell et al. (2013) examined how students’ prior experiences and perceptions of their learning environments related to their overall academic achievement. Using focus group discussions, interviews, and completion of a 77-item questionnaire, the researchers studied 773 undergraduate students from 49 disciplines at the University of Oxford. They found that students who perceived the workload as too heavy or limited only to memorization studied just enough to get through the course. Conversely, the students who believed that their learning was more about a deep understanding or finding new ways of thinking had a deeper approach to learning, which also are attributed to students’ prior experiences in other courses. While prior experiences do not necessarily predetermine a students’ ability to learn or determine their overall performance, they do shape an individual’s perspective before coming into the classroom (Barrie, Ginns, & Prosser,
2005). Also, Liu (2012) suggested that first year nursing students used their past learning experiences from high school when trying to learn new material but were often unable to connect the prior experiences with the new context. According to Barrie, Ginns, and Prosser (2005), the students’ self-described learning experiences were a “function of both their prior experiences and of the present context” (Barrie et al., 2005, p. 643).

A second factor, which relates to students’ prior learning experiences, and has been documented to contribute to student success, is the use of a learner-centered approach (Brackenbury, 2012; Poon, 2013; Rufatto et al., 2016). With this approach, the student learns at his or her own pace and in a format that is best for each student. Students value concepts such as the learner-centered approach over a traditional faculty-lecture presentation (Brackenbury, 2012). This is not to say that faculty-lectures are not important or even used in learner-centered approach, but it does indicate that lectures are not the only way to the learning process. In this approach, lectures become one tool that assists students with their overall learning process (Saulnier, Landry, Longenecker, & Wagner, 2008). Saulnier. Landry, Longenecker, and Wagner (2008) further described that a learner-centered approach:

…is not to transferring knowledge but to create environments and experiences that brings students to discover and construct knowledge for themselves, to make students members of communities of learners that make discoveries and solve problems (p. 170).

In his article, Brackenbury (2012) indicated that students were better able to acquire new knowledge and skills when their teachers shifted to learner-centered approaches. Also, Poon (2013) in her 2010 study of 260 students at Nottingham Trent University in the United Kingdom, reported that students who were able to improve learning on their own noted enhanced learning
experiences that led to improved academic success. According to Brackenbury and Poon, this type of active learning holds the students accountable, but also allows them greater autonomy over their own learning and at their own pace. Similarly, Wingert et al. (2014) argued that providing challenges to students so that the students created their own solutions was the underlying principle of a liberal arts education. Active learning allows students to not only be responsible for their own learning, but also allows them to shape their own learning experiences by developing the confidence to tackle more challenging material (Brackenbury, 2012; Poon, 2013; Wingert et al., 2014). Additionally, Kaivola, Salomaki, and Taina (2012) indicated that from the students’ perspective, the teacher must ensure that the students are ready for an activity and have the prior knowledge necessary for the assignment in order to have positive learning experiences.

Along with a learner centric approach, literature supports the impact that faculty members have on students’ learning and academic success as another factor affecting student success. Students’ perceptions of quality teaching are directly related to their perceived experiences, which are linked to more positive course outcomes for the students (Trigwell et al., 2013). Research also shows that students perceive the learning experience to be better with better instructors (Finnigan, 2009; Manning et al., 2010). A better instructor is a term that was loosely used in the literature; however, it stems from factors that students discussed, such as an involved faculty member and one that was perceived to care about their learning. Both Finnigan (2009) and Manning et al. (2010) concluded that students not only performed better statistically, but also expressed having better experiences in comprehending the knowledge when they perceived that the professor was an engaging, caring, and passionate instructor, and that there were clear expectations of the course outcomes.
Timely feedback from the faculty member is another common factor that emerged from various studies of students’ learning experiences and academic success (Dolmans et al., 2008; Fuller et al., 2000; Wang, 2014). Dolmans et al. (2008) reported that the evaluations at the end of an internship for 350 undergraduate medical students rated faculty higher when students perceived that they received timely feedback and believed that the faculty was involved in their success. This supports an earlier qualitative study, in which Fuller et al. (2000) studied 56 first-year geography students hoping to better understand the students’ learning experience. During a 2-day fieldwork experience the instructor used a descriptive-explanatory approach (lecturer-centered approach) one day and then an analytical-predictive approach (learner-centered approach) the next day. The students reported better learning experiences in a lecturer-centered approach, which contradicted the findings of other studies that showed students have better learning experiences and better academic outcomes for that particular assignment in a learner-centered approach. However, the difference in this study was that the instructor was providing more timely feedback and advice during the field experience when using the descriptive-explanatory approach versus the analytical-predictive approach during which the instructor only gave feedback when asked. Similarly, in a clinical internship study, medical students who had little or late feedback from a variety of different instructors had poorer learning experiences and academic outcomes when compared to those who reported examples of timely and informative feedback from their instructors (Dolmans et al., 2008). Furthermore, Wang’s (2004) mixed-method study of 52 students in a one-semester course recounted that students who received informative and timely feedback reported that they not only had a better learning experience, but also had better grades than their counterparts in the same course who received little informative or timely feedback.
Another factor that has emerged in literature regarding students’ descriptions of learning experiences as they relate to academic achievement is the presence of clear expectations of the goals and outcomes of the course (Dolmans et al., 2008; Fuller et al., 2000; Trigwell et al., 2013; Wang, 2014). In any teaching and learning situation, both the instructor and the students should know what the goals and desired learning outcomes should be. This allows the instructor to better assess the students and the course and also allows the students to know from the beginning what the goals and expectations are of the course and how to achieve them. This is supported by research that demonstrates that students’ learning experiences are more positive when goals and outcome expectations are clearly presented (Trigwell et al., 2013). Trigwell et al. (2013) stated that students who knew the expected course outcomes and objectives as well as their relevance reported having a more positive learning experience versus those of the students who did not feel as though they fully understood the desired outcomes. Fuller et al. (2000) reported similar results. As mentioned above, students who were given more specific information from a faculty-led lecture (descriptive educational objectives) had higher grades on fieldwork assignments vs. the students who were not given the specific objectives by the instructor. The students in the descriptive objectives group reported on a self-evaluation that they had more positive learning experiences and believed they had greater success compared to the evaluation of students who did not have the descriptive objectives.

A factor that connects each of the previously mentioned factors together is the one-on-one support students receive. This support is generally provided in a variety of settings or with different people; however, two of the more common ways are with peers that students identify with (Butler-Paisley and Clemetsen, 2018; Yomtov, Plunkett, Efrat, & Marin, 2017) or with more traditional tutoring centers (Jaafar, Toce, & Polnariiev, 2016). Focusing on peers mentors,
Butler-Paisley and Clemetsen’s (2018) study found that 13 faculty members who taught in the first-term math or writing courses at a large community college on the west coast believed that student peer interactions helped enhance learning for the students, along with growth and success for all students. They reported that the social interaction among peers in the classroom improved students’ ability to learn. They add that in some situations, peers were able to help other students understand the material in ways that the faculty member was unable. Similarly, Yomtov, Plunkett, Efrat, and Marin (2017) found in a study with 304 first-year students during Fall 2012 semester, that student peers can improve the overall experiences of other students. More specifically, the study found that for students in the same major, peers help one another feel more connected and provide that sometimes much needed motivation, encouragement, and academic support.

In summary, research shows that students who are more actively engaged in their own learning through learner-centered approaches, and who have supportive instructors that provide clear expectations and timely feedback, generally reported having more positive learning experiences which in turn lead to greater student success. These learning experiences described by students in the literature are associated with the factors that are identified with academic success. The literature also shows that the students’ prior learning experiences and knowledge also affect their perceptions of the current learning experience. The following section considers the students’ views of their efforts to attain mathematical skills and understanding at the college level.

**Student Factors and Success with Mathematical Skill Development**

An understanding of students’ learning experiences, as described in the previous section, allows the identification of factors related specifically to the development of mathematical skills.
Understanding these factors (described as learning experiences by students) in mathematical skill development is important for students, faculty, and administrators in higher education, because it might help foster the development of strategies that help improve student success. An understanding of factors related students’ learning experiences in mathematical skill development could lead to pedagogical (teaching) and andragogical (adult teaching) adaptation that ultimately retains students, helps them progress to graduation, and supports them in achieving their educational and career goals. While pedagogy is a widely accepted and generic word referring to teaching, andragogy has had less common knowledge. Andragogy, refers to the teaching of adults, has more recently become a topic of importance in finding ways to help college aged students be more successful (Peterson & Ray, 2013).

Mathematical skills are essential to a variety of different disciplines and careers. The majority of the literature on understanding students’ learning experiences in mathematical skills development is grounded in the science-based disciplines (Folkard, 2004; Matthews, Hodgson, & Varsavsky, 2013; Steyn & Du Plessis, 2007). However, there is still only limited research in this area when focused on remedial mathematics and the health professions for which mathematical skills are so critical. This section will focus on four studies by Folkard (2004), Matthews, Hodgson, and Varsavsky (2013), Rufatto et al. (2016), and Steyn and Du Plessis (2007) that have examined the relationship of students’ learning experiences and academic success with mathematical skill development, referred to as factors by the researcher.

While researching students regarding their perceptions of mathematics’ skills and their learning experiences, Folkard (2004) termed students who had an aversion to quantitative subjects as “mathophobic” (p. 209). Folkard recounted that students who were weak in mathematical skills often did poorly in the subjects that required them. His qualitative study
included 12 undergraduate students in a geography course. In both classroom observations and in small focus group sessions, there were three distinct findings. The first was that much of why students did not care for quantitative courses and did not rate their learning experiences in them very highly was due to the lack of a connection between the skills and the real world. The second was that the students believed that the material was outdated and only called for a right or wrong answer. The third was that the instructor played an important role in their experiences and achievement, primarily related to giving feedback and in providing the time needed for their individual needs. This third finding was similar to study findings on students’ learning experiences and factors contributing to student success as reported by Dolmans et al. (2008), Finnigan (2009), Fuller et al. (2000), Manning et al. (2010), and Trigwell et al. (2013), which were described earlier. However, it is important to note that Folkard (2004) clearly stated that students were not weak in the quantitative skills, but had an “aversion to them” (p. 209).

Folkard’s (2004) findings are supported by a study by Kim and Sax (2016) that utilized data from 2184 students from 27 colleges and universities. The findings suggested that student-faculty relationships do support the development of math self-concept for students in Science, Technology, Engineering, and Mathematics (STEM) majors in a positive manner. When students had positive interactions with math faculty for support, students developed a more positive and meaningful understanding with math.

Folkard’s (2004) findings were also supported by Brackenbury's (2012) study of students’ learning experiences. Brackenbury stated that when students were actively involved in their own learning, or engaged in a learner-centered approach, students generally had heightened learning experiences as compared to situations in which they were lectured and in turn, had higher academic outcomes. Students who were involved in what they called active learning
sessions in the classroom reported feeling as though they did better at learning the material and
could make the connections as to why the material was important. Similarly, students who
showed a preference for “real world problems” had better learning experiences than their
counterparts (Folkard, 2004, p. 223).

In the second study, Matthews et al. (2013) reported a 2011 study of 400 students across
two universities who were in their last year of a science major. The study focused on the
students’ perceptions of their quantitative skills in the sciences and the factors associated with
their ratings using a 4-point Likert scale. The researchers asserted that if students could
appreciate the transferability of the quantitative skills to another area that they found important
(such as their major/discipline), they were more likely to focus more on the material. Further
findings included the fact that the students’ perceptions were also related to their confidence in
the material, overall grade point average (GPA), and the number of courses in which quantitative
skills were used. Matthews et al. point out that the likelihood of increasing quantitative skill
development in students is to have them more engaged with the material that is more relevant to
their discipline or major.

Taking it a step further, a study by Steyn and Du Plessis (2007) found that by allowing
students to connect the quantitative skills with “non-mathematical skills,” the learning
experiences were enhanced and they achieved higher academic success (p. 889). Steyn and Du
Plessis’s studied first-year engineering students over a five-year period and found that achieving
competency in mathematics required learning non-mathematical skills such as study habits, time
management skills, and communication skills in addition to mathematical content. Acquisition
of non-mathematical skills was enhanced by a two semester long professional orientation course
that not only provided assistance with mathematical skills and problems, but also with personal
and academic skills, communication skills, and information technology skills. The students in the professional orientation course improved their performance in mathematics classes and felt more confident with quantitative skills.

The final, and most notable, is when Rufatto, Dickin, Florescu, Lorch, Bremigan, and Lorch (2016) found that students who were engaged in a more learner-centered course in mathematics, achieved higher grades versus the students in a more traditional lecture style course. The study examined approximately 17,000 students between Fall 2013 and Spring 2015 who were taking a liberal arts mathematics course, with up to two-thirds of the math faculty participating. The study was from a large state university and the findings suggested that students in the learner-centered courses received more A and B final grades in the course versus the students in more traditional lecture-style courses.

A limitation that exists in three studies is the fact that each study was conducted with students in the science-related field. Folkard (2004) studied students in geography, Matthews et al., (2013) studied students in their final year of a science-based major such as life-sciences or physical sciences, and Steyn and Du Plessis’s (2007) study was with engineering students. The fourth and final study by Rufatto (2016) was related to mathematics for the liberal arts majors. None of these studies were with students in the health professions or with students in remedial mathematics courses; however, the studies did provide insight into students’ perceptions about mathematics and the factors related to their experiences. The next section is specifically focused on those factors in remedial mathematics’ courses.

**Student Factors and Success in Remedial Mathematics’ Courses**

There is a dearth of qualitative literature in the area of students’ self-described success factors and learning experiences in remedial mathematics courses. Most of the research that is
available has explored students’ learning experiences with various tools used in remedial courses such as online tutoring or homework tools and students’ perceived quantitative skills development rather than the study of the experience of learning or the factors contributing to their success (Leong & Alexander, 2014). The majority of the literature reports quantitative data that supports the successes and challenges generally associated with remedial work in mathematical skills development, but not specifically qualitative responses from students in required remedial courses as already discussed within the remedial education section; however, there are a limited number of qualitative studies to mention. It is the qualitative data that serves to provide insights into how students learn and the factors they perceive has helping them achieve their success; an area important to scholar-practitioners.

Leong and Alexander (2014) concluded that students in remedial mathematics’ courses who wanted to learn quantitative skills wanted direct, clear, and timely feedback in order to move to the next module. Leong and Alexander used a mixed-methods study design to study 78 students’ learning experiences with web-based homework, their attitudes toward mathematics, and their achievement in a remedial mathematics course in a large urban community college. A questionnaire was used to collect quantitative information on the “attitudes and beliefs held by student participants regarding the web-based homework” using a Likert scale (Leong & Alexander, 2014, p. 612). For the qualitative portion, the students were asked open-ended questions that focused on their “thoughts” about the web-based homework (Leong & Alexander, 2014, p. 612). The results were consistent with other findings of factors associated with students’ success in general courses and that in mathematical skills development. Leong and Alexander suggested that “students who had lower and average mathematics achievement had more positive attitudes toward using a web-based homework system compared to higher-
achieving students” (Leong & Alexander, 2014, p. 614). The findings also suggested that the reason their attitudes were more positive was most likely due to the instant feedback the system provided. The availability of the web-based homework also allowed the students to be in control of their time as well as when and how they wanted to access the homework, which is consistent with learner-centered learning.

In another study, Hall and Ponton (2005) reported that students’ personal beliefs from prior experiences could be a contributing factor to their success or failure in developmental mathematics’ courses. The researchers compared the learning experiences of 185 random freshmen at a rural, medium-sized, state university in the Southeast, of whom 80 were in Calculus I course and 105 were in developmental mathematics course. Their findings indicated that many of the students’ learning experiences and perceived academic achievement were rated low if their mathematics’ skills were weak, thus the students in the Calculus I course had a higher sense of self-efficacy related to mathematics versus the students in the remedial mathematics course.

In a more recent study, Koch, Slate, and Moore (2012) reported on a qualitative study that included only three students from a community college in Texas. They stated, that with involved faculty and more readily available feedback, students had an increased belief in themselves and a better sense of grasping the material being taught. Students who used technology on their own, such as computer tutorials that provided instant feedback, also believed that they were gaining more confidence in learning the required mathematics’ skills. Tutoring sessions with staff and their own peers also contributed to students’ comments about their positive learning experiences in the remedial mathematics’ course. A final note of importance was the authors’ acknowledgement that was a lack of qualitative research to “examine student
perceptions about their experiences in developmental program” (Koch, Slate, & Moore, 2012, p. 63).

In a more recent study, Jaafar, Toce, and Polnariev (2016) explored students at a large community college in New York in a remedial mathematics course and found that math-learning labs provided support and benefited the students who used them. The study further demonstrated that the success of the tutoring labs was bolstered by committed faculty members. Support from administration and faculty who were committed to success of students in remedial mathematics was instrumental to encouraging students to use the one-on-one support of the math-learning labs, that also served as tutoring labs. Following the implementation of the math labs, there was higher academic success for the students who use the labs, including higher grades and virtually no withdrawals from the math courses that are supported in the lab.

Regrettably, even when students successfully complete a remedial mathematics course, the students may not have developed the quantitative skills that allow them to be successful in college-level quantitative courses. For example, Abraham, Slate, Saxon, and Barnes (2014) recounted the mathematics readiness of first-time community college students in Texas. Of the 77 Texas community colleges that were studied in 2008, 41% of the students “were not college-ready in math and low percentages of them attained a passing grade in a college-level math course” (Abraham, Slate, Saxon & Barnes, 2014, p. 39). At the same time, “94.43% of students who previously completed a developmental mathematics course could not pass an entry-level, credit-bearing college math course” (Abraham et al., 2014, p. 39). This percentage of students unable to pass a college-level mathematics course is extremely high, but the authors offered some possible explanations. The first was that the study looked at all students entering a community college in Texas who needed a remedial mathematics course, not specifically looking
at the college placement examination results or their high school records; therefore, not considering the level of remediation needed. The study also did not take into consideration the various community colleges and their student demographic or mission of the campus. While this study was conducted with community college students whose experiences might be different from those of other college students, it does support the need to re-examine the content and delivery of remedial courses in order to help students be more successful with quantitative skills development. Remedial education works for some students to be successful and for others, it does not. Identifying those students that remedial education will help is critical to the success of those students.

Bahr (2008) examined over 85,000 first year students from 107 community colleges in California. His quantitative study demonstrated that when remediation works in the community college setting, it works well. This means that students, who successfully pass a remedial mathematics course, have similar outcomes as students who were not required to take a remedial mathematics course. However, his study demonstrated that 75% did not pass a remedial mathematics course and therefore, were unable to complete a credential or transfer to a four-year school. Bahr posed a few facts that appear to answer the question of why remedial mathematics works for some and not for others. He theorized that it was the breadth and depth of the mathematics skills that the students bring with them when entering college and the first few grades students receive in these remedial mathematics courses that determines their outcomes. He related this to self-efficacy and concluded by reiterating that when a student successfully remediates in mathematics, the outcomes for that student are similar to the students who were not required to take a remedial mathematics course. He encouraged more research on identifying those factors that challenge students from being successful in the remediation of mathematics.
Student Factors and Success in the Health Professions

In 2007, Noone et al. published data supporting Brown’s 2002 findings. The two-year study at a community college focused on increasing the number of nursing students admitted into the program who were underprepared in mathematics and normally would not have met the admissions criteria. The project included a new two-year pre-entry curriculum that had developmental mathematics (also referred to in literature as remedial mathematics) integrated throughout the two years, along with other courses. Students were also required to attend a certain number of student support sessions. The focus of the study was not on the quantitative data related to how many students were admitted into the nursing program after this pre-nursing requirement but rather on qualitative data related to the students’ learning experiences and academic achievement. Students reported several key findings that had been reported in other studies but not specifically related to remedial mathematics. The findings showed communication, “real-life” examples, and contextual learning as key components of their learning experiences (Noone et al., 2007, p. 289). Students had better experiences and outcomes with learning various mathematics concepts when the concepts related to tasks they would perform in nursing such as calculating patient dosages. As well, students reported that faculty who took the time to provide timely feedback on their work motivated them to keep moving forward and to learning newer material (Noone et al., 2007). Teachers were the key to the success of the program. Instructors who made conceptual connections with other courses, such as connecting the mathematics and science courses to the nursing curriculum, garnered more positive comments throughout students’ reflections.

Authors from other health professions have reported similar research findings. A study of pharmacy students found that mathematics subjects such as algebra, statistics, and physics
were not viewed as important to pharmacy students when compared to chemistry for which the students could visualize the connection of the material to a profession in pharmacy (Prescott et al., 2014). Prescott et al. (2014) concluded that when faculty members were able to connect the knowledge and skills of science and mathematics subjects to the “applied pharmacy context,” students report better experiences or success with the subject material and a greater appreciation of the subject (p. 5).

**Summary**

In general, the literature indicates that student success exists when there is: (a) immediate and informative feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014); (b) student’s input into their learning (Brackenbury, 2012; Chickering & Gamson, 1987; Wingert et al., 2014); (c) clear expectations of goals and objectives (Prescott et al., 2014; Trigwell et al., 2013); (d) more positive prior experiences (Abraham et al., 2014; Ellis et al., 2013; Trigwell et al., 2013); and (e) involved faculty that believe in them (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; King, 2014).

Providing intense remedial work in area of mathematics and connecting the problem-solving equations to the actual profession, students had better success long term in the professions (Noone et al., 2007; Prescott et al., 2014). Students also reported that when they felt they had timely feedback and support from faculty, they were more motivated to move forward and learn new material (Noone et al., 2007). One main underlying finding in this study with Noone et al. (2007) was that the instructor was a key factor when students were having remedial education. These key findings will resurface throughout this review of literature.

In summary students’ learning experiences and their success with quantitative skills development in remedial mathematics courses depends on prior learning experiences. This is
consistent with research that has examined students’ learning experiences in a variety of disciplines. College students, as adult learners, have a desire to have timely feedback and may achieve higher achievement scores if the material is in a learner-centered approach. However, the research is limited related to successful students’ descriptions of remedial mathematics.

**Self-Efficacy Theory**

This study’s purpose was to explore the factors that students described as contributing to their successful completion of a remedial mathematics course. This research problem was guided by the self-efficacy theory as the theoretical framework. This section provides literature on the validity of self-efficacy theory and some concerns raised by researchers when it is utilized as a theoretical framework.

Albert Bandura introduced self-efficacy theory in 1977. This new theoretical framework came at a time when there was much discussion related to behavioral changes in individuals based on various treatments or psychological modifications (Bandura, 1977). However, Bandura (1977) claimed that one major missing element that contributed to behavior change was related to the belief in one’s self; thus, the theory is a social learning theory (Bandura & Cervone, 1983) also referred to as social cognitive theory (Zimmerman, 2000). Self-efficacy is defined as the belief in one’s self to produce the required behaviors or actions needed to achieve specific outcomes (Bandura, 1977, 1986, 1989, 1993). Self-efficacy as a theory has a focus on outcomes and/or performance expectations as defined by the individual. Self-efficacy theory includes four main sources of information that lead to self-efficacy or the desired outcome or expectation. The four sources are performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal (Bandura, 1977). Performance accomplishments are identified as the most influential source on self-efficacy (Hackett & Betz, 1989; Lent et al., 1991; Lopez & Lent, 1992;
Pajares & Miller, 1994). For example, performance accomplishments can include grades and meeting goal expectations or outcomes (Bandura, 1977; Lent et al., 1991; Pajares & Miller, 1994). The remaining three sources are considered directly or indirectly related to self-efficacy by researchers (Lent et al., 1991). Examples of these sources include role models as vicarious experiences (Hackett & Betz, 1989); encouragement and support (Hackett & Betz, 1989; Koch, Slate, & Moore, 2012); and interventions to reduce the anxiety levels of subject material (Hackett, 1985; Hackett & Betz, 1989). These sources have been identified in the literature as critical to an individual’s perceived level of self-efficacy. “Students’ beliefs in their efficacy to regulate their own learning and to master academic activities determine their aspirations, level of motivation, and academic accomplishments” (Bandura, 1993, p. 117). Bandura (1997) also suggested that self-efficacy may relate to students past learning experiences. Since Bandura’s introduction of his theory of self-efficacy, there has been a wealth of literature to support use of the theory in the academic setting, which is reviewed in the next section.

**Self-Efficacy in the Academic Setting**

Bandura and Cervone (1983) examined the theory by utilizing goal setting and feedback as motivational purposes. The study included 90 individuals from an introductory psychology course (45 men and 45 women) who were randomly assigned to four different treatment conditions and were required to perform a strenuous activity: with goals and performance feedback, with goals alone, with feedback alone, or without either. The results showed that when students had a goal and were provided feedback on the activity showing progress toward they goal, there was significant increase in self-efficacy. However, it was noted that goal setting alone or receiving feedback alone did not change students’ motivation level. The motivation levels were only changed when the two were combined.
Three more recent studies did show that career goals do have an impact on student success and can be connected to self-efficacy. While the studies may not have specifically measured self-efficacy, the relationship to self-efficacy could be made based on definitions and descriptions used. Hull-Blanks et al. (2005) found that among 401 first-year students, students with reported job-specific goals were more likely to have higher persistence decisions versus the students without career goals. They further indicate that goals related to careers can not only increase academic performances, but also increase ones’ beliefs academically. The data demonstrated that students without a clearly identified goal related to a career made more negative persistence decisions than their peers with specific career goals. Hull-Blanks et al. (2005) findings were supported with Willcoxson and Wynder (2010). The study with 232 students in the 2008 and 2009 academic year in a business-related major found that students who had a clear and specific career goal were more likely to persist and finish their degree program. More specifically, students in accounting in which there are requirements to practice accounting had significantly greater success rates at finishing the degree compared to students who were in more generic business majors. In a more recent study of 304 students enrolled in hospitality management, Lee and Lee (2018) found that the students who identified a specific career within the hospitality industry demonstrated better academic success compared to their peers with no clear career decisions related to hospitality management. They also found that students with the clearly identified career goal had higher grade point average (GPA) in the major versus the students with no known career goal. It is important to note that the higher GPA was specifically in the major and not their overall college GPA.

The notion that motivation and self-efficacy are related to one another in the academic setting is well documented (Bandura & Cervone, 1983; Bandura & Schunk, 1981; Trigwell et al.,
2013; Zimmerman, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992). Zimmerman, Bandura, and Martinez-Pons (1992) suggested that the connection between self-efficacy and motivation is related to goal setting. Students’ perceived self-efficacy determines their level of goal setting. For example, students with a higher sense of self-efficacy tend to set higher goals for themselves and therefore, work harder to achieve those goals. Bandura (1993) himself acknowledged the connection between self-efficacy, motivation, and goal setting. Individuals with higher self-efficacy perceptions tend to set higher goals and have stronger motivations skills to achieve them (Bandura, 1993). At the same time, Bandura expanded on this notation and stated:

There is a marked difference between possessing knowledge and skills and being able to use them well under taxing conditions. Personal accomplishments require not only skills but self-beliefs of efficacy to use them well. Hence, a person with the same knowledge and skills may perform poorly, adequately, or extraordinarily depending on fluctuations in self-efficacy thinking (p. 119).

This statement is the essence of the self-efficacy theory and why it is related to academic achievement, in particular to the research problems that are being studied. Bandura (1993) described students who have anxiety related to their academic achievement as students who have low self-efficacy. Having multiple failures with the particular goal or expected outcome continues to lower the sense of self-efficacy. However, students with higher self-efficacy look at failures differently and are usually quicker to respond to failure or setbacks.

Trigwell et al. (2013) expanded on this, reporting that self-efficacy is directly related to academic achievement. As already mentioned, their study included 773 undergraduate students who were 18 months from graduation and in a variety of disciplines. The study included two
phases. The first phase was conducted with 5-10 students in focus group discussions focused on learning styles, self-efficacy, and motivation. An interview with 28 students followed and a 77-item questionnaire. The second phase of the study was the 77-item questionnaire distributed to students across 17 of the 34 colleges at the university of which 42% responded. The transcripts of these students were used as the standard for academic achievement. The results showed that self-efficacy and motivation were directly related to academic achievement. The other findings that demonstrated an impact on academic success in this study included the quality of the teaching, deep-approach learning, workload perceptions, and faculty involvement, all of which were consistent with literature from sections already described in this chapter. The next section will focus on the role of self-efficacy in mathematics specifically, and the validity of the four sources.

**Self-Efficacy in Mathematics**

Bandura and Schunk (1981) tested self-efficacy through the use of mathematics education in children. The study consisted of 40 children from six different elementary schools. The results showed that children who set goals in a self-directed learning module progressed more rapidly than the students who did not set goals for themselves; in fact, self-efficacy increased among those who identified goals. Important to note is that the goals that had multiple subsets of goals were the ones that showed an increase in self-efficacy. Large, overarching goals tended to have little impact on self-efficacy, partly because of the student not seeing the achievement of that goal in shorter timeframes (Bandura & Schunk, 1981). Therefore, the idea that goal setting is important in the self-efficacy theory is important to the students’ achievement.

Pajares and Miller (1994) explored the relationship between self-efficacy and mathematics in 350 students at a large public university in the South. Students represented a
variety of majors and the purpose was to determine what role self-efficacy had on academic performance. The findings showed that performance accomplishments were the major influence on a student’s self-efficacy. Part of this was related to their perceptions about solving mathematics problems, perceptions about the usefulness of the problems, and prior experience. While there was acknowledgement of all four sources as being important to self-efficacy related to mathematics, it was also strongly suggested that performance accomplishments are most influential to self-efficacy. The study further found that the competency in mathematics shed light regarding students’ self-efficacy; however, self-efficacy does indicate much about students’ “math-related decisions such as pursuing math courses, majors, or careers” (Pajares & Miller, 1994, p. 201). This finding became an important fact for the current study exploring medical imaging and nursing students’ perspectives in passing a remedial mathematics course.

Expanding this notion that self-efficacy in mathematics has a direct relationship with career or major selection, Hackett and Betz (1989) determined that self-efficacy in mathematics was a better predictor in math-related career and major selections than did overall performance in mathematics alone or with past-experiences in mathematics alone. The study of 262 (153 men and 109 women) enrolled in an introductory psychology course at a large Midwestern university showed that all four of the sources of self-efficacy theory described by Bandura were critical to the overall mathematics self-efficacy and career choice. The study further expanded this by suggesting that educators focus not only on the academic performance in mathematics and past performances (although important), but to support the other sources. For example, the suggestion was for faculty members to provide encouragement and support or to have students seek that out, along with identifying role models for students as with vicarious experiences, and finally ways to reduce the anxiety around mathematics for emotional arousal.
Hall and Ponton (2005) suggested that enhancing self-efficacy could be a contributor to students’ achievement in mathematics by “enhancing the learning experiences for students in mathematics” (p. 30). Hall and Ponton, as reported earlier, studied perceived self-efficacy in mathematics in a quantitative study of 185 first year students at a four-year institution, 80 of whom were taking Calculus I, and 105 of whom were enrolled in Intermediate Algebra. Self-efficacy was measured using the mathematics self-efficacy scale (MSES) developed by Betz and Hackett (1983). They found that students who had instructors that helped them see their actual ability in mathematics had higher self-efficacy scores. When comparing the two groups of students, the students in Calculus I had higher self-efficacy scores than the students in the Intermediate Algebra course. This study also showed the relationship between verbal persuasion and performance accomplishments in the self-efficacy theory.

Not all studies demonstrate the relationship of all four sources of self-efficacy theory to having self-efficacy. Lopez and Lent (1992) studied 50 students in high school planning on attending college. The students were in an advanced mathematics course. The researchers visited the classroom and met with students during the course. They also conducted an interview after the course ended. Their findings indicated that performance accomplishments accounted for the largest portion of the students’ self-efficacy. The other three sources: vicarious experience, verbal persuasion, and emotional arousal did not significantly change self-efficacy. Self-efficacy does contribute to students’ overall mathematics performance (Bandura & Schunk, 1981; Hall & Ponton, 2005; Lopez & Lent, 1992). However, the question remains about how self-efficacy and remedial mathematics are related. This next section discusses the relationship between self-efficacy and remedial mathematics.
Self-efficacy and Remedial Mathematics

“Remedial programs that provide students with genuine mastery experiences and reduce excessive math fears may enhance students’ math self-efficacy and, ultimately, expand their range of perceived career and academic options” (Lopez & Lent, 1992, p. 11). To explore this notion, Spence and Usher (2007) indicated that self-efficacy plays a role in mathematics achievement and that it is one of the significant predictors of achievement. Their study included 164 students across 16 sections of remedial mathematics courses, 8 of which were traditional lecture-based courses and 8 online courses. The study found that students that had the online materials increased their self-efficacy when allowed to complete the material at their own pace and get immediate feedback regarding their answers and why they were correct or incorrect. These findings support the role of timely feedback as a factor contributing to student success as documented in the literature (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014), but also the value of verbal persuasion as a major contributing source in the self-efficacy theory.

Feedback directly affects the students’ perceptions regarding success, and ultimately their self-efficacy, according to Weinstein’s (2004) qualitative study that followed a variety of students in a remedial mathematics course at a large Midwestern university. He observed a class of 32 students, interviewed six of the students, and collected surveys from 18 of the students. The findings revealed how the students perceived their professors’ style and quality of instruction and its relationship to their own sense of self-capabilities. Weinstein recounted witnessing students asking peer tutors to wait to let them try the problems themselves and then ask for feedback. Toward the end of the semester, students reported that they were doing better with the instructors or tutors who took more time and gave them the encouragement as to their
ability to learn the concepts. While Weinstein stopped short of stating that all of this directly affects self-efficacy, his findings did confirm Bandura’s (1977) theory that there are four sources that contribute to self-efficacy, in particular performance accomplishments, vicarious experiences, and verbal persuasion.

Self-efficacy impacts students who are in remedial mathematics. In a more recent qualitative study exploring three students’ experiences and perceptions in a remedial course, Koch et al. (2012), found that self-efficacy did contribute to the students’ overall behavioral changes in the course. The students, all from community colleges in Texas, increased their self-efficacy when they had positive experiences related to academics (referred to Bandura’s (1977) source of performance accomplishments), faculty support (verbal persuasion), resources such as mathematics labs and tutoring centers (emotional arousals such as interventions to decrease anxiety), and goal setting. While vicarious experiences were not directly referred to, the other sources were found to have an impact in self-efficacy. Clearly, a limitation of this study was that it included only three students and these students were from different schools and with different academic goals such as majors. In fact, only two of the three students were in remedial mathematics, the other student was in remedial writing. However, the study does support that self-efficacy is impacted by several factors identified by students in a remedial course. Those factors identified were positive experiences related to academics (performance accomplishments), faculty support (verbal persuasion), tutoring and lab centers (emotional arousals) and goal setting.

Summary

Self-efficacy is defined as the belief in one’s self to produce the required behaviors or actions needed to achieve specific outcomes (Bandura, 1977, 1986, 1989, 1993). When Bandura
introduced the theoretical framework in 1977, the focus was on what Bandura described as a missing element in the social cognitive theory, which was self-belief (Bandura & Cervone, 1983). Bandura added that there were four main sources that contributed to self-efficacy. The four sources were performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal. Research has validated the relationship of these sources to self-efficacy as described in Figure 2.1. Since 1977, self-efficacy as a theoretical framework has been used in various research in academic settings to demonstrate the performance or outcomes of students to their sense of self-efficacy.
While there is a wealth of research on self-efficacy in an academic setting, there are several significant points to be made. The first is that self-efficacy is greatly enhanced when there are goals set ahead of time related to outcomes or expectations and when the individual (student in this case) receives feedback on his or her performance related to those goals (Bandura & Cervone, 1983). The opposite of this was also found. Students with a higher sense of self-efficacy were found to set higher goals for themselves (Zimmerman et al., 1992). Trigwell et al. (2013) in a more recent study found that self-efficacy and motivation were directly related to academic achievement. This is a critical finding for this research proposal in that students who
set goals, receive feedback, and see achievement in their overall performance tend to have a higher sense of self-efficacy and therefore, have the potential for higher academic achievements.

Beyond the Bandura and Cervone (1983), Bandura and Schunk (1981), Trigwell et al. (2013), and the Zimmerman et al. (1992) studies of self-efficacy in the academic setting in general, self-efficacy has been studied within mathematics, specifically how the four sources of self-efficacy contribute to a student’s sense of self-efficacy. Pajares and Miller (1994) found that performance accomplishments had a major influence on students’ self-efficacy. While they acknowledged all four of the sources, they suggested that performance accomplishments were the most influential. Hall and Ponton (2005) expanded on Pajares and Miller’s (1994) study and showed that in addition to performance accomplishments so did verbal persuasion, such as feedback, impact a student’s self-efficacy.

A connection between a higher sense of self-efficacy in mathematics also has a connection with math-related careers. One of the earliest studies, Hackett (1985) showed that a student who had a higher mathematics self-efficacy was also more likely to select a math-related career or major. She further stated that when there are ways to reduce mathematics anxiety (emotional arousal) and when grades and other success in mathematics (performance accomplishments) occur, there is a higher sense of mathematics self-efficacy, which has a direct relationship on career choices.

The literature has shown connections between the self-efficacy theory and mathematics in general and even between the theory and career selection. It makes sense that this too holds true for students in remedial mathematics. Studies demonstrate that when students in remedial courses were able to access the material online and in their own time and had direct feedback with their assignments, they had a higher sense of self-efficacy in mathematics and thus had
higher outcomes related to grades (Spence & Usher, 2007). Verbal persuasion has also been found to play an important role in increasing one’s self-efficacy, partially due to an increase in performance accomplishments (Spence & Usher, 2007; Weinstein, 2004). As Lent et al. (1991) reported, all four sources are interrelated, but performance accomplishments are the most influential to self-efficacy.

**Conclusion and Discussion**

The need for medical imaging and nursing students to have strong mathematical skills is critical to the professions (Brown, 2002; Noone et al., 2007; Revell & McCurry, 2013; Prescott et al., 2014). The skills include dose calculations and a variety of patient assessments (Harvey et al., 2010). Not only do these skills allow for accurate calculations for patient doses, but they also have the potential to reduce or even avoid patient care errors related to calculations (Revell & McCurry, 2013). Professional and accrediting organizations require programs within medical fields to assure mathematical competency as part of the professional curriculum and program outcomes (AACN, 2008; JRCNMT, 2014).

While enrollment is growing in these professions at the baccalaureate level (AACN, 2015; ASRT, 2015), so is the number of students who are not academically prepared to enter college-level mathematics courses (Attewell et al., 2006; Dasinger, 2013; Howard & Whitaker, 2011; Medhanie et al., 2011; Melguizo et al., 2014). Remedial mathematics represents the largest percentage of remedial education in higher education (Attewell et al., 2006; Li et al., 2013). How a student is placed in a remedial mathematics course is still individualized by each college or university; however, there is evidence that national placement examinations tend to have a moderate to strong correlation with placement versus the grade in the course, which helps students to be successful (Mattern & Packman, 2009; Scott-Clayton, 2012). Accuplacer, the
placement examination published by the College Board, helps college and universities determine their placement scores based on factors such as student demographic and the type of college or university (Mattern & Packman, 2009). Yet, regardless of the data surrounding placement decisions, remedial education is still a discussion in higher education.

Remedial education is sometimes criticized due to the increased costs, potential delays in graduation, or even stigma associated with the courses (Calcagno et al., 2007; Martorell & McFarlin, 2011). However, the vast majority of literature supports the value of remedial education (Attewell et al., 2006; Bahr, 2010a, 2010b; Benken et al., 2015; Bettinger & Long, 2004; Li et al., 2013). When students are successful in remedial mathematics, there is an increase in students’ academic success in college and in graduation rates (Bahr, 2010b; Benken et al., 2015). However, much of this literature is focused on large quantitative studies that demonstrate the success of students in remedial education. Understanding the students’ perspective is equally important.

Faculty and administrators focus on the outcomes of the students when describing success; however, students tend to focus on their experiences when describing success (Weinstein, 2004). The students’ learning experiences have been of interest to researchers for years in order to understand what constitutes academic success from the students’ perspective (Dolmans et al., 2008; Finnigan, 2009; Fuller et al., 2000; Prescott et al., 2014). Chickering and Gamson (1987) provided early work in understanding students’ learning experiences related to success. They found there were connections between students and faculty, active learning, feedback, and general communication and success in education. Since this time, studies have shown that factors students often describe in their success is the learner-centered approach (Chickering & Gamson, 1987; Wingert et al., 2014), an involved faculty member (Folkard, 2004;
Fuller et al., 2000), timely feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014), clear course outcomes (Prescott et al., 2014; Trigwell et al., 2013), and prior academic achievements (Brackenbury, 2012; Trigwell et al., 2013). These factors may be even more important when examining mathematics.

Folkard (2004) used the term “mathophobic” (p. 209) to describe students who perform weak in subjects that require mathematical skills. This is particularly important when students select majors or programs in college, which is generally associated with self-efficacy (Hackett, 1985; Hackett & Betz, 1981; Hackett & Betz, 1989). Therefore, self-efficacy becomes a central theme to understanding the factors and how they may or may not be a factor.

Bandura (1977, 1989, 1993) defined self-efficacy, as the belief in one’s self to produce the required behaviors or actions needed to achieve specific outcomes. There are four sources of information that lead to self-efficacy, or the desired outcome (Bandura, 1977). As mentioned the literature indicates that student academic success exists when there is: (a) immediate and informative feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong & Alexander, 2014); (b) student’s input into their learning (Brackenbury, 2012; Chickering & Gamson, 1987; Wingert et al., 2014); (c) clear expectations of goals and objectives (Prescott et al., 2014; Trigwell et al., 2013); (d) more prior experiences (Abraham et al., 2014; Ellis et al., 2013; Trigwell et al., 2013); and (e) involved faculty that believed in them (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; King, 2014). Each of these factors could be categorized into one of Bandura’s four sources (figure 2.2).
Figure 2.2.  
Self-efficacy Model with Factors from Literature Cited.

Efficacy Expectations

<table>
<thead>
<tr>
<th>Source</th>
<th>Mode of Induction</th>
<th>Potential Success Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Accomplishments</td>
<td>Participant Modeling Performance Desensitization Performance Exposure Self-Instructed Performance</td>
<td>Prior Academic Achievement (Trigwell et al., 2013) Timely Feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong &amp; Alexander, 2014) Learner-Centered Approach (Chickering &amp; Gamson, 1987; Wingert et al., 2014) Active learning (Brackenbury, 2012)</td>
</tr>
<tr>
<td>Vicarious Experience</td>
<td>Live Modeling Symbolic Modeling</td>
<td>Timely Feedback (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; Leong &amp; Alexander, 2014) Involved Instructor (Dolmans et al., 2008)</td>
</tr>
<tr>
<td>Verbal Persuasion</td>
<td>Suggestion Exhortation Self-Instruction Interpretive Treatments</td>
<td>Clear Expectations (Prescott et al., 2014; Trigwell et al., 2013) Involved Instructor (Dolmans et al., 2008; Folkard, 2004; Fuller et al., 2000; King, 2014) Learner-Centered Approach (Chickering &amp; Gamson, 1987; Wingert et al., 2014) Active learning (Brackenbury, 2012)</td>
</tr>
<tr>
<td>Emotional Arousal</td>
<td>Attribution Relaxation, Biofeedback Symbolic Desensitization Symbolic Exposure</td>
<td></td>
</tr>
</tbody>
</table>

Self-efficacy as a concept is well documented in the literature (Bandura & Cervone, 1983; Bandura & Schunk, 1981; Trigwell et al., 2013; Zimmerman, 2000; Zimmerman et al., 1992). Goal setting for the students is connected to their self-efficacy (Zimmerman et al., 1992). Students with a high sense of self-efficacy tend to set higher goals for themselves (Zimmerman et al., 1992). Bandura (1993) also described how a student with high self-efficacy views failures differently and can usually respond to the failure or setback quicker than someone with a lower sense of self-efficacy. Of the four sources related to self-efficacy, performance accomplishments have the most influential impact on self-efficacy (Hackett & Betz, 1989; Lent et al., 1991; Lopez & Lent, 1992). However, the other sources are all interrelated (Lent et al., 1991). Figure 2.1 demonstrates the literature that supports each of the four sources of self-efficacy. Self-efficacy does have a role in remedial education (Koch et al., 2012).

Koch et al. (2012) found in a qualitative study that self-efficacy did contribute to students’ behavioral changes a course. They showed that the sources of self-efficacy in Bandura’s model played a role in the students’ self-efficacy, with performance accomplishments being the major contributor. However, the importance of faculty support (verbal persuasion) and tutoring resources (emotional arousal) were critical, along with goal setting.

This literature review has demonstrated the need for mathematical skills for the medical imaging and nursing professions and the lack of these skills within the professions. As the number of students in these programs increases, so does the number of students needing remedial mathematics. There is literature that shows what students describe as helping them be successful academically. Self-efficacy not only has been shown as a factor itself, it also becomes an important determinant in students’ selection in their college major. Many of the factors that students describe as contributing to their success can be related to one of the four sources of
Bandura’s self-efficacy theory. Given the focus of this research study on the need for strong quantitative skills in the medical imaging and nursing professions, the use of the self-efficacy framework plays an important role in the overall role of identifying the factors that contribute to the students’ successful completion of the remedial mathematics course.

However, there is a lack of literature that demonstrates how a student can be successful when he or she enters college as a first-year student and has a goal of entering the medical imaging or nursing professions (known to require strong mathematical skills), but lacks those skills as determined by placement tests. Given the need for strong quantitative skills in these professions and the high stakes associated with passing the remedial mathematics course, one might ask why some students pass the remedial mathematics course and others do not. Do successful students simply have the capacity for achieving quantitative skills and others do not, or are additional factors at play, which ultimately contributes to their success? Does self-efficacy have a role in their success? Might identification of these factors be useful in helping less successful students pass remedial mathematics? Answering this needed question is important to both of the programs at a college where the majority of students enter their first year with plans on majoring in these programs, yet they lack the skills needed to progress into the required prerequisites.
CHAPTER THREE: METHODOLOGY

Introduction

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. A qualitative case study addressed the following research question:

1. What factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course?

There is a wealth of quantitative research at the macro-level focusing on the value of remedial education. There is also extensive quantitative and qualitative research on self-efficacy in both the academic setting and with mathematics specifically. However, there is a lack of research on the topic of students in medical imaging and nursing programs and their successful completion of a remedial mathematics course. This study proposed to explore those factors that students described as contributing to their successful completion of a required remedial mathematics course. This chapter outlines the methodology for answering the question by describing each of the following: the research paradigm, qualitative research tradition, methodological approach, participants, recruitment and access, data collection, data storage, data analysis, and the trustworthiness and validity of the study.

Research Paradigm

The research paradigm is a “basic set of beliefs that guides actions” (Guba, 1990, p. 17). These paradigms include four philosophical assumptions that researchers make relative to qualitative studies (Creswell, 2013; Morrow, 2007). Creswell (2013) and Morrow (2007) state that the philosophical assumptions are specific to ontology (one’s view of reality), epistemology (what is the knowledge and how it is justified), axiology (role of values in the research), and
methodology (the process of research). There are multiple research paradigms which include postpositivism, interpretivism-constructivism, and ideological-critical (Butin 2010; Morrow, 2007). Yin (2014) used the term relativist as an interpretivist orientation. Yin (2014) described the interpretivist paradigm as the participants’ multiple perspectives and meanings. The research paradigm used in this study was the interpretivist paradigm. Morrow best described the interpretivist paradigm as one that has “as many realities as there are participants” (Morrow, 2007, p. 213). In fact, Morrow also stated that in this paradigm, the researcher’s values are known to exist. Butin (2010) described interpretivist perspective as not having one right answer, but that all the researcher can do is to “accurately and thoroughly document the perspective being investigated” (Butin, 2010, p. 60). The goal of interpretivism is to search for meaning though patterns (Butin, 2010). Creswell (2013) stated that the philosophical assumptions in qualitative studies can be explicit and the researcher should discuss how they are demonstrated throughout the study. He also stated that there is an interactive component between the researcher and the participants.

This study used the interpretivist paradigm because its purpose was to explore the factors that students described in their individual success in a remedial mathematics course. The researcher represented the results from the student’s perspective, but the interpretation of the study was from the interactive relationship between the researcher and the participants in the study as described by Creswell (2013). The researcher has described his positionality but the findings represented the participants thoughts and reported their responses rather than his own bias.
Research Tradition

Three research methods are commonly used in the field of education: qualitative, quantitative, and mixed-methods (Creswell, 2012). This study was a qualitative research study. Creswell (2012) states that the choice of research methods “is based on matching the approach to a research problem, fitting the approach to your audience, and relating the approach to your experience” (p. 26). Qualitative research “seeks a deep understanding of the views of one group or single individuals” (Creswell, 2012, p. 128). Qualitative research also allows for a more “open-ended stance” and can allow for the research questions to be “changed based on the responses of the participants,” which Creswell describes as inductive (Creswell, 2007, p. 128). The questions and methods of qualitative studies fluctuate and evolve based on how participants interact and respond. The study design and methods evolve based on the participants’ views or ideas rather than on those of the researcher (Creswell, 2012).

Qualitative research allows the researcher to gather data that goes deep into the research question or questions and allows for the gathering of responses from a variety of perspectives and opinions that are not as obvious on the surface (Butin, 2010). Morrow (2007) describes qualitative research as complementing quantitative research through use of the exploratory process or the addition of open-ended questions that enhance the research in a study. She further explains that qualitative research explores ideas or variables that have not been identified in previous research or are variables that are difficult to identify.

Qualitative research seeks to answer questions of “what” or “how” versus “why” (Morrow, 2007). Qualitative research, in general is used to study the experiences of participants (Morrow, 2007). It is this fact that makes the qualitative method useful in situations where there is little or no research previously done on the topic or on the variables in question (Morrow,
Morrow (2007) furthers states that participants’ answers allow for an in-depth view of a phenomenon.

Additionally, this study lent itself to the qualitative method given that the researcher was seeking to gain a deeper understanding of the factors that students describe as contributing to their successful completion of the remedial mathematics course. As explicated in chapters one and two, there is a great need to know more about why some students who enter college with the goal of becoming a healthcare professional in medical imaging or nursing are successful in remedial mathematics and some are not; yet, there is very little known about these students and why some are successful. While ample quantitative data has been collected at the research site regarding who passes and who does not, including data on the students’ demographics, none has been collected on the students’ perspectives as to why they did or didn’t pass.

There is a general lack of qualitative studies about students with aspirations of entering healthcare, but who are unable to demonstrate competency in mathematics based on placement examinations when entering college. Quantitative research supports the value of remedial education at the macro-level, but there is a dearth of research at the individual level, especially among students seeking entry into the health professions. At the site under study, an understanding of the factors explored in this study allowed the faculty and administration to have a greater understanding of what was helpful to the students who were successful in progressing into the medical imaging or nursing programs. Allowing the participants to speak freely and have open-ended questions aligned well with qualitative study methodology, as described by Creswell (2013).

As already noted, the researcher has a bias that was described in his positionality statement. This was acknowledged throughout the study and appeared not to have an impact on
the study and its findings. In fact, Creswell (2013) notes that having the researcher involved is a key instrument to qualitative research. Being the director of the imaging program and an advocate for student success was beneficial in allowing the students to be comfortable and open about their responses versus with someone with whom they are not familiar. They were also describing their experiences with a course, which was not part of their major. The researcher made clear to the participants his role at the study site.

In summary, this study meets the qualitative research elements attributed to a qualitative study design and was appropriate to use. Qualitative research allowed the researcher to have an in-depth understanding of the factors that students described as helping them be successful in a remedial mathematic course. The findings of this qualitative study add to the literature of students’ learning experiences, focused on who intend to enter a profession depended on mathematical skills, but are required to take a remedial mathematics course.

**Research Approach**

While there are a variety of potential research approaches that were appropriate for this study, the researcher selected the case study method. According to Yin (2014), this design is “preferred when examining contemporary events, but when the relevant behaviors cannot be manipulated” (p. 12), as was the case in this study. Yin defines a case study from two perspectives, the scope of a case and the features of a case. His twofold explanation includes the “investigation of a contemporary phenomenon” (p. 16) and a “distinctive situation in which there will be many more variables of interest than data points” and “benefits from the prior development of theoretical propositions to guide data collection and analysis” (p. 17). In other words, his definition is:
An empirical inquiry that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context, especially when the boundaries between phenomenon and context may not be clearly evident. In other words, you would want to do case study research because you want to understand a real-world case and assume that such an understanding is likely to involve important contextual conditions pertinent to the case. (p. 16)

Merriam (1998) states that a case is a bounded system, meaning the case itself has boundaries such as a thing, an entity, or a unit. The case itself can be a student, a class, a school, or a community (Merriam, 1998). The phenomenon of interest is intrinsically bounded because it has some boundaries, meaning the case itself has a finite number of people and/or time (Merriam, 1998). In this study, the bounded system included participants who are students, faculty members who teach the remedial mathematics course, and documents that are part of the remedial mathematics course or are associated with the students’ academic records. For purposes of this study, the students are individuals in their first or second year of the medical imaging or nursing program at one school, who successfully passed a required remedial mathematics course based on Accuplacer scores at time of entry into the college. The original proposal for the inclusion of faculty included full-time experienced faculty, half-time faculty and adjuncts with varying levels of experience. However, during the recruiting phase, only full-time and part-time faculty who were experienced in teaching the remedial mathematics course agreed to participate in the study. There were no adjunct faculty in the study. The documents for analysis included: course syllabi, teaching materials, academic grades and records, advising records and records of participants’ visits to tutoring and support centers.
In employing the case study method, the data was collected from three sources: student participants, from faculty via a faculty focus group centered on faculty perceptions of the student experience in remedial mathematics, and through document and artifact analysis, which yielded data on materials and resources available to students during the remedial mathematics course. The case study approach allows the researcher to collect data from multiple sources (Merriam, 1998) which subsequently allows for data triangulation and constant comparison (Boeije, 2002). The individual student interviews and the faculty focus group session were the main sources of data for this study. Interviewing is one of the most common forms of data collection (Merriam, 1998; Yin, 2014) and therefore, was used in this study as the main data collection method. As stated previously, documents related to remedial mathematics were also gathered and analyzed, including course syllabi, teaching materials, academic grades and records, advising records and records of student visits to tutoring and support centers. Document analysis and coding allowed the researcher to mine data that illuminated the student experience both individually and collectively.

As mentioned, this research study focused on one group of students who were successful in completing a required remedial mathematics course and were able to enter into the medical imaging or nursing major at one college, as well as a group of faculty who taught the remedial mathematics course, and the documents associated with the course and the students. Using this approach allowed the researcher to fully describe the factors that the students described as contributing to their successful completion of the remedial mathematics course. Knowledge of these factors may now possibly help more students to be successful in completing a required remedial mathematics course. The researcher gathered and analyzed artifacts including recorded
interviews, focus group sessions, and documents as mentioned. Data collection and analysis is described in greater detail in various sections of this chapter.

Participants

This study consisted of two groups of participants. The first group of participants included eleven first and second year medical imaging and nursing students (four medical imaging and seven nursing students) at the research site who were required to take a remedial mathematics course (QR 101A) their first year at this site and were subsequently accepted into their respective programs. The initial proposal called for ten to twelve students in the respective programs. The second group of participants included three faculty members who teach in the remedial mathematics course. Therefore, a total of 14 participants were included in the study. According to Miles et al. (2014), researchers doing qualitative studies typically study smaller sample sizes as compared to individuals conducting quantitative studies. The student participants were in their second or third year of college, but in their first or second year of their professional programs. These participants entered the college (the research site) in fall 2015 or fall 2016 and were prescreened for recall, as discussed later in the section on sample collection. The faculty participants were individuals who had taught the remedial mathematics course for more than 2 semesters and had faculty appointments within the mathematics department at the institution. Each of the faculty participants was full-time at the college. Two were tenured faculty members within the mathematics department and one was a staff lecturer.

Approximately 50% of the incoming first year students in fall 2015 and fall 2016 intended to major in medical imaging or nursing. The medical imaging program accepts all students each fall semester based on the admission requirements of a 3.0 GPA and C or better in all of the prerequisite courses, and on the results of interviews with faculty and members from
the clinical sites. Similarly, the nursing program accepts all students from the class that meet the admission requirements of a 3.0 GPA and a C or better in all of the prerequisite courses. All incoming first-year students are required to take a college-level placement examination to determine into which mathematics and writing courses they should be placed.

In fall 2015 entering first year class, 171 students (69%) were required to take one of the quantitative reasoning sequences (foundation mathematics course) before moving into a higher-level college mathematics course. Of these 171 students, 96 (56%) had to take the remedial co-requisite course (QR 101A), which was a lab. Among these students who had to take the remedial co-requisite course (QR 101A), only 45 (47%) achieved a passing grade of a “C-” or better in order to move into a higher college-level mathematics course. Only 40 students (42%) of the 56% who were required to take the remedial co-requisite course (QR 101A) achieved a “C” or better. A “C” or better is the minimum grade for programs in medical imaging and nursing prerequisite courses in order to be accepted into the major. While quantitative reasoning is not a specific required prerequisite course for medical imaging or nursing, it does determine who is eligible to move into the prerequisite mathematics and science courses. The 40 students who passed the remedial mathematics course (QR 101A) and who were accepted into medical imaging or nursing were considered for this study.

Purposeful sampling is often used in qualitative studies (Creswell, 2012, 2013; Miles et al., 2014). Creswell (2013) commented that purposeful sampling is important, because the participants can “purposefully inform an understanding of the research problem and central phenomenon in the study” (p. 156). Maxwell (2005) added that in many qualitative studies, participants are chosen by a selective process rather than a random process. Purposeful sampling was used in this study. More specifically, criterion sampling was used. Criterion sampling
works well as it is essential that the participants in the study have all experienced the phenomenon being studied (Creswell, 2013). Qualitative studies also tend to use convenience sampling, which samples participants in a specific context (Miles et al., 2014). The sample in this study was one of convenience and was purposefully drawn from medical imaging and nursing students in their sophomore or junior year of college, which is also the first or second year of their medical imaging or nursing program. The sample was drawn primarily from the initial 40 students who were required to take the remedial mathematics course in fall 2015, passed with a letter grade of a “C” or better, and gained acceptance into their respective program of choice. In order to recruit enough students for the study, some of the participants took the remedial mathematics course in fall 2016, but still met the same criteria. The faculty were selected from faculty who had taught remedial mathematics at the research site for more than two semesters and were full-time.

A potential limitation of the student sample was that more students were in the nursing program versus the medical imaging program. With purposeful sampling, the goal of the study was to have similar numbers from both the medical imaging and nursing programs with respect to their overall cohort sizes. Another limitation could have been the setting of the research site; however, the study has reported the demographics of the participants to place the findings in context. Limitations are further explained in Chapter 5.

**Recruitment and Access**

The research site was the place of employment of the researcher and initial conversations occurred with the administration of the site regarding the need to understand why only a small percentage of students are able to pass the remedial mathematics course and eventually gain entry into either the medical imaging or nursing programs. Given that this study was a problem
of practice at the institution, the administration supported the study and readily provided access. Approval to conduct the study was granted and the study was approved by the site’s Institutional Review Board (IRB) and Northeastern University’s IRB. A meeting was conducted with the program directors of the programs in medical imaging and nursing so that they were informed of the research study that involved their students. Initial discussions had already occurred before the study’s proposal and was supported, but additional details about the specifics of the study were shared after IRB approvals were granted.

**IRB Protection and Approval**

After the Doctoral Thesis Proposal (DTP) was approved, the first step was to gain IRB approval at the research site where the study took place. The IRB is a review board at the institution that reviews research studies in order to protect human subjects, specifically the potential harmful impact or risk to participants (Creswell, 2013). The IRB also provides an extra safeguard to ensure the researcher is practicing ethical standards and that the risks (if any) to the participants are minimized (Creswell, 2013; Miles et al., 2014). The researcher completed the Protecting Human Research Participants Course through the National Institutes of Health (NIH). The IRB process involved an application detailing the research study, along with all forms to be used in the study, such as the consent-to-participate. An Agreement for Study Participation, as suggested by Miles et al. (2014) is similar to the consent-to-participate document that was completed by all participants. The students and faculty had an option to not accept the invitation to participate in the study. If a student did not choose to participate, it would in no way would affect their status at the college and that was made clear on the invitation. In addition, the faculty members also had the choice to elect not to participate. The consent-to-participate form is Appendix A. The consent-to-participate form outlines for the participant, the purpose of the
study and their participation. It stated the participant may drop out at any time and again, their decision to participate or not would have no impact on their academics at the college. The form also provided information regarding confidentiality. After IRB approval had been granted by the research site, the IRB application for Northeastern University was submitted. No research was done in reviewing the students’ records to determine the sample of the population until IRB approval had been granted at both institutions. Once the dual IRB approvals was granted, the selection process started.

**Sample Selection**

Step one of the selection was for a list of the names of the students who were in the first or second year medical imaging and nursing programs to be given to the registrar’s office. From that list, the registrar identified all the students who were required to take remedial mathematics (QR101A) and passed the course and then returned the list to the researcher. All those who were identified were sent an invitation via email to participate in the study. The invitation included why the study was being done and what or how the results would be utilized. The email invitation is found in Appendix B.

When the student accepted the invitation to participate in the study, he or she was sent a questionnaire by Survey Monkey that consisted of six questions in order to determine if the student understood what the study was about and if the student could legitimately describe what he or she believed contributed to his or her successful completion of the remedial mathematics course. The questionnaire is in Appendix C. The questionnaire was important in the selection process, because of the need to address the issues associated with recall in a retrospective study design. All information was returned to the researcher and the researcher made the final
selection of participants. Only students who reported being able to reflect on their specific experiences in remedial mathematics were selected.

The sample selection for this study followed the sampling process as outlined above. Purposeful and criterion sampling was used. The criteria for selection included: answering “YES” to the five questions and if the student was able to provide an answer to the descriptive question. This helped the researcher identify which students would be able to answer additional questions and provide clear feedback during the interview process. The final selection of participants for the study included those who could best describe the factors they believed contributed to their success in the course. The researcher ensured that there was an equal distribution of students from the two programs so that findings could be better generalized.

Table 3.1

*Sampling Matrix of the Students who were Participants*

<table>
<thead>
<tr>
<th>Program</th>
<th>Average Number of Students in Program (Cohort Model)</th>
<th>Study Proposed Selection Range</th>
<th>Study Actual Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Imaging</td>
<td>30</td>
<td>4-5</td>
<td>4</td>
</tr>
<tr>
<td>Nursing</td>
<td>80</td>
<td>6-8</td>
<td>7</td>
</tr>
</tbody>
</table>

To recruit the faculty focus group, the researcher reached out via email to the faculty members who had taught the remedial mathematics course for at least two semesters and asked for their participation in the study. The recruitment email is in Appendix E. As noted above, the researcher had already had discussions with administration and faculty regarding the research study and it was supported by both. Five faculty members at the institution met the inclusion criteria and could participate in the study. The researcher believed that the majority would participate in the faculty focus group in order to provide data for this much needed study at the institution. Due to scheduling and timing of the focus group, three participated. The faculty
participants’ information was kept confidential and followed the same process as with the student participants regarding confidentially.

In summary, the researcher gained IRB approval for the study to ensure the researcher was being ethical in the research process, while at the same time protecting the participants. Confidentiality and informed consent information were made available to all participants and their signatures acquired prior to the interviews. The sampling process was purposive and was identified in this section and in the section on participants.

**Data Collection**

Data collection in a case study consists mainly of interviews, observations, and documents (Creswell, 2013; Merriam, 1998; Stake, 1995). Data was collected for this study primarily through interviews either as individual (students) or through a focus group (faculty). Documents used in this study included course syllabi, teaching materials, academic grades and records, advising records and records of student visits to tutoring and support centers. The next sections provide specific information related to the sources of data collection.

**Student Interviews**

The interviews focused on issues related to answering the research question, what factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course? Merriam (1998) states that interviews are important and necessary when the researcher is “interested in past events that are impossible to replicate.” She further states that interviews are necessary when the situation(s) cannot be observed. The interviews were semi-structured with open-ended questions. Rubin and Rubin (2011) state that interviews must align with a standard set of questions, but they must also remain fluid based on the responses from the participants and the need of the researcher to clarify or expand on the
answers. The intent was for each individual participant interview to last approximately one (1) hour. The average time for each interview was approximately 50 minutes. The interviews were recorded electronically so that the researcher could access the data multiple times during the reporting phase. There were two recorders used in the event one of the recorders stopped or did not work. The participants were assigned an alias name in order to maintain confidentiality. The interviews occurred at the study site, in a neutral location such as one of the library study rooms. The location was selected by the student participant. This allowed for privacy but also prevented the student from having to conduct the interview in the researcher’s office, which could have been viewed as a faculty-to-student relationship versus a doctoral student conducting research.

During the interview, the researcher took notes, which helped the researcher when reviewing the recorded interview sessions. It also allowed for the researcher to make notes during a response that needed more detail or clarification. In addition to the practicality of note taking, it allowed for backup data in the event there was a problem with the recording of the interview (Creswell, 2012).

The interview outline and questions are in Appendix D. As mentioned, the interview was semi-structured. This allowed for a plan and consistency among the interviews. The questions were asked of all the participants, but they allowed for flexibility (Creswell, 2012). The interview was completed within the one-hour time frame proposed to the participants, which respected the participants’ time. The questions allowed for probing. This allowed for more detail related to each question and facilitated a greater depth of understanding for each of the participant’s responses (Creswell, 2012). As suggested by Merriam (1998), the questions did change somewhat because the data analysis occurred simultaneously with data collection. This simultaneous analysis is consistent with the constant comparative method, which allowed the
researcher to focus on identifying emerging themes after each interview, which altered the
questions in subsequent interviews in light of these themes. The content of each of the
interviews was analyzed in the context of each of the previous interviews (Boeije, 2002).

The researcher was the one to conduct the interviews and asked all of the questions. All
sessions were recorded using QuickVoice, an application from Apple that is password protected
by the researcher as well as Rev Voice Recorder, which allowed for quick transcription of the
sessions. Both applications allowed for storage and the ability to label the various sessions and
to play them back multiple times. The recorded interviews through the Rev Voice Recorder
were transcribed for analysis and that analysis is discussed in the sections to follow.

Document and Artifacts Collection

Documents are additional data sources that provide additional insight into the research
study (Merriam, 1998; Yin, 2014). Documents that can be used in a case study are typically not
produced for the sole purpose of the research, but are materials that already exist with or without
the research study (Merriam, 1998). In fact, the majority of the documents that may be used are
already present as public or personal records and physical material (Merriam, 1998). The
researcher did seek out documents that provided additional sources of data. These included
course syllabi, teaching materials, academic grades and records, advising records and records of
student visits to the tutoring and support centers.

Documents are a reliable source of data according to Merriam (1998). Documents allow
insight into participants’ perspectives, which is at the root of qualitative research (Merriam,
1998). The documents that were used in this study are described in more detail; however, it is
important to note that documents do allow for triangulation with information that is gathered
from interviews (Merriam, 1998). The data collected in this study was guided by the research
question. As with the interviews, the researcher was the primary instrument for gathering the documents used as data. The documents were checked for authenticity and accuracy by the researcher, which did take time to explore and determine if the documents were of value to the study (Merriam, 1998).

As already mentioned, the questionnaire sent to students prior to participant selection was used as one document source. While the questionnaire was produced for the purpose of participant selection, answers to the questions did provide some insight into the students during the interviews. Creswell (2012) note that questionnaires may provide useful information, but may be difficult to interpret. The questionnaire in this study was used to make the final participant selection, but it gathered information from both closed and open-ended questions relevant to? The questionnaire is found in Appendix C.

Other documents that were used were the participants’ academic grades and record in the form of a transcript. Merriam (1998) describes personal documents, such as the academic records, as a “reliable source of data” (p. 116). The information can provide additional information on the topic at hand, “which is what the qualitative research is seeking” (Merriam, 1998, p. 116). Examining the academic grades in all of the participants’ quantitative courses (including the remedial mathematics course) provided additional data related to factors described as contributing to their successful passing of the required remedial mathematics course beyond what the students described in the interviews and what the faculty focus group related.

Additionally, course syllabi and teaching materials were examined in order to gain insight into what resources the students had available to them. The resources that were available to students provided useful information during the data analysis for triangulation purposes (Bowen, 2009). The course syllabi in particular helped confirm or deny what students said about
what was available to them, the structure of the course, or information about the faculty. Course materials assisted in a way that provided the content on the material that students may or may not have described. Course materials included the software that students used in the lab or on their own that provided homework problems or equations. Course materials also included tools, techniques, and examples faculty used during classroom discussions or lectures. The textbook was also considered as part of the course materials, but did not provide much useful information during the data analysis.

Additional materials that were located and were used were academic support schedules, notes, and tutoring assistance given to the students in this study. The material was helpful in determining which students sought out assistance on their own or if they were coached to do so via the faculty member. Schedules and notes from these students provided additional insight into with what the students were needing assistance, such as remedial mathematics concepts, coaching, and testing taking skills.

In summary, documents that were gathered and used in the study provided more data for analysis and provided data that could not be observed because the study was retrospective. As Merriam (1998) discusses, the documents helped the researcher uncover meaning and provide more understanding of the research problem by providing additional insights into the study. The documents did allow for triangulation that will be discussed in the analysis section.

**Faculty Focus Group**

Beyond the individual student interviews and document analysis, the third source of data was a focus group discussion with three faculty members who taught remedial mathematics. The focus group with the faculty was exactly one hour in length and was guided by a brief set of questions that were developed after the student interviews began, again which allowed for the
constant comparative method to be used for analysis. The questions explored included what successful students did to succeed; what students who failed tend to do; and any positive or negative impacts they see as a result of students being in a remedial mathemetic course. The focus group allowed the researcher to explore another source of data and provided insights that were used with the individual student interviews and the documents gathered for the study. The focus group allowed for additional insight into the analysis of the interviews and provided data for triangulation. The focus group questions are in Appendix F.

The focus group was recorded electronically so that the researcher could access the data multiple times during the reporting phase. There were two recorders used in the event one of the recorders stopped or did not work, just as with the student participants’ interviews. The faculty participants were assigned a number in order to maintain confidentiality. The interviews occurred at the study site, in a reserved conference room. During the session, the researcher took notes, which helped in the researcher’s review of the recorded interview sessions. It also allowed for the researcher to make notes during a response that needed more detail or clarification.

As with the interviews, the researcher was the one that conducted the focus group session and the one that asked the questions. The focus group was transcribed in the same manner as noted above in the interview section. The analysis of the transcript from the focus group session is discussed in the data analysis section.

Summary

Data collection is an important, systematic approach to gathering information for the purposes of seeking to answer the research question (Merriam, 1998). The data collection techniques and the specific information gathered is determined by the problem, purpose, sample,
and theoretical framework (Merriam, 1998). Due to the nature of this qualitative case study, data was gathered through interviews with students, variety of documents, and a focus group with faculty who taught remedial mathematics.

The interviews with the students were approximately one hour and were semi-structured to allow the interviews to be fluid enough to capture key ideas and themes. Documents that were used were course syllabi in remedial mathematics, course materials that were available to the students, students’ academic records, and schedules or notes from the academic and tutoring centers. The faculty focus group allowed for a different perspective on remedial mathematics by shedding light on what they believed were factors that help students succeed or not. All three sources (interviews, document reviews, and faculty focus group) allowed for triangulation of the data.

**Data Storage**

All data was stored electronically on the researcher’s computer in a password protected secure web-based tool, Office365. The researcher’s computer was password protected and encrypted to prevent the information from being stolen. Office365 is an encrypted, cloud-based system that allows only the researcher access to the files. The recordings from the interviews were electronic and stored in a similar manner as the electronic data. The QuickVoice and Rev Voice Recorder application is not web-based and was only on the researcher’s devices. Only the researcher had access to the data, except for the interview and focus group recordings. All participants were assigned a pseudonym name that was used in the study to keep their identities protected.

The recordings were sent to an outside vendor for transcription, who was required to sign a confidentiality statement. Confidentiality was maintained since individual names were not
used, but instead participant pseudonyms were used when reporting data or quotes from specific
participants. A variety of vendors provide transcription services; however, the decision was to
use the Rev Transcription service as it was part of the Rev Voice Recorder. The recordings were
sent to the transcription service as soon as the recording was completed through the same app on
the mobile device. Once the interviews occurred, the turnaround time for transcripts of the
interviews was 24 hours, thus data analysis could begin within 24 hours of the interview. Once
the interviews were transcribed, and the researcher verified the accuracy of the transcripts, the
recordings were deleted from the researcher’s account on the Rev transcription website.

Data Analysis

In qualitative research, data analysis includes the preparation and organization of the
data, and includes multiple steps such as coding and category creation of words in the transcribed
interviews (Creswell, 2013). Once the data is prepared and organized, it is then organized and
reduced into themes by the use of codes and the data displayed in discussions, tables, or figures
(Creswell, 2013). The table might include two columns, one for the themes and a second
reflecting the data from which the theme was created. Merriam (1998), Miles et al. (2014), and
Yin (2014) suggest analyzing the data concurrent with the collection. This will allow for the
researcher to fill in gaps or test new ideas that might emerge during the interview process (Miles
et al., 2014). Thus, the data was analyzed as was collected, as recommended by Boeje (2002),
Merriam (1998), Miles et al. (2014) and Yin (2014). Analyzing the data as it is collected allows
for different questioning as insights are gained and expanded upon over the course of data
collection (Merriam, 1998). In this study, data analysis began with transcripts from the
interviews, followed by document analysis and then the one focus group transcript, which was
compared constantly to the analyzed transcripts from the interviews. Specific detail about the data analysis is described next.

**Coding and Theme Identification**

A qualitative study is focused on sentences and words that participants use to answer questions or describe events, thoughts or feelings. These words and sentences are drawn from raw data that is clear and can be analyzed (Miles et al., 2014). This is done by multiple cycles of coding (Miles et al., 2014). “Codes are labels that assign symbolic meaning to the descriptive or inferential information complied during a study” (p. 71). Saldana (2013) divided coding into two cycles: First Cycle and Second Cycle. The First Cycle allows the researcher to put the sentences or statements into data chunks, which allows for detecting reoccurring patterns in the transcripts, which are then coded (Miles et al., 2014; Saldana, 2013). Second Cycle methods allow the researcher to take these patterns which are coded to create smaller categories (Miles et al., 2014). It is these smaller categories that allow the researcher to develop “higher level analytic meanings” (Miles et al., 2014, p. 73).

Coding uses deductive coding and inductive coding (Merriam, 1998). Deductive coding is a list of codes that are created prior to the collection of data (Miles et al., 2014). This is also referred to as start list. The start list comes from a variety of sources such as the research question, problem area, or from the researcher (Miles et al., 2014). Creswell (2013) suggests starting with fewer codes and add as needed during the data collection analysis phase. Deductive coding can also occur after the analysis in which the researcher is grouping codes or categories together. While these codes are potentially important to start with, the real interest is in inductive codes (Merriam, 1998). Inductive coding reveals codes that are new and emerge during the data collection process and are important to the researchers who uncover potentially important factors
in their work (Miles et al., 2014). Over time and data collection, the codes can and might change for a variety of reasons such as little or nothing in the transcript fits them (Miles et al., 2014).

Merriam (1998) suggests there is a “right way and wrong way” (p. 162) to data analysis. The right way is to analyze the data simultaneously with the collection of the data as already mentioned. Merriam (1998) outlines steps to be taken after each interview to capture tentative themes simultaneously with the data collection. The steps are:

1. After the first interview, review the purpose of the study.
2. Read and reread the data that was just collected, making notes in the margins related to comments important from the interview.
3. Create a personal memo capturing the reflection, tentative themes, and ideas from the first set of data.
4. Note things to ask on second interview.
5. After second interview, complete steps 1-4.
6. Compare memo and notes of the two interviews and continue the process till the interviews are completed.

Merriam (1998) suggests that once the data collection is complete, the researcher now has a “set of tentative categories or themes” from which to work (p. 162), which serve as answers to the research question, and ultimately to state the findings and conclusion of the research. In this study, the researcher began with a start list of codes and themes in order to start the analysis and continued to develop more codes after each interview. The researcher created a codebook prior to the start of the data collection and analysis phase that included the code name, a description, and an example of the code as suggested by Saldana (2013). A codebook was kept and all codes
were entered in the document with the name, a description, and the examples so that it could be understood by anyone who looks at the material.

For example, there were multiple codes created regarding faculty. The initial code was simply faculty involvement. After the first student participant interview and constantly comparing the data of the sequential interviews, several codes began to emerge around faculty. These codes included:

<table>
<thead>
<tr>
<th>Code Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Availability</td>
<td>FA</td>
</tr>
<tr>
<td>Faculty Investment in Student</td>
<td>FIS</td>
</tr>
<tr>
<td>Faculty Offering of Help</td>
<td>FOH</td>
</tr>
<tr>
<td>Faculty Relationship-Personal</td>
<td>FR-P</td>
</tr>
<tr>
<td>Faculty Student Relationship</td>
<td>FSR</td>
</tr>
<tr>
<td>Faculty Teaching Style/Adaptability</td>
<td>FTSA</td>
</tr>
<tr>
<td>One-on-One-Faculty Student</td>
<td>OOO-FS</td>
</tr>
</tbody>
</table>

Another example was related to the resources and services that students found helpful. Examples of these multiple codes were:

<table>
<thead>
<tr>
<th>Code Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q Center</td>
<td>QC</td>
</tr>
<tr>
<td>Q Center Academic Coaching</td>
<td>QCAC</td>
</tr>
<tr>
<td>Q Center Peer Tutoring</td>
<td>QCPT</td>
</tr>
<tr>
<td>Questionable Value of Remedial Math</td>
<td>QVRM</td>
</tr>
<tr>
<td>Recognizing Need for Help and Seeking It</td>
<td>RNH</td>
</tr>
<tr>
<td>Testing</td>
<td>T</td>
</tr>
<tr>
<td>Value of Discipline</td>
<td>VOD</td>
</tr>
<tr>
<td>Value of Homework</td>
<td>VOH</td>
</tr>
</tbody>
</table>

**Constant Comparison**

Once the analysis began with the creation of codes from the data, the grouping of the codes and constant comparison of the codes also began (Merriam, 1998). The constant comparative method was developed by Glaser and Strauss and can include a variety of methods for analyzing the data, such as memo writing, reading and rereading the transcripts, the coding and recoding of data, and the drawing of diagrams (Boeije, 2002).
As the data collection begins there can be multiple codes; however, in order to manage the codes over time, the researcher needs to constantly compare the various codes and determine if some of the codes could be combined (Merriam, 1998). The researcher also identifies potential new ideas or concepts that should be explored with the next interviewee or allows the researcher to shift and examine that data with a different lens (Boeije, 2002). Given that the researcher started to analyze the data after the first interview and continued the analysis after each interview as outlined earlier from Merriam (1998), the researcher constantly compared the codes, combined similar codes, and created new categories for the similar codes. Using the faculty example above, the seven codes were combined to create four codes:

<table>
<thead>
<tr>
<th>Faculty Student Relationship</th>
<th>FSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Faculty Availability</td>
<td>a. FA</td>
</tr>
<tr>
<td>b. Faculty Relationship-Personal</td>
<td>b. FR-P</td>
</tr>
<tr>
<td>Faculty Investment in Student</td>
<td>FIS</td>
</tr>
<tr>
<td>a. One-on-One-Faculty Student</td>
<td>a. OOO-FS</td>
</tr>
<tr>
<td>Faculty Offering of Help</td>
<td>FOH</td>
</tr>
<tr>
<td>Faculty Teaching Style/Adaptability</td>
<td>FTSA</td>
</tr>
</tbody>
</table>

This allowed for a more manageable process in reporting the findings. In addition, it is important that the categories that have been created with the codes reflect the purpose of the research (Merriam, 1998), which these did.

Merriam (1998) suggests that not only should the categories reflect the research purpose, but they should also be exhaustive, mutually exclusive of one another, sensitive in that an outsider should understand the nature of the category, and congruent. In order to have the categories congruent, a chart or table can be created in order to visualize the created categories (Merriam, 1998). The chart would include the category assigned, the description of the category, and examples of the codes used to create the categories. Merriam (1998) also suggests limiting the number of categories. She suggests that fewer categories will help communicate the findings
easier. Based on Guba and Lincoln (1981), Merriam (1998) suggests guidelines for developing the categories. These are the frequency with which something is said, the audience that the study is intended for, the uniqueness of a category, and categories in which additional problems are discovered.

Throughout the data analysis, the researcher continued to compare and condense categories as suggested by Merriam in order to manage the data. Categories that were created were unique and were mentioned by multiple student participants. Examples of a few of the categories were:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Faculty</td>
</tr>
<tr>
<td>2.</td>
<td>Available Math Resources and Services</td>
</tr>
<tr>
<td>3.</td>
<td>Lab Component of the Course</td>
</tr>
<tr>
<td>4.</td>
<td>Peers</td>
</tr>
</tbody>
</table>

Boeije (2002) provided a purposeful approach to analysis of the data using the constant comparative method. The constant comparing allows the researcher to decide what data needs to be gathered next based on the analysis and reflection on previous data (Boeije, 2002). For example, the first interview was analyzed and divided into codes and themes. Then the second interview expanded on ideas and themes from the first interview and some questions were enhanced that needed more details or were missing from the first interview. This cycle of comparison and reflection on new data with the previous data was repeated several times. The comparison is only completed when there is no new information that can be described (Boeije, 2002). This constant comparison increases the internal validity of the findings (Boeije, 2002; Merriam, 1998). It is important to note that the constant comparison does not happen just between the new data and the previous data. It is a constant comparison of the new data to all of
the previous data, allowing for multiple comparisons (Boeije, 2002). The goal is not to compare everything to everything, but to have a plan in place for comparison.

The interviews used a more traditional application of the constant comparison method in which the first interview was conducted and analyzed. Ideas, codes, or themes from that first interview helped inform and shape the second interview. The second interview was compared to the first and so forth until the interviews were completed. The documents that were used were constantly compared to the interviews, along with the faculty focus group. The method of coding of the faculty focus group was similar to that described for the student interviews. Once the constant comparing had occurred within the same group (student interviews and faculty focus group), the constant comparison occurred between the groups. In this study, this included the constant comparison between the student interviews and the faculty focus group session.

**Document Analysis**

Document analysis is a systematic procedure for studying electronic material in combination with other qualitative research methods as a means of triangulation (Bowen, 2009). Bowen described document analysis as using the documents being examined and interpreted to determine the meaning and gain a better understanding of the knowledge of the research question. From this point, the data from the documents is then organized into themes and categories through content analysis. Documents are a vital part of data collection in order to provide rich descriptions and for triangulation (Bowen, 2009). Documents that are personal records or public records provide insight to the researcher in understanding the meaning of the research problem. Documents provide supplementary research data and provide for tracking of historical changes and developments. It is the mixed use of documents that Bowen describes as providing “greater confidence in trustworthiness of the findings” from the convergence of
information (p. 30). However, he cautions the researcher not to simply use the same language found in the documents, but rather find meaning in the document and the contribution of the document to the research problem.

Documents that were used in this study included the course syllabi and materials that were used in the course. In addition to the course documents, the participants’ academic records and grades were analyzed, along with schedule and notes from the academic support centers. Information that was found in these documents were coded and categorized similar to the transcripts from the interviews. As suggested by Bowen (2009), the documents were analyzed together with data from the interviews and the focus group so that themes emerged across all three data sets.

The researcher skimmed, read, and interpreted the documents as suggested by Bowen (2009). This allowed for an iterative process to combine elements from content analysis and thematic analysis (Bowen, 2009). Content analysis, he explains, is the process of organizing the information into categories. Thematic analysis is where patterns of themes become categories. Codes from the transcribed interviews were applied to the content in the documents. Bowen also suggested that the documents can help both pre and post interviews, although no post interviews were done. The documents can provide leading questions to be asked in the interviews, as well as to the focus group; however, the documents did not provide any additional or new information that was not already captured by the interviews. The documents did provide validation to what the student participants described. Due to timing of the interviews that occurred at the end of the semester, the interviews were completed first, followed by document analysis and the focus group session.
In this study, the documents that were collected were analyzed as Bowen (2009) described. The documents were coded using inductive coding. This consisted of first cycle coding (Saldana, 2013) or open coding (Merriam, 1998). This level of coding generated numerous codes. A codebook was kept as already mentioned.

**Organization**

Data from the interviews, document collection, and the focus group were coded and categorized as noted above. Initially, the researcher was going to utilize a computer-assisted qualitative data analysis software (CAQDAS) to organize the data for the researcher. The software allowed for the collection of large amounts of data that could be captured from interviews or focus-group sessions (Yin, 2014). The CAQDAS program could allow the researcher to make notes and comments that could be attached to the chunks of data or codes and to which the researcher can refer back (Miles et al., 2014). This is called jotting and allows for a more reflective process by providing the researcher a field to take notes in the original raw data. However, after the study began, the researcher found it easier to organize the information and analyze the data by hand versus utilizing the software that required more knowledge to utilize.

There is also analytic memoing that is an extension of note taking and allows the researcher to synthesize the descriptive notes into higher level meaning as he or she read the material (Miles et al., 2014). In addition to allowing notes to be made around the actual data, it is a way for the researcher to keep notes about the participants and reflections that occur at the time of data collection or even when beginning to start the data analysis process (Merriam, 1998; Saldana, 2013). The researcher in this study took advantage of jotting and memoing through note taking means during the study. This also allowed the researcher to keep detailed records of the research process in this study.
For this study, a codebook was utilized for each new creation of a code through the inductive process. The codebook was used for all codes created through the individual interviews, faculty focus group, and document analysis. Individual student participants’ interviews, the faculty focus group, and the document analysis were the three sources to gather data and utilized the constant comparative method. This included comparing data within the individual sources and between the sources. This allowed for triangulation of the data and increased the validity of the study. In addition, as already noted, the researcher’s bias was controlled for with knowledge of the bias throughout the study. Controlling for the bias occurred by making clear the intentions of the study to the participants, using triangulation of the data, and keeping the research question firmly in mind (Miles et al., 2014). Trustworthiness and validity also helped control for bias through the collection, coding, and analysis of the study. These will be discussed in more detail in the following sections.

Finally, after the inductive analysis of the transcripts from the interview and the focus group, and the documents and artifacts, a deductive approach occurred for the purpose of identifying themes. As mentioned in Chapter 1, self-efficacy was the theoretical framework that guided this study. These themes allowed the researcher to compare the findings of the study to traditional definitions and examples of self-efficacy gleaned through literature. This helped to determine if self-efficacy related to the findings of the study, based on what had been cited in the literature.

**Trustworthiness and Validity**

Trustworthiness is equally as important in qualitative studies as it is in quantitative studies. Merriam (1998) and Miles et al. (2014) state that there are several issues that affect the trustworthiness of the results. Those issues are objectivity, reliability and dependability, internal
validity and credibility, external validity and transferability, and utilization and application. Trustworthiness and validity tend to be the terms used in most qualitative studies (Creswell, 2013). Regardless of the term used, there are several techniques for establishing trustworthiness and validity. Creswell (2013) and Merriam (1998) suggest several techniques that this study used, including clarifying researcher bias, triangulation, peer review, member checking, and rich and thick descriptions.

**Clarifying Researcher Bias**

The researcher was explicit about the bias that may exist in the study and clear how neutrality was maintained (Miles et al., 2014). Creswell (2013) stated that it is important that the researcher’s biases and assumptions are clearly stated from the beginning so the reader is aware. The statements made by the researcher included past experiences and biases at a minimum (Creswell, 2013). In this study, the researcher discussed his positionality in Chapter 1 of this doctoral thesis, which revolved around his having taken a remedial course and still being able to enter the medical imaging field, as well as now serving as the program director for the imaging program, which is one of the programs under investigation in this study. In this study, neutrality was maintained by ensuring the participants knew the researcher’s purpose of the study, the bias, and utilizing the techniques described in this section.

**Triangulation**

Researchers use multiple sources, methods, and theories to provide evidence that could support the themes their study identifies (Creswell, 2013; Merriam, 1998). Triangulation occurs when the researcher locates evidence relevant to the themes or perspectives, from different sources (Creswell, 2013). The use of triangulation allows for the validation of the findings or conclusions of the study based on three sources (Miles et al., 2014). This study used three
sources to validate the findings of the study: the individual interviews, documents mentioned in the data collection section, and the faculty focus group. The three sources of data allowed for triangulation and support for the findings found in Chapter 4. Categories derived from the codes were identified in both the interviews (individual and focus group) and the documents. The constant comparison method assisted in identifying the categories.

**Peer Review**

Part of the research process should include external checks on the research and data (Creswell, 2013; Lincoln & Guba, 1985; Merriam, 1998). The role of the external reviewer, also referred to as peer reviewer, was to ask the hard questions related to components of the study, for example, methods, and interpretations of the data (Creswell, 2013; Merriam, 1998). Peer review provided another perspective on the study, and allowed for interactions between the researcher and the peer with regards to any questions the peer had (Creswell, 2013). The peer reviewer was part of the process after the proposal was approved and throughout the entire data analysis phase. These interactions were noted and used as debriefing sessions (Creswell, 2013; Lincoln & Guba, 1985).

**Member Checking**

Soliciting participants’ views on the findings and interpretations are a valid technique to establish credibility (Creswell, 2013; Lincoln & Guba, 1985). Merriam (1998) suggests providing the interpretations to the participants and asking if the “results are plausible” (p. 201). Creswell (2013) suggests that this could be accomplished through focus groups. This study utilized member checking by providing each student participant the interpretation of the findings from the interviews to determine if the themes were correctly identified rather than conducting a focus group for the same purpose. Six of the student participants responded to the member
checking document by saying the findings captured their descriptions of how they successfully passed the remedial mathematics course. Two students in particular, Joy and Marcus, provided specific detail about how specific findings were correct and what that meant to them. In addition to this, Joy provided feedback that while she did not believe she mentioned one of the findings related to prioritizing time to practice math problems, she completely agreed with the finding and provided her own example. This email to the student participants allowed for member checking to be utilized in validating the analysis of the individual interviews.

**Rich and Thick Descriptions**

When the researcher describes the participants in detail, it allows the reader answer questions related to transferability (related to other settings) (Creswell, 2013; Lincoln & Guba, 1985). This detail was used when describing not only the participants, but also the details about the setting and the themes (Creswell, 2013). The descriptions included specific details about movement and activity (Creswell, 2013). All of this detail allows the reader to decide if the study and the findings are transferable to other settings (Creswell, 2013). The researcher of this study provided rich and thick descriptions of the participants and the findings of the study, which can be found in Chapter 4.

**Summary**

This research study explored the factors described by medical imaging and nursing students as contributing to their successful completion of a required remedial mathematics course. The questions for this study was addressed though a qualitative study with an interpretivist paradigm. A case study best addressed the methodology in this study and included a total of 14 participants. The participants included eleven students who were in the medical imaging or nursing programs and who were required to take a remedial mathematics course their
first semester; and three faculty members who taught the remedial mathematics course. The student participants selected were purposefully selected to meet the inclusion criteria and the answers from the initial questionnaire that provided detail as to if they remembered the course and what did they believed helped them pass, if anything. Data was collected through individual interviews with the participants (students) and a focus group with faculty, and from documents related to the participants’ academic records, visits to the academic centers, and materials related to the course for teaching and the syllabi. The interviews were transcribed and the researcher used inductive coding to identify the themes during the data analysis. The analysis occurred simultaneously with data collection to allow the researcher to reflect on previous interviews and gain new insights or to expand on newer themes identified by the participants. The categories that were created from the codes were constantly compared and condensed using a codebook; specifically, the constant comparison method was used for data analysis. After the study was analyzed, deductive coding was used to compare the findings to definitions and examples of self-efficacy in the literature. The validity of the study was established using a variety of techniques including triangulation, peer review, member checking, and rich and thick descriptions and allowed for the researcher’s bias to be controlled. This study did benefit the research site (and may benefit other institutions with similar programs and student demographics) by identifying factors that might help additional students be successful in the future.
CHAPTER FOUR: FINDINGS

Introduction

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. A qualitative case study addressed the following research question:

1. What factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course?

There is a wealth of quantitative research at the macro-level focusing on the value of remedial education. However, there is a lack of research on the topic of students in medical imaging and nursing programs and their successful completion of a remedial mathematics course. This chapter first describes the eleven participants, followed by the findings. Each finding is described in detail followed by supportive evidence, followed by a section related to additional findings that do not necessary relate to the research questions, but are important. The chapter concludes with a summary.

Study Participants

The majority of data for this study was gathered through interviews with eleven student participants, all of whom, based on their entrance placement exams, were required to take a remedial mathematics course their first semester at the college. A second source of data was a focus group session with faculty participants who teach in the remedial mathematics course. Faculty were questioned regarding their observations of, and experiences with students who successfully complete the course. Documents related specifically to the remedial mathematics course provided a third source of data, as did the review of relevant records from the tutoring center. The focus group and document review were conducted for the purpose of triangulation.
and provided additional information beyond that obtained from the student participants’ interviews.

Table 4.1

*Demographics of Student Participants*

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>Major</th>
<th>Year in the major and Year in college</th>
<th>Self-described math experience prior to college</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcus</td>
<td>Male</td>
<td>Medical Imaging-Nuclear Medicine</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 3&lt;sup&gt;rd&lt;/sup&gt; year in college</td>
<td>Better when it’s applied to the real world; not good with theoretical math</td>
</tr>
<tr>
<td>Joy</td>
<td>Female</td>
<td>Medical Imaging-Radiography</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; year in major; 3&lt;sup&gt;rd&lt;/sup&gt; year in college</td>
<td>Not good at math; math does not click; math is not easy</td>
</tr>
<tr>
<td>May</td>
<td>Female</td>
<td>Medical Imaging-Sonography</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Math is a challenge; never comes easy to her</td>
</tr>
<tr>
<td>Don</td>
<td>Male</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Horrible at math; needs extra time and help to understand; can’t remember all of the steps</td>
</tr>
<tr>
<td>Ann</td>
<td>Female</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Not a good math student; does not like math, especially if can’t apply it to real-life situations</td>
</tr>
<tr>
<td>Jane</td>
<td>Female</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Dislikes math; never clicked; always needs additional help with math</td>
</tr>
<tr>
<td>Sue</td>
<td>Female</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Not good at math; numbers get confusing; brain doesn’t get math</td>
</tr>
<tr>
<td>Betty</td>
<td>Female</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Had no interest in math; never a fan of math</td>
</tr>
<tr>
<td>Roxanne</td>
<td>Female</td>
<td>Nursing</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 2&lt;sup&gt;nd&lt;/sup&gt; year in college</td>
<td>Math was never a strong suit; not a favorite subject; became unsuccessful in high school algebra and gave up</td>
</tr>
<tr>
<td>Mary</td>
<td>Female</td>
<td>Nursing</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; year in major; 3&lt;sup&gt;rd&lt;/sup&gt; year in college</td>
<td>Liked some math but not math that was abstract; liked math when she liked the teacher</td>
</tr>
<tr>
<td>Joshua</td>
<td>Male</td>
<td>Medical Imaging-Nuclear Medicine</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; year in major; 3&lt;sup&gt;rd&lt;/sup&gt; year in college</td>
<td>Had to work at math; not his favorite subject</td>
</tr>
</tbody>
</table>
The participants are described in the order in which they were interviewed. Chapter three described the student participants’ sampling strategy which was to have 4-5 medical imaging students and 6-8 nursing students. Table 4.1 provides an overview of the student participants’ demographics and demonstrates the sampling strategy was met.

**Participant 1: Marcus**

Marcus is in the first year of his major, which is medical imaging with a concentration in nuclear medicine. While he is in the first year of the professional program, he is a third-year student at the college. Marcus came to college knowing he wanted to major in medical imaging. He provided many details about his experience in math prior to college, how he knew he would be placed in the remedial course because of his performance on the placement test prior to college, and his experience with the remedial mathematics course. When asked how he passed the remedial course, he quickly referred to the professor by stating, “I loved the teacher personally. She was willing to work with you no matter what.” Other factors that he identified was having a personal academic coach, tutoring services, and a desire to get a job at a leading academic medical center in medical imaging.

**Participant 2: Joy**

Joy is in her second year of the medical imaging program, making her a third-year student at the college. She selected her major in medical imaging after doing a job shadow and realizing she could see herself in the profession. She remembers the remedial mathematics course well. She described how she knew she would be in the course after taking the placement exam, because she never liked math in high school. She claimed, “…it just doesn't click for me. I really have to focus and sit there and study.” However, she stated that she was determined to pass the course in order to take the prerequisite math and science courses, because she “wanted
[to get] in the program.” When asked how she passed the course, she quickly answered, it was because of the lab that the students had as part of the course. She went on to say that she put more time into her remedial mathematics course than any other course that semester.

**Participant 3: May**

May is also a medical imaging student, but with a concentration in sonography. She is in her first year of the program and a second-year student at the college. May claimed that while her grades in math in high school were satisfactory, it was because she was always in the “lower level math courses.” In fact, her description of math was, “It's always something I've had challenges with, like my mom jokes around and says we're a math challenged family. It's just something that's never come easy to me. Even with the MCATs, I've been proficient but there were a few times where I was right below proficient, to needs improvement.” She remembers getting the textbook for the course and saying to herself, "This isn't going to be good." When asked what helped her pass the course, she said her friend who would “…come to my room every night if I had homework and sit with me for an hour and do it out with me. That's how you know it's a true friend, sitting there with you for an hour. She'd sit through and she wouldn't give me the answers, she'd make me understand it…”

**Participant 4: Don**

Don is a first-year nursing student, who is in his second year of college. He claims that he does not like math, never has and still does not; however, if he is able to connect it to real-life situations, he’s able to at least get through it. In general, Don’s statements regarding the course were negative. He mentioned multiple times that he “hated math.” When asked about why he wants to major in nursing, he claimed that he did look at other professions, but that because his sister was a nurse, he felt he understood the profession and could see himself doing the job. He
believes that math that is related to dose calculations for patients is easier for him, because he can apply it to what he will be doing. When asked about what helped him pass the course he claimed he struggled in the course; however, he said, “Working with other students. My friends were doing well in it” and that he just had to practice, “going over the steps again and again.” He also mentioned that he “connected” with the faculty member and that no matter how easy the material may have been, she was always “willing to go over it [with him].”

Participant 5: Ann

Ann is a first-year nursing student and a second-year student at the college. Ann has always wanted to be a nurse as both of her parents are, so she feels that she knows the profession. She likes the challenges, but recognizes the fact that she does not like math and that it is a struggle for her. She claims she is “…just not a math person.” When talking about the remedial mathematics course, she remembered feeling “…really incompetent. I was, wow, my first college exam I got a 58. Am I really supposed to be here?” For her, it was upon receiving this exam grade that she realized she “needed to change, actually get help, get some insight on actually how to do this class.” Thus, when asked what she thought helped her to pass the course, she responded with “getting help; I kept doing the problems over and over again.” But equally important to her was her statement “It's just that motivation. I can't afford to have a low grade because I [was] also trying to get into the nursing program.”

Participant 6: Jane

Jane is in her second year of college and in the first year of the nursing program. She has wanted to be a nurse for a long time and became a Certified Nurse Aide (CNA) while in high school. But when asked about her thoughts about math in high school, she said “Personally, I hated it. I hate math so much.” She went on to say “it didn’t click with me.” She explained that
one of the biggest factors in her passing the remedial mathematics course was the professor. She really liked her because of her availability, and she was able to help her understand the material by relating it to the real world. She pointed to three things that she believed helped her pass the remedial mathematics course. These included the lab portion of the course, the time and effort she put into the course, and her motivation to get into the nursing program. She stated “I found myself trying harder in math class than in any other class [that semester].” When asked why she put so much effort into the course, she replied, “Because if I didn't pass QR, I wouldn't be a nurse. [The nursing advisors were always saying] you have to have this [passing] grade in class to even be considered to be in the program. Like that kind of scared me, it pushed me to do better in my class.”

**Participant 7: Sue**

Sue is a first-year nursing student who is in her second year of college. Being in the medical field was always a dream of hers; however, she claims that math was never her “strong suit.” She clarified this statement by saying, “Numbers, they've always been really fuzzy in my head for some reason. Even with a tutor in 8th grade, I barely passed with a C plus. My brain doesn't get it.” She remembers taking the placement exam and realizing that she would be placed in a lower-level math course, because she could not remember how to do many of the math problems that were on the exam. However, she did well in the remedial math course. When asked what was different this time, she replied with “spending a lot of time on the course, regardless of how much time it would take, I would do it.” Ultimately, she claimed “it was a prerequisite for nursing.” As with participant six, motivation to matriculate into the nursing program helped her pass the course.

**Participant 8: Betty**
As a first-year nursing student and in her second year of college, Betty felt that she was never good at math. She claimed she has never had any interest in math, but wanted to be a nurse from the time she was a child. She also became a Certified Nursing Aide (CNA) in high school. Betty made jokes about her college placement exam by saying, “I'm pretty sure I did really bad. Like I think I bombed the math [portion of the exam]. I got like a really low score.”

She knew that she would be placed in the remedial mathematics course because of the exam results; however, she described the remedial math course as “easy” compared to what she would hear other students talk about. Beyond her thinking the course was easy, she did comment on the fact that the lab portion of the course did help her understand the few topics that she struggled with. Betty added that, “With math, you just have to do a bunch of practice problems until you get them right, [be]cause it's not like you can actually memorize anything really.”

**Participant 9: Roxanne**

Roxanne is also a first-year nursing student in her second year of college, who is also an athlete. She became extremely interested in the medical field when her brother became terminally ill. Spending months with various healthcare professionals, she quickly realized how much her family depended on the nurse to help them with questions or to understand things the physician had told them. That is when she made up her mind that she wanted to become a nurse.

She remembers vividly the remedial course as being the “same experience I had in middle school or elementary school, when I don't like something, I shut down.” The difference was she remembers getting back the first test score and said, “it took that for me to kick it into high gear, go for more academic support, study a little more in this class.” When asked what helped her pass the course, she quickly answered it was the tutoring services and an academic coach. She added the services provided “…encouragement. Aside from just tutoring and helping you
academically, I think they [academic coaches] are also trained to encourage you and also help you set goals and be a little more independent.”

**Participant 10: Mary**

Mary is a second-year nursing student who is in her third-year of college. During high school, she claims that she did an observation at the hospital and knew from that point she wanted to be a nurse. She was excited to participate in the study and share her experiences about the remedial math course because she believed it helped her be successful in other courses. When describing her high school experience, she noted, “I liked algebra. I didn't like geometry, [it] didn't really make sense to me. I would go after school a lot for help. I always got confused. I don't know if it was the shape part or just all the math and the angles, and stuff. I just didn't understand that, but I liked algebra.” She described that in order to do well on a math test, the material needed to be fresh in her mind. When asked what helped her pass the remedial math course she stated, “I was working way harder on this class than anatomy.” She continued by saying, “I think the repetition. Going to the Q Center a lot, getting that help,” helped her pass the course. She mentioned several times throughout the interview, that she had a “driving force” to get her through the course and when questioned about that, she stated, “Just to get into Nursing. Getting there, since freshman year I wasn't in it. I really wanted to prove that I deserve to be in the nursing program.”

**Participant 11: Joshua**

Joshua is a first-year medical imaging student with a concentration in nuclear medicine, but in his third-year of college. Joshua came to the United States of America from Ghana specifically to study medical imaging in college. Because he was an international student, he had a slightly different challenge in math, even with units of measurement. He described his
experience with math in high school as similar to that of the other students. He said, “I had a negative feeling towards it [math], right from the get go.” He provided an example of when he struggled with math, “…compared to equations where they tell you find X, and then you have to do a whole go back in circles to get to that. It would not make sense, 'cause sometimes I want to know the why and how we're doing this. Sometimes in math that was not really making sense for me.” The factors that helped him pass the course were similar to those of the other students. Joshua said that in order to pass math, he “just needed to practice, it's just practice, practice, practice.” He added that beyond just practicing, he attended the tutoring center and believed that his faculty member helped. He said “She was always available” and “she gave extra effort.”

**Faculty Participants (Focus Group)**

The focus group was conducted with three faculty members for the purposes of triangulation. It consisted of a one hour interview and occurred after the individual interviews with the eleven student participants were completed. The overview of the faculty participants’ demographics is provided in Table 4.2.

Table 4.2

**Demographics of Faculty Participants**

<table>
<thead>
<tr>
<th>Faculty Participant</th>
<th>Sex</th>
<th>Status at Research Site</th>
<th>Total Years Teaching</th>
<th>Years Teaching Remedial Math</th>
<th>Teach math courses beyond remedial math?</th>
</tr>
</thead>
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<td>1</td>
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<td>Full-time tenured faculty</td>
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<tr>
<td>2</td>
<td>Male</td>
<td>Full-time tenured faculty</td>
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<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Female</td>
<td>Full-time staff lecturer</td>
<td>16</td>
<td>16 (5 at this site)</td>
<td>No</td>
</tr>
</tbody>
</table>
Findings

Interviews with the eleven medical imaging and nursing students led to the identification of seven factors that answered the research question. The question was, what factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course? The seven factors are summarized in Table 4.3.

Table 4.3

*Research Study’s Seven Findings.*

- Self-awareness of the need for help
- Utilizing the college’s academic support services and resources
- Career-driven motivation
- Faculty commitment
- Participation in a required lab component
- Peer support
- Prioritizing time for math to practice problems

Acronyms and Definitions

There are several terms or acronyms that the student participants use that are important to mention before describing each of the seven factors.

**Academic Center for Excellence (ACE).** This is the center on the college campus that houses the academic coaches, tutors, advisors, and other services to support students’ success in their college career. Here is where the students would physically visit in order to obtain additional help with the remedial mathematics course such as tutoring, academic coaching, or meeting with their advisor. The center is located on the second and third
floor of the Library, which is situated in the center of the campus. Tutoring and coaching services might be delivered in a private cubicle, private office, or an open table with one or more other students in a large open room. The setting varies depending on time of day and available tutors or coaches.

**Learning Commons.** The new name of the ACE center, as mentioned above.

**Quantitative Reasoning (QR).** This is the remedial mathematics course referred to in this study. Specifically, the course is referred to as QR 101A and is the equivalent of four credit hours. It has a required lab component to which the students in the study often refer to as the lab. The lab is three hours per week, in addition to the actual lecture-based component of the course, which is one hour three times a week.

**Quantitative Center (Q-center).** A center within the Learning Commons that only provides tutoring specific to math and science courses. Mathematics tutoring is provided by peer tutors and faculty members within the mathematics department, or by professional staff hired solely for tutoring purposes. Students may request a specific appointment with any one of these individuals or they may be randomly assigned a tutor if they seek help during the walk-in sessions, where no appointment is required.

**Factors that Contributed to Successful Completion of Remedial Mathematics**

As previously listed, seven factors were identified from the eleven student participants. The following sections identify each factor, provide a definition of the factor as related to this study, and provide evidence to support the finding.

**Self-awareness of the need for help.** The first factor identified is self-awareness of the need for help. This factor is defined as students’ recognition that the knowledge needed to pass the math course was greater than or different from what they currently possessed and that they
needed to do something differently. For many of these participants recognizing the need to get help in order to be successful in the math course was a personal decision, not one that was mandated by the course faculty. The manner in which they came to the recognition varied from the reality shock of their first test grade to their general feelings or experiences in the course. For some, the recognition occurred even before the course when they had to take the math entrance placement exam and realized they did not have a fundamental knowledge of math for math at the college-level.

Multiple student participants indicated that they made the conscious decision to get the help they needed in order to pass the course. One explicit example is from Ann who described her acknowledgement after her first test, one on which she did not do well.

I did not know how to study for this class. I had no idea at all. I'm the type of person that is independent. I don't generally get help from people. Going into my first test, I was like okay. I think I studied well enough to pass, but no. I did not study as well as I thought I could have studied, and I bombed that first test. I got a 58%. It was really bad. Then I reassessed myself. I had two choices. Either get help or just stay where you are, and I'm like I am not failing my first college class. I know that for a fact. I know this is not going to be the first class I am going to fail.

Similar to Ann, several other participants also reported that it was the shock of the first test that made them realize they needed to get help in order to pass the course. Sue said, “I thought I did really well on it [test one], and when I didn't I was like obviously I'm going to have to change the way that I study for it.” Marcus said, “I thought I killed it. I did not. I think I got like a 50% on it. It was bad. Yeah, it was really bad. So, I kind of got down on myself. I wanted to do good, so
had to figure out what to do.” This feeling that Marcus describes of being down on himself translated into his acknowledging to himself that he needed to get help in order to pass this course.

Roxanne acknowledged her need for help after she had a similar experience of not doing as well as she had hoped on the first exam. During the interview, she mentioned that she had set goals for herself. When specifically asked about her first exam grade she simply said she was, “mad, upset.” When asked about this feeling of why she got mad or upset, she stated:

Just because when I came [to college], obviously as a first-year student you have your set goals and your plans, so I didn’t reach my goal for the exam grade that I wanted so I was frustrated, but I feel like it took that for me to kick it into high gear, go for more academic support, study a little more in this class because I was doing better in the other classes.

For some of the participants, the point at which they took the entrance placement exam was the time when they realized that college math was potentially going to be harder than the math in high school and that they didn’t have the knowledge base for college level math. Betty remembers taking the placement test and added, “Yeah, I knew it was [being placed in remedial math] cause I did poorly on…I’m pretty sure I did really bad. Like I think I bombed the math. I got like a really low score.” Similarly, Sue claimed:

It was the placement test. When I took the placement test, I was like, “oh my gosh, this is so easy.” It was like pre-algebra and algebra, or something like that. That’s what I got a B in [in high school], so I was like I got this. I thought I nailed it and then it was like, “Nope, you didn’t nail it.” I was like, “okay.” I got placed in QR.
For others, it was being in a college math course that made them realize they needed help. Don stated “I feel like college math is way different than high school math, because it’s so fast-paced.” May supported this when she said, “it’s a lot different than high school because no one’s going to hold your hand to help you get through it, but it was definitely at a fast pace, which didn’t work well for me.” Later in the interview, May added “when it would come time for the exam, I literally had no idea what was going on.” Jane simply stated she “was so scared. Because it’s a math class and I know how I am in math. I’m so scared of not getting the material.” Joy added that she realized she needed help in the remedial course because of her feelings in the course. She added:

So, I feel like I didn’t have a foundation with it, like I said. So I had to start from scratch.

When we were going over basic things at the beginning, I’m like okay, I actually don’t know what this is. Because when you start a class sometimes, they’re [faculty] like yeah, [you] learned this in high school, and it’s like no, I didn’t actually.

Ann acknowledged her need for help in math when she compared the remedial mathematics course to high school and said, “I was really struggling with that in high school. I just don’t get help, but with math it’s different. I actually need to get help.”

Participants’ self-awareness of their need for help in order to pass the course was typically the first factor that many of them described. This acknowledgement occurred either after the first low test grade, the college math placement test, or their general feelings about the mathematics. After this acknowledgment, the student participants would identify and describe factors that helped them successfully pass the remedial mathematics course.

**Utilizing the college’s academic support services and resources.** The second factor that was identified as contributing to the students’ success was the use of resources and services.
This is defined as students obtaining help from tutors, coaches, and online software to learn to study for, and pass the course. The tutoring and coaching center at this institution is referred to as the Q-center, more formally identified as the quantitative center. As noted previously in the definitions, the Q-center is a center within the learning commons that provides a focus on quantitative skills. Therefore, all math related services such as tutoring and coaching occur in the Q-center. Academic coaches are available to any student who wishes to seek help from an individual who is aware of the demands of college, the needs of students, and the expectations of faculty; and can guide the student in meeting his or her challenges and goals. The students are able to schedule and meet with their academic coaches as needed. In addition, the academic coaches reach out to students periodically to check on them and evaluate their progress, as well as discuss their progress with their instructors. They assist them in accessing appropriate resources on campus and help them with time management, study skills, and goal setting, as well as life management skills. The math specific tutoring services are provided by students who have demonstrated knowledge in the relevant math, as well as faculty members who teach that particular math. In this study, the tutors could be students who successfully passed the course and passed the training and assessment courses, staff, or faculty members who teach QR 101A, the remedial mathematics course.

The resources and services on campus are generally well received by most students, and the study participants were no exception. Many of the participants discussed how invaluable they were, and how and when they would utilize them. Mary stated simply, “I would be at the Q-center all the time.” When asked more specific probing questions about the Q-center, she recalls various tutoring sessions before test days, “I think the night before, or a couple nights
before, they’d hold test sessions. I remember there’s always be so many people at the Q-center.”

Joshua too found value in the Q-center’s tutoring services.

Yup, it was helpful, it was not just because I’m listening to my professor, but other students that have gone through the class, they have ways that they studied it. That was good too. I was not very picky with who was supposed to teach me something. It was good to see what other people are thinking, not sticking to one thing at a time.

Jane and Joy also found value in the tutoring services and expressed their gratitude to the tutoring staff; and specifically attributed the center as helping them pass the course. Jane mentioned, “I did use the Q-center. I forgot how many times I went, but I know I went more than two or three times…” When asked did the Q-center help, she enthusiastically replied, “It did, they helped me a lot. I liked going to them.” Joy’s experience with the Q-center was also with tutoring. She stated that the math course got a “…little bit harder, as you go on in the chapters. So, I started using the Q-center for that…” She indicated, “I learn better when someone shows me examples and how they can figure it. I can’t do it on my own. And, yeah, they help me solve this, …” When asked about who helped her the most in the Q-center, she said, “she was a student, and she was graduating.” Roxanne added to the statement about Q-center and peer tutors, “…because I think my specific tutor just excelled. She excelled so I looked up to her.”

Not all participants found the peer tutors as helpful, but did find value in the tutoring services. Some participants preferred the times during which faculty members were in the Q-center helping to tutor. Ann made this clear when she stated:

Actually, there was a couple of tutors that helped me. One or two of them were really helpful, but there were some like they don’t really know what they’re talking about, but I
appreciate that they’re trying to help me, but they didn’t’ really help me. I like the ones that are faculty because they actually had more experience with QR, and they know what to expect for the material. The other non-faculty, they’re good, but…I don’t know how to explain it. It’s like they’re trying to help you, but it’s different from a faculty member, because they actually know what they’re talk about, you know?

While tutoring was mentioned multiple times by many of the student participants, the use of an academic coach was also mentioned multiple times. Roxanne described in greater detail, her decision to go to the Q-center and how she initially sought the help of an academic coach. She indicated:

“I used that frustration [failing the first test] to, that’s the reason why I actually went to it, it was called the ACE center, but now it’s the Learning Commons. I got an academic coach. It was right off the bat. I had an academic coach and she was amazing. She was amazing.”

Roxanne added, “The resources are there so why not take advantage. It’s not so much that it’s like I was eager to seek the help, but it was there and I was eager to succeed and if that’s what I had to, then I had to do it and I did it.”

Roxanne’s description of how and why she used an academic coach was similar to other student participants that used an academic coach. Mary and Marcus also described their experience with an academic coach, but in slightly different ways. Marcus recalls that he was in a program, called the PRIDE Scholars, which assigned the students in the program an academic coach on day one at the college. He described the program and how his academic coach was always following up with him and his professors regarding his progress and many times would reach out to him before he could see her. When asked about where or to whom he reached out
for help when he hit a barrier, he specifically mentioned his academic coach, “I went, first I went to Melanie, which is the academic coach. Then, she kind of pointed me in the right way for help.”

Mary did not have an academic coach initially, but she reached out for help in the Q-center for the remedial math course and was assigned an academic coach. Her experience with her coach was similar to others in saying, “She helped me with the QR. Being organized. I’ve had one ever since…I liked that organization and just that someone’s there helping you get through it.”

Many of the responses from the student participants were echoed by the faculty in the focus group. Overwhelming, faculty agreed with one of the statements made, which was, “I see the motivated students wanting support by keep asking where and how they can get additional help.” One faculty member added, “For some we are very successful with some of the resources we have added. For example, the Q-center and holding review sessions called QR after dark.” Another faculty added that she is “…always reminding the students of the Q-center and the benefits of additional support there.” The faculty in the focus group supported the students’ responses. In fact, upon review of the attendance list in the Q-center as part of the document review, many of the students participating in this study were on the list as requesting support.

In addition to the Q-center for help, students also had access to a software program for their homework. The software would provide multiple examples and practice problems. The software would also allow them to see what they got wrong and where in the various steps to make the corrections. It then would allow them to attempt another problem. Jane, May, Joy, and Ann all described the online homework as helpful because it would allow them to do the material
on their own and at their own pace, but also provide feedback as to what they got wrong and how
to correct it moving forward. Joy best states this value when she replied:

It [online homework] would have help me solve this, so if you got it wrong, then you
could do [the] “help me solve this [function]”. And it would give you the steps, so you
could write it in your notebook, the steps. So, then you could study them, so it really
gears you toward success with all stuff being there.

Ann adds that, “At the end, it would show you what you got wrong and you can review and
stuff.” May replied, “I honestly think the homework aspect is why I passed because I had 100 in
the homework portion.”

While the potential function of the homework software was described as being valuable
to their success, the mechanics of the program software was a frustration expressed by many.
Many students mentioned that they liked the ability to get immediate feedback and doing the
online homework on their own, but it could be a source of frustration. A representative quote of
this frustration is from Sue:

Homework was rough. That was online, and it took forever, I feel like. Some of its
multiple choice, some of it was open ended, so you had to type in the answer, but if let’s
say the answer was .5, and you type in .5, it was like “You’re wrong. It’s .50.” And
you’re like, “That’s the same thing. What?” It always said you were wrong even though
you were right. I’m like “That doesn’t make any sense.” It wasn’t’ the class, it was like
the programming, I feel like, of the actual assignment if it’s not that exactly, it’s wrong.
There’s different forms you could write things. If it didn’t specify if it wanted it in a
fraction or a decimal, like say you wrote it in a decimal, it’s be like, “No, we wanted a
fraction.” I’m like, “You should have written in the directions you wanted a fraction.”
Jane expressed a similar frustration, “I hated it, it’s so very tedious. And what always happened to me was if I forgot to put a decimal point or didn’t round one number up, I’d get it wrong and have to do the whole thing over again which was annoying.” Interestingly, despite their frustration, they persisted with their online homework. Also of note, the syllabus for the remedial course did not demonstrate that the students were mandated to use the on-line homework in any particular way, but did allow the students to do it as many times as needed and to submit their final attempt/score to the instructor. During the faculty focus group, one faculty member said, “I see successful students spending a lot of time on the online homework. It’s adaptive technology, which helps them focus on the problems they struggle with, but allows them to bypass the ones they get right. I think that really builds confidence in the students.” One might speculate that their persistence could have been a function of their motivation, which is the third factor identified as contributing to their success in remedial math.

**Career-driven motivation.** Career-driven motivation, is defined in this study as students’ determination to persist in doing whatever was necessary to pass the course so that they could move into the program of their choice. All but one student participant described the motivation as them being accepted into the program or major of their choice. Passing the remedial mathematics course was considered “high stakes” for some in that they knew math was not one of their strengths, and acceptance into the program of their choice was contingent on their passing the course. For others, the motivation was fueled by family members, who pushed them to do well and encouraged them in order to get into the program of their choice. Regardless of how the students described their motivation, what they ultimately described centered in some way, on their determination to enter the program or major of their choice because of the career they were actively pursuing.
The theme is best exemplified in a quote from Jane that made clear that passing the remedial mathematics course was critical in order to move into the nursing program:

Because if I didn’t pass QR, I wouldn’t be a nurse. They [nursing advisors] would always tell you when we had the meeting with nursing, …you have to have this grade in class to even be considered to be in the program. Like that kind of scared me, it pushed me to do better in my class.”

Jane’s comment was echoed by many, including Joy, May, and Roxanne. Joy made clear that not passing the course was not an option when she stated, “Because I need to pass. Yeah, that was my drive because I knew I had to take stats to get into [radiology], so I was like I need to do this.”

Ann provided a similar description of her motivation, but addressed it from the perspective of her future and what it meant should she not pass the remedial mathematics course. She described passing the course as, “It’s just that motivation. I can’t afford to have a low grade because I’m also trying to get into the nursing program. If I slack off now, it’s really going to affect me in the future. So, I’m thinking ahead in the future what my standing would be if I actually don’t do well in this class. That’s my main motivator.”

Several students mentioned that the remedial math course was tough for them. Many of these student participants, as noted in Table 4.1, admitted early in the interview that math was not their strongest subject and/or that they did not like math. This dislike for math was a challenge, but their motivation to enter the profession career of their choice became a factor in doing well and overcoming it. Sue was motivated to get into the nursing program as well, but she discussed it in the context of her high school math. She felt that the stakes were higher with this math versus what she did in high school. She says, “I, like in high school, I wouldn’t have
been so uptight about it, but because nursing is so intense and there’s so much on the line, they
don’t really allow room for failure at all. I was like, “Can’t really let this beat me down like I
would in high school.”

While many participants mentioned that getting into the major of their choice was a
motivation for their doing well in the course, some described being motivated by their
relationships with family and others. However, it is noteworthy, that when the student
participants described these relationships with family or others as a source of motivation, what
they described was in some way related to the program that would lead them to their desired
career. Joshua, the student who moved to the United States to attend college, said that he was
“…motivated by my parents and family, cause my sisters are all in the medical field.” He further
acknowledges his family stating that they, in a kind and compassionate way, said to him:

…you cannot do this, you cannot get a bad grade or you cannot slack, you should not do
this. That keeps me going, it’s just that I know where I’m from, that’s just a something.
I know it’s not easy coming to another country and then you try to start, so that keeps me
motivated. I know I just want to be better than where I come from.

Joshua was not alone in describing his motivation from family. Roxanne also provided an
emotional comment in the interview when asked what helped her pass the course. She paused
for a moment and said:

I’ll be honest, my parents, they had their basic levels of education but post-secondary
they didn’t have much like I said and my brother passed away, he didn’t get to finish his
education so it’s just like my sisters and I, not that we have a lot on our shoulders but it’s
like, you really don’t’ have any excuses not to put your all into an education that’s being
granted to you. I was like, “okay, you have to do well in school or there’s no reason you shouldn’t.” It’s the only thing I have to focus on.

Marcus stated it simply as “It was honestly hard work and dedication. I just knew what I had to do to move on and I didn’t want to let anyone down that knew I was going into nuclear medicine to be honest.”

While the career-driven motivation was the majority of what the student participants described, others did mention motivation related to achieving good grades in general. Ann, for example, indicated, “I guess it goes back to [the] high school thing. I always wanted to get an A in math, ...that was my main driving force. I can say to myself I actually got an A in a college course. That was basically my main drive to it.” Another participant, Mary, mentions throughout the interview, the importance of her doing well in the remedial mathematics course. She admitted early in the interview that she was never a strong student in math and would really only understand it if she could apply it to something and/or she liked her teacher. The reason she wanted to do well in the math course was that she too wanted to be in the nursing program, but she also wanted to make the Dean’s List and prove to herself she could do math. She states:

I like doing well. I really wanted to make Dean’s List, that was my goal. To get the A, it makes me proud of myself and just a big relief off. I’m like, “Wow.” It makes me realize I’m doing good and to be proud of myself. Not that I know…My parents are saying, “You should be proud of yourself. If you don’t’ get Dean’s List, you’re still working so hard.”

However, Mary did later admit that while she was motivated by the grades, Dean’s List, and to prove to herself she could do it, getting into the nursing program was a major motivator. She
states, “I just wanted to show I really could do it. I really wanted to be in the nursing program and I really tried hard.”

In addition to grades, two other participants mentioned that they did not try as hard in high school as they were in college because the stakes were perceived to be different. Jane compares the two as “I’m like I don’t care if I need help, I’m gonna get help. Cause, I don’t know, in high school I probably was like that [did not study] cause at the end I’m gonna graduate. Here’s it’s either you’re in or you’re not.” When asked for her to clarify in or not, she says she was referring to the nursing program and add, “Yeah and that’s what scared me, I don’t want this taken away from me.”

May, who admits that she struggled with the course but passed in the end, said that it was the motivation of getting out of the class that helped her. She quotes, “...because I know QR, you have to take QR to move on, so I know I was stuck with it. It definitely made me anxious because I wasn’t grasping the information and I knew that if I didn’t’ get the grade I was going to have to retake it, which would set me behind in everything.”

During the focus group session with faculty, each faculty member at various times responded about they always can tell who the students are in competitive entrance programs, because, “…the students work harder.” A statement from one faculty member that all agreed with was, “Nursing students are the most passionate of all majors here.” Upon review of the notes from several of the academic coaches regarding these students who was seen by an academic coach was comments related to their desire and wish to enter the program of their choice.

In summary, while some students did discuss grades as a motivator, either receiving a passing grade, demonstrating to others or themselves they could pass the course, or simply
passing the course to move into the program of their choice, grades as a motivator was ultimately related to their choice of career. The drive to gain acceptance into the program of their choice, and subsequently their careers, was evident throughout their descriptions. Many also discussed the role of their faculty as a factor that contributed to their quest to do well in the course.

**Faculty commitment.** Faculty commitment, as a fourth factor in this study, is defined as students’ descriptions of their instructors’ dedication to helping them to pass the course. Many of the students made clear the importance of their relationship and connections with their respective faculty. The themes that emerged under this factor include the students’ perceptions of their faculty’s investment in them either through the faculty’s teaching style, how the faculty could adapt to their needs, or their overall connection to the faculty member.

The faculty’s teaching style was important to many participants, especially if the students’ believed that it made a difference in their learning. Teaching style as described by the student participants included being organized by providing an outline of the material to be covered that day on the white board or ensuring every student in class understood the material and not introducing new material until it was time. Perhaps the teaching style mentioned most often was when the instructor would write on the white board and use a more interactive approach versus using only PowerPoint presentations. The value of this interactive approach was supported by Roxanne who said her professor would, “…do exit slips after some classes, just a one question thing and I think that was his way, my professor’s way, of assessing this is a major part of what I taught you. Do you know it?” She also added that the remedial math course, “was the first class I had during the day so we would go in and he would say the agenda for the day, he’d write it on the board and we would just dive in the lecture.” This organized style was important to Jane as well, as she said her professor was “…very organized and stuff. I think
that’s what I like about her.” Sue added by saying, “He would just come in, and he had his idea of what he wanted to do, so he would go over example problems, kind of lecture within the example problems, and then we would have to do some stuff, like time to ask questions.”

Others felt that their instructor adapted to their specific individual needs and/or to those of the class as a whole. Don, who best described adaptability, said his professor would go over the material on the board in a “step-by-step” manner and would “...just slow it down with us.” Joy said, “I like when she would just stop and go over it step-by-step so we could see each step and how to get that number to move to the next step.” Jane’s comment about her faculty’s commitment captured those of many of the participants. “Because there were times when a lot of people did not get it besides me and she would go step by step slowly, no matter how long it took us. She wasn’t going to move on to the next step or the next subject until we got it, like every student.”

When students felt they had a connection with the professor, they felt comfortable talking with that professor. Marcus believed his professor really understood him as an individual and felt that he had a connection with her, because of unspoken words and action. He mentions, “I wanted to pass the course and understand math, because as I’ve said, I don’t really like all math especially if I can’t apply it to something. I think she got that when I would meet with her.” Providing opportunities for students to get additional help with material outside the course was also seen by student participants as their faculty being invested in them by providing these resources. Marcus discusses how he felt the professor helped him be successful in the remedial math course. He remembers his faculty saying, “If you guys need help, go to the Q-center, come to me, make office hours.” He adds, “She was always telling us to reach out for help if we needed it. She was always there if we need it. That’s one thing, she always said in every class,
that she was there to help and also gave a lot of resources like the Q-center or the academic coaches.”

Others recalled similar experiences. Don adds that his “staying extra [after class] and going over homework with her” helped him be successful. Joshua adds to the discussion about his professor, but also describes that it was because she was approachable:

She would take time off when she probably has to go, and try to help you understand the question. I liked her because of [her] positive attitude, easy going, easy to approach, and created time for students to ask questions and review material, those are the key factors.

Jane, Joy, and Joshua all comment on how helpful their instructor was during office hours and having the one-on-one contact with their faculty. Jane says, “I loved going to her office hours. She was very…I don’t know the proper word for it. She was really good at explaining, and she told me what I’m doing wrong and how to fix it. I like that.” Joy adds that the office hours were helpful, even when they were on a Friday afternoon, “And if you needed more time, even after lab, she had the office hours on Friday afternoon. It’s like afterwards, so she would stay longer with you, which was also helpful.”

Joshua, the international student, focused on the one-on-one approach. He remembers math in high school and said he was always afraid to ask questions, because he felt that he was being criticized; however, in this math class he felt differently. He says, “I was afraid, I hated being criticized, but the thing is when I came here, she was not. You can approach [her] at anytime, anywhere and you have a question and [she would] pull you aside and you talk about it. That for me was a very big plus and helped me understand things more.”

Important to the students’ developing a connection with their faculty, was for faculty to be approachable and available for students. Roxanne’s description of her faculty member
summarizes some of the positive things participants had to say about their faculty members. She says, “This professor, much easier to approach. Little more witty. Had some jokes. Kept us alert in class. You could tell that he likes what he’s teaching I would say, and was willing to help and wanted to see us succeed so it was much easier for me to go up to him and ask questions.”

Faculty that participated in the focus group were passionate about helping the students in remedial mathematics to do well. Their vivid examples of when they could see the student became engaged with the math material was motivating. Their descriptions of who their students are, stories about their backgrounds, and success stories after the remedial course were encouraging. It was clear that these faculty members wanted to help see the students be successful.

While most of the participants mentioned their faculty member in a positive manner, there were two participants who did not have similar positive experiences. May and Don did not believe their faculty member was a contributing factor to their passing the remedial math course. May describes her professor as being rushed and not taking the time to help the students understand math. She says:

Yeah, we’d go to class and then the professor was usually a few minutes late. So, she’d [be] coming late and then she’d be rushing to put the PowerPoint on the board. And then, she’d whirl through the PowerPoints and be like, “Does anyone have any questions?” Right at the end of class. And people were like “Um…” They have questions but she’d just go back to the PowerPoints and be like, “This is what I said. This is how you do it.”
Don added that he did not believe his instructor was committed to him passing the course, because she would compare his class to other classes she was teaching. He did not believe she was committed to teaching remedial students. He quotes:

“It wasn’t anything that the teacher was a bad teacher, it was just probably because she was so advanced herself, because she teaches others [courses] like pre-calculus and stuff, maybe she just assumed that we know the stuff that…or we should know it already. She would compare us to other classes. How I viewed it is that we were in the intermediate and there would be an advanced QR [course]. Because the other class would be ahead of us, and then she would say, “The other class is ahead, so ….”

In summary, most student participants perceived their faculty as being committed to helping them pass the course. This was demonstrated through the students’ perceptions of their investment in them as students or the connections they described with their faculty. When students believed the faculty member was adapting their teaching style to ensure students were understanding the material, there was a sense of faculty commitment.

**Participation in a required lab component.** Many participants discussed the lab component of the course and the benefits they received from their active participation in the lab experience. This factor is defined as the experiential learning portion of the remedial math course that provided students the opportunity to actively solve math problems by applying class content in a faculty-facilitated, student-centered time period. The benefits identified by the student participants include more time to practice solving problems and having the flexibility of the lab hours to do what was deemed important to them rather than being structured. The lab component is three hours long while the class component is three, 50-minute lecture hours. The
lab was described as being a place where some could take their tests and quizzes so that they had more time, as well as a place where they would get direct feedback on their individual work.

Ann’s description of the lab portion of the remedial mathematic course was something that many of the participants expressed:

I thought at first what is a math lab? I thought labs only happen in science. I was so confused. But it was just a bunch of more problems sets and just worksheet problems. If you have any questions, the professor’s available. Which is great because if you have any questions for an upcoming exam, she could be there to say, oh, you’re doing this right, you’re doing this wrong. It was more guidance. It actually helped me. Which is interesting because I have friends who just took QR without lab. They said that they didn’t really get a lot of extra guidance when it came to exams, but since I had lab, I had extra practice and extra problems which got me more prepared. Yeah, I thought that was a very beneficial thing.

Roxanne added that her instructor in lab was different from who she had in class, but ultimately the lab allowed her to practice problems. She stated that lab, “…was just practice, practice, practice so she would open her PowerPoints and then her practice questions.” Betty noted that, “We did group work when we had labs, so we’d have a partner, so like if I was confused, I mean, me and my partner would talk it through and help each other.”

Participants viewed the lab as beneficial, but their reasons varied. Sue felt that the lab was helpful because of how the professor organized the lab and the flexibility the lab offered for her learning:

Most of it [the lab] I think the professor wanted to focus on what we did that day or the past week. He would say, “If you have any questions, or is there anything from lecture
that you didn’t get and you want to go over it again?” It was kind of like a second lecture if you want it to be, or it could be working on [math problems] with a partner or with a group. You could work with whoever you wanted to. I liked that set up of the lab.

Joy, who described the remedial math course as a challenge, because she says she is not good with math, said it was difficult for her “…to learn math in 50-minute class sessions, so the lab…compensated.” She did add that she did not “…want to be here on Friday afternoons [for the lab portion], …but it did help, like I said, in the long run.” Don also felt that the 3-hour lab provided additional learning time for math beyond the 50-minute lecture course, stating, “She’d go over it more, because during class she didn’t want to waste so much time on one question. So, our lab time was to go over what we didn’t know.” Having additional time allowed student participants to review the material in which they were struggling with. Mary provided an example of an area in which the lab helped her with a particular example:

…the labs, she’d go over things everyone had a tough time on, which I liked. I even remember fractions at one point, I think. For some reason, I was never good at fractions and stuff or anything like that. That did help, that part. It was more like reviewing [in] lab, which I like that.

Jane, also suggested that the additional time helped her pass the course, but her focus was slightly different. She describes her experience with lab as having the ability to have additional time on tests and quizzes:

I think the big difference was in the lab we took…because lab was a lot longer than regular lecture. But we always took major exams and quizzes [there]…it was like the quizzes that we took during lab were quizzes that were based on really dense material, so that’s what I liked. We did use lab for some teaching and extra help type stuff, but that’s
the main difference. We relied on lab to look back and see where we went wrong on, you know, like that.

Others, including Mary and Marcus, also agreed that the 3-hour lab allowed them to take their time on tests and quizzes, which they appreciated. Mary mentioned that, “…the lab was beneficial in that I got to take my tests there and I didn’t feel pressure from with the time [constraints].” Faculty agreed that there were times in which students, who needed additional time, could do this in the lab. Two of the three faculty member commented on the fact that the lab gave them extra time to be with the students and to slow things down for them. But the majority of the comments from faculty were about how they read on their course evaluations that the one-on-one time in the lab is the most helpful. One faculty member states:

In the lab, when they get one-on-one attention, it is very helpful, especially for the students that are in the lower spectrum. That’s the time they get the attention they need and lot of encouragement, positive reinforcement, and to get the help.

In addition to the comments from both the student participants and the faculty at the focus group session, the syllabi clearly define the lab, the importance of the lab, and the requirements. Notes in these students’ records from both academic coaches and tutors discussed the fact that students were saying that they were attending the lab sessions.

Ann too liked the lab portion of the course, but for her it was because she could get the one-on-one attention to see what she was doing right or what she was doing wrong and simply said, “I liked the feedback.” Feedback was important to many of the participants, even in the form of peer support.

**Peer support.** Peer support is the sixth factor identified. It is defined as the use of help from friends or roommates to learn and practice math. Several of the participants discussed the
value of having their friends help them with math. Sue, Don, Jane, Joy and May provided some of the most direct quotes to which others referred. Many of these same student participants also used the college supported resources like tutoring, but found their friends, whom they considered as peers, as being a direct link to their passing the course. The discussions around friends focused on one of two situations. The first was that of a group of friends all struggling with the math problems from the remedial course and working together to find solutions and to learn from one another. The other discussion was around a friend not in the remedial math course, who understood the concepts, helping the participant learn the material. Sue and Jane’s comments are representative of what others mentioned, in that each of them would get together with their friends to study the material and try and solve the math problems together. Sue’s description of working/studying with her friends was not atypical, but she does mention that because she was new at the school and did not know a lot of people, she made a connection with a student who was in a similar situation as her:

I [would] do the work with my one friend. We were in the same class. We sat next to each other. We would do the homework separately, but we would text each other, like, “did you do it yet?” or like, “what did you get for this?” I definitely worked with her a lot, because I didn’t really know a lot of people. Then we started working together more often. I feel like we kind of work together because we’re both at the same stress level. Jane presented a similar experience, but focused on that the fact that they had fun together while studying the material, which she believes helped her understand the material better:

I was like to my roommate, I was “like do you get this [QR], I don’t get this at all.” We would always be in our room the three of us, one of my other friends lives across the hall,
we would do my math class together and we would like rip our hair out `cause it was really a tedious thing. They helped me with them, we would help each other. We would solve all the problems and see where we went wrong and show each other. We would always like write it down how we got the answer and look at it together, look at the book and where we messed up. Yeah that helped. That’s one thing I remember when we would study together we would have fun with it. We had fun doing it and I felt like that helped us.

Others expressed that they “connected” with their friends who understood the material better than they did and were willing to spend the extra time helping them learn. Mary, Don, and May all expressed gratitude to their friends who helped them learn the material even after they would spend one-on-one time with the instructor or use the tutoring services provided by the college. Mary and Don both had simple, but direct quotes regarding how their friends helped them. Mary simply says, “I actually had one of my friends who was in the class and helped me a lot.” When Don was probed further about how he passed the course after his description of how he struggled with some of the material, he says “Working with other students. My friends were doing well in it.” Don, who did not elaborate much on questions without probing questions, thought it was “Just going over the steps with friends, I guess.” But, it was May that provided the most detailed answer of how her friend helped to shape her experience and eventually, to whom she attributes passing the course. May, who repeatedly mentioned that she struggled in the course, but did pass, described her friend as:

One of my friends that lived down the hall would always come help me with my homework because she’s crazy smart and can understand anything. She tutors in Q-center now for QR, but she would come help me and sit through me doing my
homework. So, she’d come to my room every night if I had homework and sit with me for an hour, do it out with me. She’d sit through and she wouldn’t give me the answers, she’d make me understand it. She’d bring her notes, which were a lot better than the ones that I was given. She’d reteach me everything in a different way. …but the part that helped me the most was having my friend try to teach me every night.

May added one final comment about her friend, whom she again claims is the sole reason she passed the course. “That's how you know it's a true friend, sitting there with you for an hour [every night].” At the end of the interview when asked if she had anything else to add, she mentions that her advice to other students would be to “…ask your peers because your peers are pretty bright, too.” Faculty members commented on the fact that they try and encourage peer support, because they have witnessed students who “…pair off with their peers in lab or class, tend to begin asking higher level questions and seek additional and more complex problems to solve.” The peer support outside of the classroom either through friendships or through group activity was perceived by the students as fundamental to their success.

**Prioritizing time for math to practice problems.** Most of the student participants discussed how remedial mathematics had to become a priority in order to pass the course. Prioritizing time for math to practice math problems over and over again is the seventh factor, and is defined as putting math first above anything else, including socializing with friends, and studying for other courses, so that time could be spent on solving math problems step-by-step, and repeating them over and over again. All but two participants discussed how the remedial mathematics course became the course they focused on the most during that first semester, even
when they had other courses related to their major, including anatomy and physiology. Many of these same participants said the reason the remedial mathematics course became the priority over other courses was because they needed to visualize the math problems written out step-by-step and to practice them over and over until they understood it. Mary, Jane, and Ann had brief, but clear statements regarding the time commitment in the remedial mathematics course and how the course became the priority over all other courses. Mary states, “I was working way harder on this class than anatomy.” Jane adds to this by saying, “I found myself trying hard[er] in math class than in [any] other classes. Probably because of my math lab and the exams and the quizzes.” Ann remembers telling herself after failing the first exam, “I basically spent most of my studying time with QR, which is good but also bad, because I kind of neglected my other classes a bit. But, I’m failing QR at that point, so my mentality is you’ve got to spend more time on this.”

In regards to investing more time with the remedial mathematics course, participants explained that the reason the time commitment had to be so great was because they just had to practice the math problems over and over in order to understand the math concepts. Ann and Joshua both discussed how they needed to constantly practice the math problems over and over. Ann described her experience in the following way:

It’s just constant practice, practice, practice until it’s ingrained in my head. It’s mostly just practice. You just have to put time and effort into it. You can’t cheat QR. You just need to practice it, practice a lot of problems. It is a hard class, but you can pass it if you just put time and effort.”
Joshua adds, “Math I need to practice, it’s just practice, practice, practice. ‘Cause I was not good at it [math], so I had to create, you have to keep practicing to become good at something, so I try to keep practicing, practice.

Upon asking more probing questions about why participants needed to spend considerably more time with the remedial math course, several participants admitted it was because they struggled to remember each step of a math problem or equation in order to have an answer. A representative quote from the participants came from Don. He responded, “Maybe because it was just so difficult to remember the steps, ‘cause you know how you have to do steps and remember everything like that, so that was probably why.” Other participants, such as May, again who admits that she struggles with math concepts in general, thinks that having step by step instructions helps with understanding how to do the equations. She adds, “His homework, he’d give you a problem and he’d step-by-step give you instructions on how it’s done on a piece of paper.”

Another reason that participants felt like they were putting more time into the course, when compared to their other courses, was because of the way they were studying for the course. Studying meant practicing, practicing and more practicing of math problems. Betty indicated that, “With math, you just have to do a bunch of practice problems until you get them right, ‘cause it’s not like you can actually memorize anything really.” Ann also says the reason she did well in the course (she received an A in the course) is because of her dedication to practicing the problems. When asked about her time commitment and how that helped her pass the course, she says, “I would also say hard work ultimately. Just pay attention even though it’s meticulous as it is, you still have to do it. I would just keep doing practice problems and just practice and practice. Because that A is not given to me. You have to work hard for that A. That A will
come when you work hard. It’s the fruition of hard work.” Along the same notion of dedication, Joy adds that she would study differently for the math course compared to some of her other courses. She would “…get my notebook, my pencil, my computer, and I would just shut everything out and do it.”

When probed as to whether studying for the math course took time away from other courses, participants elaborated on the amount of time it took to practice problems as already mentioned; however, Roxanne provides detailed information on how her study habits had to change, which also required more time. She claims her old study habits were to review the material a day or so before a test, but quotes in order to pass the remedial math course, “Those were my old study habits that had to die and had to die very quickly.” She described her new study habits as including reviewing the math material right after class and making notes for herself. Later that day or night after class, she would practice the problems from class and make her own notes. She would continue to review her notes over and over, even after moving on to new material.

Other participants reported similar changes, more specifically, the need for visualizing the problems. Many of the participants, including Marcus, Joy, May and Mary, discussed how they needed to visually see the steps written out and develop an understanding of those steps in order to begin to study and/or do the problems on their own. Marcus said that he too would need to write things out and then would attempt to create his own problems. Marcus says

I want to see it done first. I’m very good at finding answers, but if I could have someone show me first, that’d be ideal. Then I kind of copy what they do for a couple of times, and then it’s ingrained in my mind. Then, I throw curve balls at it, and see, “Oh, is this
still working? Is this still working?” I like a double check kind of, where you give me a
problem and you have the answer, and I say, “hey, is this the answer? Yep? Okay.”

Another example is from Jane. Jane says, “...and YouTube videos helped a lot cause I’m
a visual learner. So, seeing it done helped a lot…” When asked more about her being a visual
learner, she says, “I think seeing it just like, sticks better. Cause just hearing it probably, just
going in one ear and out the other. I have to see it done, step by step.”

In fact, many students discussed this need to write it down to understand it was helpful,
but did take time. Joshua says, “Cause I like writing stuff down. I feel like it helps me retain
more. I did not do it very often, but I figure out it’s very helpful when it comes to retaining
information.” The faculty supported these answers. One quote that summarizes the faculty’s
responses was, “…repetition is key in learning math, so I try to repeat the same idea over and
over.”

**Additional Findings**

The study revealed two additional findings that did not specifically address the research
question, the first being the students’ perceptions of the value of a small school. Betty, described
her decision to leave the study site after one semester, because she felt it was too small and not
enough of the perceived college experience; however, after spending a semester at a larger
school, she returned. She laughs and says, “honestly, I probably think it’s for the best, because I
don’t think I would have been able to be a nurse if I was somewhere that big and distracting.”
Joy thinks the reason she is able to get additional help is because of the small school
environment, because the professors “know you in the hall.”

The second finding was the students’ perceptions of the value of applied math versus
theoretical math. This finding was related more to learning math in general, rather than
described by students as a factor specifically related to their passing the remedial math course. In fact, every student participant described how they could better understand math if they were able to see its real-world application. Sue provided an example:

A lot of the example questions were like if you want to put money in the bank, how long let it sit there, and a bunch of terminology that I don’t remember. I feel like it’s important to know that. I get the point of the class, and I get what we’re learning was important. I think since it was real life, I was able to connect to it and be like, “Oh yeah, I’m going to need to know this, so I have to do it.” It made sense.

Joshua’s description of what he believed was “theoretical” math was echoed by others, “Find X. I don’t need to find x, I’m not going to use x anywhere.” Ann added that she is okay with basic mathematics of adding and subtracting numbers, but does not see the point in taking additional math courses, “...complex math, like algebra and calculus, it’s like I’m not really going to use that in my future career.” Marcus describes it as “Anything that I can put to real life and is not theoretical, I do really, really good in, but not so much the theoretical stuff where it’s like all theory and you’re putting Y and XB in it.”

May also described math as being easier to understand if she could relate it to something, “But with QR, you can’t relate that to anything. That relates to nothing.” Don had similar descriptions, but when asked about math in nursing specifically, there was a disconnect, as he responded, “yeah, but that’s like, baby math. Nursing math is really not hard. It’s just how many liters or how many fluids does a person use.”

While neither of these two findings was described by students as specifically related to how they passed the remedial mathematic course, they do reflect their thoughts and feelings about math and the study site in general. The findings could be important in another context.
Chapter Summary

This chapter presented the findings of the seven factors that students described as helping them pass the remedial mathematics course. In addition to these seven factors, two additional findings were discussed, though their direct relationship to the students’ success in remedial math was not clearly articulated. First, it was apparent that the students in this study valued the small college environment; and second, that learning math within the context of real-world applications helped them to better understand the material. Figure 4.1 provides a visual depiction of the findings and how they are related to the research question.

The oval in the diagram represents the student. In the center of the oval is the student’s success in remedial mathematics. Within the oval are two sections that represent the findings as related to the students’ themselves. At the top of the oval are the students’ individual actions, which include prioritizing time and practicing math problems. At the bottom of the oval are the findings related to the students’ attributes of self-awareness of the need for help and their motivation related to their career choice. Outside of the oval are the findings related to factors helping the student. The left side of the oval represents the faculty commitment and peer support (the specific individual(s) the students mentioned as helping them successfully pass the remedial mathematics course). On the right are the services and resources the college provided including the tutoring and coaching services, online course software, and the lab component of the remedial mathematics course.
The first factor that was identified was the empowerment of the students themselves in recognizing they needed to seek additional help in order to pass the course. This self-awareness, was most often precipitated by the return of their first failing test grade that was not what they had hoped for or expected. Many of the students expressed how they had struggled with math in high school or that they simply did not like math. Many also recognized their lack of knowledge in math based on their performance on the college-entrance placement exam. For these students, being placed in the remedial mathematics course was not a surprise, but failing the first test was not expected.

Once the students acknowledged to themselves that they needed additional help, the second factor identified was the utilizing the college’s academic support services and resources. The majority of the resources and services students used were provided by the Q-center, the
location on the campus where they could obtain dedicated math tutoring by staff and/or faculty, or from other students who had previously taken the course. Students felt comfortable going to the Q-center in order to get help. However, it was also noted that many of the students expressed their frustration with the mechanics of their online math homework, a resource they found more distracting than helpful. Using the period instead of the decimal point, resulted in an incorrect answer, even though the answer was correct, thus lowering their scores on the homework, and increasing their frustration.

Motivation was one of the most fully described factors identified by students. The majority of the students described their motivation as driven by gaining admission into the program or major of their choice. Many of the nursing students described the fact that they had wanted to be a nurse for a long time and that they were going to do whatever was necessary to get into nursing. The medical imaging students had similar motivational thoughts regarding the importance of getting into their program, but did not typically describe it with as much determination as that of the nursing students. This could be due to the fact that none of the imaging students describe their dreams of being in the medical imaging field as early as elementary or high school as some the nursing students did. Participants described other motivational factors such as having good grades, being on the Dean’s list, and even proving to others that they could do it. Some even attributed their motivation to do well to their parents or family, and did not want to disappoint them.

The fourth factor was the faculty. To say that the faculty played a significant role in their success in the course would be an understatement. Many of the students felt that it was because their faculty member took the extra time to help them, that they passed the course. They described their faculty’s willingness to help them after class, during office hours, and/or even in
the hallway. The one-on-one relationship they described with their faculty was a key theme, with the approachability of the instructor, being very important.

Another factor that students described as contributing to their success in the remedial mathematics course was the 3-hour lab component that extended beyond the traditional class time, which was 50 minutes, 3-times a week. Student participants described first not seeing the value of the lab, but then quickly realized the inherent value of the concentrated 3-hour block with the one-on-one attention from the faculty, working with peers in groups, and/or doing additional problems outside of their homework.

Peer support was identified as the sixth factor. Several of the participants described their friends as helping them in the course, even if they described utilizing the college-sponsored resources and services to learn the course material. Many felt their friends knew the material and could better guide them toward understanding the material and on their own time. The participants who described getting support from their peers also described things like having fun learning math together.

The final factor identified in the findings was how students made the math class a priority and would study for it more than any other course, including the courses that were required for their majors, such as anatomy and physiology. In addition to making the math class the priority, they also described that the course took a great deal of time, because they had to practice, practice, and practice math problems; and for many, it meant learning the problems step-by-step.

In summary, students described seven factors that contributed to their passing the remedial math course. It is the knowledge of these seven factors that could be of value to the study site, because the majority of students currently entering the college as first-time students are placed into remedial math based on the college-entrance placement exam and many do not
succeed in passing it. Some leave the college, some do not gain admission into their desired major, and some eventually matriculate into another major. Currently, about fifty percent of the incoming first-year class has expressed interest in majoring in medical imaging or nursing. Knowing the factors that might help them to succeed could contribute to both the students’ success and that of the college.

The experiences described by these medical imaging and nursing students do provide insight into what helped them pass a remedial mathematics course. The institution might wish to utilize these factors, or even build on them, to provide opportunities for future students to be more successful with the remedial mathematics course. Additional institutions with similar demographics might wish to explore opportunities for these factors, when applicable, to be incorporated into their remedial courses. The following chapter examines the conclusions of the study and discusses these factors in relation to the implications to the future of the remedial mathematics course. The chapter will also provide recommendations for future research related to the topic of remedial mathematics.
CHAPTER FIVE: CONCLUSIONS AND DISCUSSION, IMPLICATIONS FOR PRACTICE, AND RECOMMENDATIONS FOR FUTURE RESEARCH

The purpose of this study was to explore the factors described by medical imaging and nursing students as contributing to the successful completion of a remedial mathematics course. A qualitative case study addressed the following research question:

1. What factors do medical imaging and nursing students describe as contributing to the successful completion of a required remedial mathematics course?

This study explored what factors students in medical imaging and nursing described as helping them pass the remedial mathematics course in order to progress through the curriculum and gain acceptance into their program of choice. Purposeful sampling was used to identify the students who were in either the medical imaging or nursing program, and who (based on the college entrance mathematics placement exam) were required to take the remedial mathematics course their first semester at the college. Eleven students participated in the study, four of whom were in the medical imaging programs and the remaining seven in the nursing program. In addition to the student participants, three faculty members who teach the remedial mathematics course were included for triangulation purposes. Individual in-depth interviews with the student participants were the primary source of data. The faculty participants’ data was collected through a focus group session. In addition to the interviews, supporting documents were gathered to gain a better understanding of the resources available to the students, which were used as a source for triangulation purposes. The constant comparison method was used to analyze the qualitative data and resulted in the identification of seven factors to answer the research question.
This chapter describes the research conclusions, the theoretical framework of self-efficacy, implications of the findings for practice, limitations of the study, and recommendations for future research. The conclusions were drawn from the identified factors and discussion of how these factors and conclusions relate to prior research is presented. In addition, the conclusions and discussion will address how these factors relate to the theoretical framework of self-efficacy.

Conclusions and Discussion

Four conclusions were drawn from the findings of this study: 1) having a career goal and rigorous program entrance requirements served as strong motivators for students to pass the remedial mathematics course; 2) self-direction (manifested as seeking one-on-one support) was integral to success; 3) perceived faculty commitment contributed to student success; and 4) learner-centered curricular design of remedial mathematics benefited students. Each of these conclusions will be discussed in relation to the literature, as well as the theory of self-efficacy, which was presented as the theoretical framework for this study.

Conclusion One: Having a Career Goal and Rigorous Program Entrance Requirements Served as Strong Motivators for Students to Pass the Remedial Mathematics Course

This first conclusion was drawn from the students’ repeated statements that passing the remedial math course was critical to their gaining entry into their major, whether it was medical imaging or nursing. Their career choice served as a strong motivating factor, driving them to do whatever they had to do to pass the course. This drive and motivation to gain acceptance into either the medical imaging or nursing program(s) was apparent in each of the eleven student participants.
Students were well aware of the medical imaging or nursing program entrance requirements. Every student mentioned that they knew what grade they needed in each prerequisite course as well as the overall grade point average (GPA) they needed in order to gain acceptance into their programs. Students discussed the admission criteria and what was expected of them in their prerequisite courses in order to gain acceptance into their programs, with their advisors, their first-year seminar faculty, their academic coaches, tutors, and peers, and during information sessions conducted by faculty from medical imaging and nursing. Several of the student participants even mentioned that family members reminded them of what they would need to do in order to progress and be successful in their respective professional programs. This knowledge served the students well, as it made clear the need to pass the remedial mathematics course if they were to take the prerequisite courses.

The necessity of passing the remedial mathematics course was also driven by the students’ goal of entering their chosen career path. In fact, the majority of nursing students described a long-standing desire to be a nurse. They would provide specific examples of when they were children and knew what they wanted to be. Some of the nursing students even completed certified nursing assistant (CNA) courses while in high school. Other nursing students volunteered in the summers and/or on the weekends at their local community hospitals to gain more experience in the nursing field. The majority of the medical imaging students did not describe a specific time at which they knew they wanted to go in the field of medical imaging, but would mention that they selected the institution because of the reputation of the medical imaging program. In either case, each student knew what would be required of them in order to gain acceptance into their respective programs and this knowledge of the programs’ expectations and admission criteria before starting college served them well.
Research on the role of goal setting as a factor contributing to students’ success in remedial mathematics is limited, and literature on the role of a career goal as a factor for health science majors is essentially non-existent. A limited number of studies, although not specifically related to health science majors, do demonstrate the importance of career goals in academic success. The role of goal setting as a factor was presented by Kim, Newton, Downey, and Benton (2010), who reported that when students are meeting set expected learning goals, there is an increase in their meeting their career goals. The study also found that motivation pushes someone toward success and that this motivation can be an “overall desire for success,” as well as “situation-specific motivation” (p. 122). In this study, the requirement to pass the course served as the set expected admission criterion, which resulted in students’ motivation to pass the course and achieve their career goals.

The findings in this study related to the career goal as a motivator for students to pass the remedial mathematics course is supported by three studies; however, as already mentioned are not related to health science majors, but are career focused majors. Hull-Blanks et al. (2005) found that goals related to a career related to academic persistence. Their findings found that the career goal was a likely motivator for students who faced a variety of challenges, including academic success. A more recent study, Lee and Lee (2018), found that students who wanted a career in hospitality demonstrated higher grade point averages (GPA) in their courses required for the major versus the students who were not majoring in hospitality.

The impact of the students’ career choices on their success in the course was further supported by faculty in the focus group. Faculty stated that they could see that students with a clearly articulated career goal appeared to work even harder to meet the expectations of their respective programs. In this study, the students’ career choices seemingly stimulated the drive
and determination to gain acceptance into their chosen major; and in some way, might have served as a personal attribute from which the other factors contributing to their success were generated. Students in this study recognized that if they did not do well in the remedial mathematics course and pass the course, they were not going to be successful in gaining acceptance into their programs. In this study, Jane best described what many of the students said, “Because if I didn’t pass QR, I wouldn’t be a nurse.” Willcoxson and Wynder (2010) reported that students in a major that is specifically related to a major that required specific accreditation or certification were more likely to persist and complete a degree versus the students with a lack of career goals. While the study was focused on business majors, the example that individuals wishing for a career in accounting (with certification-type requirements) had greater persistence and degree attainment versus students in a general marketing major. Having this goal, drive, and desire to gain acceptance into the program was what allowed the students to engage in many of the other factors that helped them be successful in passing the remedial mathematics course as noted in the findings and in the conclusions to follow.

**Conclusion Two: Self-direction (Manifested as Seeking One-on-One Support) was Integral to Success**

The second conclusion from the study is that students benefited from seeking one-on-one support with mathematics. The first step students had to take when recognizing they needed help in the class was admitting they needed help in order to pass the course. The students’ descriptions of when they knew they needed help came from within; a self-awareness that they needed help in order to understand math and solve math problems. This need for help was not prompted by their faculty, but rather by the fact that the students knew they had to pass the
course if they wanted the opportunity to matriculate into the medical imaging or nursing program. Once the students made the decision they needed to get help, they found the support they needed through one-on-one connections with someone they trusted. For the students who found this help, the outcome was described as something like a light bulb just going on and their saying “I got it!” This focus on getting help from others became a priority in that semester and was identified by all students except one. One could speculate that the “I got it” statement could have contributed to an increase in their self-efficacy and strengthened their commitment to their career goals.

There is limited literature on the role of students seeking one-on-one support in helping them specifically pass a remedial mathematics course. However, several studies (Butler-Paisley and Clemetsen, 2018; Di Tommaso, 2012; Jaafar, Toce, and Polnariev, 2016; Koch, Slate, & Moore, 2012; Weinstein, 2004; Yomtov, Plunkett, Efrat, and Marin, 2017) were found, the findings of which support the findings of this study; that when students work with someone one-on-one, they more often report the more positive statement of “I got it.” Koch, Slate, and Moore (2012) report on a qualitative study of three students from a community college in Texas. While the number of participants was small, and the course was a remedial writing course, the study showed that the students benefited from the learning center on campus where they got additional, individualized help. It was reported that the student participants benefitted from meeting with someone who would show them where changes needed to occur with their grammar and writing mechanics. This finding is similar to the findings of this study in which student participants, such as Joy, said “I learn better when someone shows me examples and how they can figure it. I can’t do it on my own.” Other examples from the current study revealed that students would go to the learning center on campus, called the Q-center in the Learning Commons to get help with
specific problems or topics they were having a difficult time trying to understand. The value of seeking this help was supported by a study by Jaafar, Toce, and Polnariev (2016) who found that effective math-tutoring labs that are supported by administration and faculty improved student achievement. The students in their study who used the math lab had higher grades in mathematics and virtually no withdrawals from those classes compared to students who did not use the lab. Based on the interviews and this researcher’s review of the student log-in sheets, all but one student used the resources available in the Learning Commons and all of them passed the course. However, perhaps the most notable one-on-one support came from the student participants’ own peers.

Half of the participants specifically mentioned friends they had in class or on campus who helped them pass the remedial mathematics course. Koch, Slate, and Moore (2012) reported that tutoring sessions with student peers contributed to what students described as a positive learning experience. A sample quote from Jane in this study said, “We would always like write it down how we got the answer and look at it together, look at the book and where we messed up. That’s one thing I remember when we would study together we would have fun with it. We had fun doing it and I felt like that helped us.” Others expressed that they “connected” with their friends who understood the material better than they did and were willing to spend the extra time helping them learn. These statements are supported by two studies that demonstrated the value of peers. Butler-Paisley and Clewetsen (2018) found that students who were supported by peers had increased opportunities for support academically and did not feel as though they were alone in learning. Yomtov, Plunkett, Efrat, and Marin (2017) also found that peer mentoring helped students to feel more supported at college, which helped with persistence towards graduation. While this study was not looking at specific courses and the academic
success in those course due to peer mentors, it did show that students who had peer mentors felt more supported and more motivated to push forward with their academic successes. What is more compelling are the findings of Weinstein’s (2004) qualitative study in which students reported that their self-belief in learning remedial mathematics increased with support and positive feedback from faculty and their own peers, which is consistent with Bandura’s (1977) self-efficacy theory, which will be discussed in the next section. Di Tommaso (2012), who also conducted a qualitative study examining remedial students found that a few participants described their peers as providing a more enjoyable educational experience, but did not go into detail as to what constitutes an enjoyable educational experience.

This conclusion, in which students sought one-on-one help with the remedial mathematics material from someone whom they believed was helpful is clearly of interest. The findings of this study provide clear evidence that one-on-one support from a tutor, academic coach, and peers was a major benefit to students in this study in helping them successfully pass the remedial mathematics course. This is a finding that can be of significant value for students in remedial mathematics.

**Conclusion Three: Perceived Faculty Commitment Contributed to Student Success**

The third conclusion relates to the connections that the students had with their respective faculty, whom they identified as helping them to pass the remedial mathematics course. More specifically, students described faculty attributes that they perceived as evidence of the faculty member’s commitment to their success. These attributes included altering their teaching styles to help them learn, committing their time, and providing feedback.

First, student participants in this study described how particular faculty generally taught the remedial mathematics course, and would then provide specifics on how the faculty member
would change his or her teaching style if students were struggling. The majority of the comments described how the faculty member would slow down his or her teaching and go step-by-step through problems. The step-by-step approach was best described by Joy, who said, “I like when she would just stop and go over it step-by-step so we could see each step and how to get that number to move to the next step.” This step-by-step method was mentioned by the majority of participants. Not only did they discuss the step-by-step method, they would describe how seeing each step helped them to better understand the material. While the majority of the students did not discuss their individual learning styles, it was clear they wanted and appreciated when the faculty adapted their teaching styles if necessary, and provide a visual of each step of an equation or math problem in order to solve for the correct answer.

It is noteworthy that the initial review of the literature did not capture how students’ best learned mathematics or how faculty flexibility in teaching style contributed to students’ success. However, after the students’ consistent descriptions of how learning math step-by-step was most helpful to students, the researcher conducted another a literature search. While the results were still limited and not specifically focused on remedial mathematics, one study was found.

Kay and Kletskin (2012) report on 288 first year students in a pre-calculus course at a small university in a metropolitan area. The study found that two-thirds of the students watched video podcasts because of the step-by-step video explanations. They further found that the video podcasts were liked by students not only because they helped them learn the math concepts and problems, but because they could be watched when and how they wanted to learn (Kay & Kletskin, 2012).

Faculty commitment to student success was also perceived as occurring when the faculty member would consistently provide opportunities or avenues through which students could get
additional help through a variety of resources. The faculty’s recommending additional resources or opportunities for obtaining help made them feel important. They also perceived the faculty’s commitment when faculty took time after class and/or during office hours to help them, even when they might be pressed for time. Several of the student participants specifically made statements similar to that of Joshua, who said, “She would take time off when she probably has to go, and try to help you understand the question.” Others had similar comments about how their professor would always stay late and help him or her understand the material.

The findings in this study related to students’ perceptions of faculty involvement and commitment are well supported in the literature. Finnigan (2009) and Manning et al. (2010) report that students have better learning experiences with better instructors. While the term better instructor is a broad term and was not defined in the literature, one could argue that involved faculty members whom students perceive as caring are the better faculty. According to Manning et al. (2010), not only do students perform better statistically, they expressed having better experiences in comprehending the knowledge when they perceived that the professor was an engaging, caring, and passionate instructor. Trigwell et al. (2013) expands on this and showed that students’ perceptions of quality teaching are directly related to their perceived experiences and more positive outcomes for students. In a more recent study, Kim and Sax (2018) found that students majoring in Science, Mathematics, Engineering, and Technology (STEM) fields in college have a much higher sense of self-concept in mathematics when there was a positive faculty-student relationship and support. Similarly, the findings of this study support the research from Finnigan (2009), Kim and Sax (2018), Manning et al. (2010), and Trigwell et al. (2013) because student participants in this study described ways that their professor demonstrated engagement and caring.
Faculty feedback was also perceived as evidence of faculty commitment. While the student participants did not specifically use the word feedback when they described their faculty member, they did allude to the importance of feedback when they described how they felt their professor cared about them when they would sit with them and go over the problems step-by-step and show them where they missed a step or did a step incorrectly that lead to the wrong answer. While feedback is not well documented in the literature as evidence of caring, its importance in improving students’ success is well documented (Dolmans et al., 2008; Wang, 2014). Dolmans et al. (2008) reported on 350 undergraduate medical students and found that when students received timely feedback, they believed their faculty was invested in their success. Wang (2000) reported on 55 undergraduate students and found that the qualitative data showed that students liked prompt feedback. Wang also added that the feedback results indicated that the quality of students learning experiences and the prompt and in-depth detail helped students better understand and apply the material. Faculty feedback in this study was also described as it related to how students benefited from learner-centered approaches in the remedial mathematics course.

**Conclusion Four: Learner-Centered Curricular Design of Remedial Mathematics**

**Benefited Students**

The fourth and final conclusion is one that students described in detail. The use of the required math lab that was part of the course and the online homework were described by students as beneficial. The learner-centered approach is one in which the student learns at his or her own pace and in a format that is best for each student (Brackenbury, 2012; Poon, 2013; Saulnier, Landry, Longenecker, & Wagner, 2008). While the students did not use the term
“learner-centered,” the term is one that is widely used and accepted in higher education by faculty and administration alike (Brackenbury, 2012; Poon, 2013; Wingert et al., 2014).

The majority of the student participants in this study commented on the fact that they wanted to attend the required three-hour lab session. While some commented in the beginning that they had no idea what the lab would be like or how it would be beneficial, every student commented on the benefit of the lab when it came to being able to pass the course. When asked what the students would do in the lab portion of the course, every answer differed. For example, Betty said, “We did group work when we had labs, so we’d have a partner, so like if I was confused, I mean, me and my partner would talk it through and help each other.” On the other hand, Roxanne said, “…it was just practice, practice, practice,” so she would open her PowerPoints and then her practice questions.

Students described the lab in a variety of ways; however, the majority of the descriptions centered on its flexibility and one-on-one time. It allowed them time to work with partners and ask questions of their faculty; work individually on specific problem sets and get the time with the faculty member alone; or it would be time in which the professor could go into more detail with specific problems which the traditional 50-minute class time did not allow. Each of these is an example of a learner-centered approach. The lab was clearly designed to meet the individual needs of the students in remedial mathematics.

The merits of the learner-centered approach are well documented in the literature (Brackenbury, 2012; Poon, 2013; Saulnier, Landry, Longenecker, & Wagner, 2008). Brackenbury (2012) reports that when students are actively involved in their own learning, or engaged in a learner-centered approach, have heightened learning experiences and achieve higher academic outcomes. The findings of the Brackenbury study relate to this study, because
students in this study described how when they were in the lab component of the course and were able to focus on the things they wanted to focus on and/or work with other students, they had a greater understanding of the material. They also reported that the lab and the flexibility of the lab were two of the reasons they passed the course. Many of the student participants described how they were not sure if they could have completed the course, like some of their peers, if they had not had the lab portion.

In an earlier study, Saulnier, Landry, Longenecker, and Wagner (2008) described the learner-center approach as one in which the faculty member is able to create “environments and experiences that bring students to discover and construct knowledge for themselves, to make students members of communities of learners that make discoveries and solve problems” (p. 170). Their study best captures what the required lab component of the course did for the students in this study. During the faculty focus group, similar comments were made by faculty in that they tried to create an environment that shifted the ownership of learning to the student, but at the same time provided an environment that encouraged students to discover and solve problems on their own or with their peers. Each of the faculty members believed that when students took the opportunity to discover and solve problems on their own in a controlled environment, they were more successful in passing the course. This finding is consistent with a learner-centered approach. The faculty comments in this study are supported by the findings of Rufatto et al. (2016), which showed that when faculty implemented learner-centered pedagogy in mathematics’ courses the students performed better academically. In fact, the study showed that there were fewer failing letter grades given by faculty for the courses that were taught with a learner-centered approach when compared to the same courses in which the approach was not used. The findings of this study also add to the literature that supports active learning. Active
learning, which is learner centered allows students to not only be responsible for their own
learning, but also allows them to shape their own learning experiences and develop the
confidence necessary to tackle more challenging material (Brackenbury, 2012; Poon, 2013;
Rufatto et al., 2016; Wingert et al., 2014).

Web-based online homework platforms, such as that used by the student participants in
this study, are another method used in a learner-centered curricular design, which has been
shown to be useful in remedial mathematics courses. In a study by Leong and Alexander (2014),
it was reported that the students who found the online homework to be beneficial or had more
positive experiences with the homework were students who had lower than average mathematics
achievements. The researchers suggest this was due to the instant feedback that was provided by
the web-based system when students submitted their answer (Leong & Alexander, 2014). The
availability of the web-based homework allowed the students to be in control of their time, and
when and how they wanted to access their homework, and gave instant feedback, all of which are
consistent with learner-centered learning (Leong & Alexander, 2014). These findings are
consistent with the findings of this study. Ann, for example, adds that, “At the end, it [on-line
homework] would show you what you got wrong and you can review and stuff.” Similarly, in an
earlier study, Koch, Slate, and Moore (2012) found that students in remedial courses who used
technology on their own, such as computer tutorials that provided instant feedback, gained more
confidence in learning the required mathematics skills. The findings of this study are consistent
with the findings of Leong and Alexander’s (2014) and Koch, Slate, and Moore’s (2012) studies
in which students who utilized online or web-based software programs for homework and
tutoring described them as helping them successfully pass the remedial mathematics course.
Self-Efficacy Connections

Self-efficacy was the theoretical framework used for this study. Self-efficacy is defined as the belief in one’s self to produce the required behaviors or actions needed to achieve specific outcomes (Bandura 1977, 1989, 1993). Self-efficacy, as a theory, has a focus on outcomes and/or performance expectations as defined by the individual. There are four main sources of self-efficacy that lead to the desired outcomes or expectations. The four sources of efficacy belief are performance accomplishments, vicarious experiences, verbal persuasion, and emotional arousal (Bandura, 1977). Early work with self-efficacy provided examples of what could be identified in each of the sources. Performance accomplishments can include grades and meeting goal expectations or outcomes (Bandura, 1977; Lent et al., 1991; Pajares & Miller, 1994). Role models could be an example of vicarious experiences (Hackett & Betz, 1989). The use of encouragement and support are supported for verbal persuasion (Hackett & Betz, 1989; Koch, Slate, & Moore, 2012), and emotional arousal is supported by interventions to reduce the anxiety levels associated with the subject material (Hackett, 1985; Hackett & Betz, 1989). In general, Bandura (1993) connected the students’ self-efficacy academically to their level of motivation and accomplishments.

The potential relationship of the findings and conclusions of this study to self-efficacy are readily apparent when examined within the context of the theory of self-efficacy, and the four sources of efficacy beliefs. While this was a qualitative case study, and self-efficacy was not objectively measured, it can be postulated that the factors and the conclusions that were drawn regarding the factors that contributed to students’ success are evidence of self-efficacy when compared to that in the literature. Each of the four sources of self-efficacy are described next
with support from the literature to demonstrate how conclusions of the findings in this study are related.

The first source of self-efficacy identified in the self-efficacy theory is performance accomplishments. Early literature reports that performance accomplishments include grades and meeting goal expectations or outcomes (Bandura, 1977; Lent et al., 1991; Pajares & Miller, 1994). A more recent study by Vuong, Brown-Welty, and Tracz (2010), with 1291 second year students at five different California State University campuses, found that students’ “persistence to maintain a grade point average that allows them to continue in their chosen program of study” also supports the self-efficacy theory (p. 60). The findings and conclusion of this research study’s example with performance accomplishments involves the students’ description of knowing what they needed to gain acceptance into the medical imaging or nursing programs and that they were determined to get the grade necessary to pass the course. Earlier, Bandura and Cervone (1983) found that goal setting and feedback were considered motivational to students and supported the self-efficacy theory. More specifically, they found that when students had a specific goal and could see the progress to meeting that goal, they had a significant increase in their self-efficacy. Later, Zimmerman, Bandura, and Martinez-Pons (1992) found that students with a higher sense of self-efficacy were found to set higher goals for themselves. They go further and state that students with a higher sense of self-efficacy set high goals for themselves and worked harder to achieve those goals. This could be said of this study as well, in which the students who were determined to gain acceptance into the career program of their choice (a high goal) were clear that they needed to pass the course to progress, and the goal of gaining acceptance became their primary focus.
Vicarious experiences, the second of the four sources, can include “seeing others perform threatening activities without adverse consequences, which can generate expectations in observers that they too will improve if they intensify and persist in their efforts” (Bandura, 1977, p.197). Di Tommaso (2012) found that the use of peer mentors is effective for students engaged in remedial mathematics and these mentors can be someone with whom the student can connect. In this research study, students often referred to friends who helped them with the math problems or peer tutors with whom they were connected, as role models. This perception allowed them to see that they too, could do these math problems. Earlier, Bandura (1983) found that students with high sense of self-efficacy responded differently to failures and were quicker to respond to these setbacks. Relating Bandura (1983) to the findings in this study and in particular, the second conclusion, students often commented that after their low grade on the first test in the remedial mathematics course, they quickly sought help through the tutoring center and ultimately improved their grades.

Verbal persuasion, the third source of self-efficacy as described by Bandura (1977) relates to the feedback. Bandura (1977) claimed that when students are “persuaded that they possess the capabilities to master a difficult situation and are provided with the provisional aids for effective action, they are likely to mobilize greater effort” (p. 198). Dolmans et al. (2008) reported that when undergraduate medical students received timely feedback from their faculty and there was a belief that the faculty was vested in their learning, there was a higher engagement from the students. Weinstein’s (2004) qualitative study not only supported verbal persuasion, also supported conclusion three in the findings in this study. Weinstein concluded that students perceived their professors’ style and quality of instruction as critical to their own sense of self-capabilities. In this research study, students’ perceptions about their faculty’s
support and belief in them helped them be successful. Expanding on this in a later study, Wang (2014), reported that students believed they knew the material better based on the faculty’s involvement in providing timely feedback, along with persuasion from that faculty. In this study, students commented on the fact that they benefited from having feedback from their faculty when they took the time to show them what they were missing or what they were getting correct. In addition to the feedback from faculty, students had access to the online homework, which also provided instant feedback, as well as the tutoring services from peers, tutors, and academic coaches. Related to this study, students felt that their faculty was supportive and committed to their passing the course when they provided them extra time outside of class, gave them feedback, modified their teaching styles, and provided them with additional resources, all of which are part of verbal persuasion.

The fourth and final source of self-efficacy is that of emotional arousal. Bandura (1977) suggested that finding coping strategies to reduce the levels of stressful, emotional arousal that can lower one’s belief in his or her ability, can “reduce avoidance behavior” (p. 199). Koch, Slate, and Moore (2012) also found that math labs and tutoring centers decreased students’ anxiety because it allowed them to see what they were doing right and how they could correct things which they did not understand or got wrong. While the authors did not directly connect this to emotional arousal, this is what Bandura (1977) was describing. This was supported in this study when students repeatedly described the benefits they received from the required math lab component and the services of the learning commons, which included tutoring and academic coaches. Those benefits were encouragement, seeing the problems solved by a step-by-step method, the ability to work with peers, and to learn at their pace. Many of the students
commented on the fact that the tutors and academic coaches helped them to remain calm and to see that they could get the right answers and pass the course.

As already mentioned, this study did not measure self-efficacy, however, the findings and conclusions are clearly supported by the literature on self-efficacy. A study that has already been mentioned, Koch, Slate, and Moore (2012), is one study that supports the majority of the sources in self-efficacy and the conclusions of this research study. They stated that students increased their own self-efficacy when they had positive academic experiences (performance accomplishments), faculty support (verbal persuasion), mathematical resources (emotional arousals) and goal setting. This research study supports the findings of Koch, Slate, and Moore (2012). Figure 5.1 makes clear, the connections between the findings of this study and the literature related to self-efficacy.
Figure 5.1

*Self-efficacy Sources in Relation to Findings of this Study and the Support from Literature.*

<table>
<thead>
<tr>
<th>Source</th>
<th>Findings from this Study</th>
<th>Literature Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Accomplishments</td>
<td></td>
<td>Hackett &amp; Betz, 1989</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Koch et al., 2012</td>
</tr>
<tr>
<td></td>
<td>Career Goals, Program</td>
<td>Lent et al., 1991</td>
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<tr>
<td></td>
<td>Entrance Requirements</td>
<td>Lopez &amp; Lent, 1992</td>
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<td></td>
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<td>Pajares &amp; Miller, 1994</td>
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<td></td>
<td></td>
<td>Vuong, Brown-Welty, &amp; Tracz, 2010</td>
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<td></td>
<td></td>
<td>Zimmerman, Bandura, &amp; Martinez-Pons (1992)</td>
</tr>
<tr>
<td>Vicarious Experience</td>
<td>Peer Support Tutors,</td>
<td>Bandura, 1983</td>
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<tr>
<td></td>
<td>Academic coaches</td>
<td>Di Tommaso, 2012</td>
</tr>
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<td></td>
<td></td>
<td>Hackett &amp; Betz, 1989</td>
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<tr>
<td>Verbal Persuasion</td>
<td></td>
<td>Hackett &amp; Betz, 1989</td>
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<td></td>
<td>Feedback Faculty Tutors,</td>
<td>Hall &amp; Ponton, 2005</td>
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<td></td>
<td>Academic coaches</td>
<td>Koch et al., 2012</td>
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<td>Spence &amp; Usher, 2007</td>
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<td>Wang, 2014</td>
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<td>Weinstein, 2004</td>
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<tr>
<td>Emotional Arousal</td>
<td>Math Lab Component Math</td>
<td>Hackett, 1985</td>
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<td></td>
<td>related support services</td>
<td>Hackett &amp; Betz, 1989</td>
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<td></td>
<td></td>
<td>Koch, Slate, &amp; Moore, 2012</td>
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<td></td>
<td></td>
<td>Lopez &amp; Lent, 1992</td>
</tr>
</tbody>
</table>

**Implications for Practice**

The findings and conclusions in this study have implications for the site of this research study and, in particular for me as a program director in the medical imaging program. Other institutions of higher education with similar student demographics and educational programs may also draw implications from the findings and conclusions of this study.
Implications for Researcher

There were two findings that were not a surprise to the researcher. These included the faculty commitment and the utilization of academic support services and resources. Both of these findings have been well supported in the literature. At the same time, this study revealed several surprising findings. These included the power of students having the self-awareness of the need for help (versus their being mandated to get additional help due to unsatisfactory performance), students’ participation in the required lab portion of the course (as the experience has been that students often complain about having a required 3-hour lab), and the high level of peer support. The high level of support was one that the students sought out for themselves, whether it was from friends in the course or friends who were not in the remedial course. What was even more impressive was the dominating role of the career-driven motivation, which could lead to additional opportunities for future research and will be discussed in the following section.

For myself as program director of the medical imaging program at the research site, there are several implications that can be drawn from this study. First, it might be beneficial to look at students using a holistic approach from the moment they enter the college versus waiting until they officially enter the professional program. Doing this could result in more opportunities for students to utilize the seven factors described in this study in order to progress into the program. My goal, as program director, is to ensure that the students coming into the college in the first year remain the cohort of students that matriculates into and graduates from the program. Prior to knowing these factors, it was difficult to identify what factors would assist students in remedial mathematics and therefore, in doing well in more of their prerequisite courses. In fact, as this study concludes, work is underway for the next incoming, first-year class. The college mathematics placement exam is in progress and decisions are being made as to which math
courses students should be placed. I have identified students who have expressed an interest in medical imaging and who have placed in remedial mathematics. I, along with two other staff members in the Learning Commons have been granted a co-curricular grant at the research site, to implement a learning community for the students who were placed in remedial mathematics and are interested in imaging. The objectives of this learning community, with support of the grant, will be to leverage the factors that students in this study identified as helping them successfully pass remedial mathematics. One of the faculty members, who was involved in the focus group of this study and about whom many of the student participants provided positive comments, will be the professor of the course. In addition to the remedial mathematics course, these students in the learning community will also be in the same first-year seminar (FYS) course, as well as the same biology course. These three classes together will create the learning community. In addition to this, myself as the program director and an identified academic coach will routinely meet with the students and will attempt to provide opportunities for students to have access to the findings in this study.

This study has additional future implications for both myself and the research site. One is to explore ways to possibly screen students for self-direction and career motivation. At the time of this study, there was not a mechanism to screen students for this; however, this study’s finding related to career-driven motivation provides an opportunity to examine tools or ways for such screening.

Implications for Research Site

Many of the incoming first-year students at this institution who have clear hopes and goals of entering either the medical imaging or nursing program do not have the required quantitative skills (as demonstrated on their college placement exams) and are thus placed in the
remedial mathematics course. Based on the findings of this study, there could be opportunities for faculty and administration to work together to leverage the factors that the student participants described as helping them to be successful in passing the remedial mathematics course. The start of the conversations with faculty, administration, and staff should be related to those areas which will be impacted by students taking the remedial mathematics course. The first discussion could focus on the possibility of screening students for self-direction and career motivation as already mentioned.

Another important implication that should be taken under consideration is a review of the faculty who are teaching the remedial mathematics courses in the fall. Based on the findings of this study, the professors who had a positive impact on the students are much valued, and described by the students as helping them successfully pass the remedial mathematics course. When students felt that their professor was committed to their success, there was a connection that students described as helping them pass the course. Allowing faculty the time to work with students in remedial math is also important. When the faculty are pushed for time to get to their next class or have too many students in one section, it could appear to students that they are not committed to their success. Allowing this extra time between classes or not having overloads could increase the time that faculty can spend with the students in remedial math, who need additional support with quantitative skills.

Another implication would be to make available more of the one-on-one support provided through the Learning Commons on the institution’s campus. The study found that the one-on-one support students received was described as a factor that helped them pass the course. However, it is important to note that there are financial constraints that must be considered with offering more one-on-one support. One way to address the cost is to facilitate peer-to-peer
support. Creating structured and inviting spaces, conducive to one-on-one peer support, as well as more flexible open/community times on campus could foster more peer support. The findings in this study demonstrated that the student participants valued their peers, when available.

A final implication from the findings of this study is to enhance and leverage the math lab and online homework. Student participants in this study valued the time they had in the lab. The value was in allowing the students to work in, and/or create an environment that helped them learn in their own way and allowed for one-on-one access and feedback from the faculty. The online homework provided instant feedback, something the students found extremely beneficial when working out math problems. Being able to see the step-by-step approach and where they went wrong, provided them the additional support they needed to pass the course.

**Implications for Other Institutions**

The findings of this study could also be of value to other institutions of higher education, all of which are under scrutiny from various organizations regarding their retention, graduation rates, and the cost of education. Admitting students into an educational institution also means providing resources as needed to help them be successful. For institutions of similar size, with multiple health science programs, the previous recommendations might be worthy of consideration. The increase in the number of first year college students needing remedial mathematics continues to be a concern in the United States, and will remain so in the near future.

Medical imaging and nursing programs garner huge interest from potential students for a variety of reasons, most of which relate to their having well defined career goals, and the strong possibility of employment upon graduation. In order to retain many of these potential students, an institution could utilize the findings of this study to develop or enhance the support services that the students in remedial mathematics described as being helpful. The implication for other
institutions is to not only have the necessary quantitative data on their students, such as the number of students needing remedial mathematics, but more qualitative data as well, such as who their students are and what will help them to be more successful in the course.

Institutions with a large number of underprepared students in mathematics should ensure that there are enough resources available to the students. This includes tutoring, academic coaches, online resources, and math labs. As already mentioned, this also incurs a financial risk; however, retaining students and increasing graduation rates is a beneficial return on investment (ROI). Not being able to provide resources could leave students feeling as if there is no help for them and that they are simply not able to keep up with college work and will subsequently leave that institution or college.

Along with resources, another key factor these students believed help them pass the course was faculty who were committed to their success. Institutions interested in increasing the success rate of remedial mathematics should consider whom they select to teach the course. Simply getting someone to teach the course may not mean the individual is the most committed to the topic or can invest the time and energy that is necessary in working with students who struggle with quantitative skills.

**Recommendations for Future Research**

This study’s findings revealed the factors that medical imaging and nursing students who were successful in passing a required remedial mathematics course described as contributing to their success. However, while the findings of this qualitative study might be helpful to the research site and to other academic institutions with similar student demographics, the study did have its limitations. These limitations have led to several recommendations for additional research. Limitations of this study include:
1. Participation in the study was voluntary, which could have resulted in the participation of only the highly motivated students.

2. The study population was limited in size (n=11) and the setting was limited to one institution and two programs of study. Thus, the findings might not reflect those of other students or programs of study.

3. The study only explored those factors that successful students described as helping them pass the course, it did not explore the challenges that students who did not pass the class experienced.

Therefore, based on the limitations and the findings of this study, recommendations for additional research should be considered:

1. This study explored the factors that students currently in the medical imaging or nursing programs described as helping them to be successful in the remedial mathematics course. However, there is an opportunity to explore the implications of these findings by examining the graduation rates of these students. This study only explored students who were accepted into the program of their choice and did not look at whether they successful graduated from the program of their choice.

2. This study was focused on students who had already been admitted into the medical imaging or nursing programs. Future research should explore students in other majors, both professional career programs and programs within the liberal arts. This might provide more generalized findings relevant to the factors which students describe as contributing to their success in remedial mathematics.

3. To explore the long-term success or not of the students needing remedial mathematics is to study a similar group of students from this study regarding certification board results
and potentially post-graduation work in the field. This may provide additional information related to the quantitative skills required for their careers and the knowledge they have about those skills.

4. Consideration for future research should also include students who were not successful in remedial mathematics or were not able to gain acceptance into a program with strict entrance requirements. Having an understanding of the differences between the two groups of students could either validate these findings or not, many of which were consistent with the literature related to student success factors.

5. This study was conducted at a small private college in New England. Future studies should occur at a mix of institutions including smaller state supported schools, large private and public colleges, and universities. Students’ select different types of institutions for a variety of reasons and exploring these factors across a variety of institutions and student demographics could provide additional useful information for students to be successful in remedial mathematics.

6. As much as the researcher guarded against the potential bias inherent in his role at this site, students and faculty did know the researcher, which could have had an impact on the students’ willingness to discuss their successes. A study conducted by a different researcher to determine if the findings are similar or different could be beneficial.

**Concluding Thoughts**

This study has provided insight into what students describe as helping them successfully pass a remedial mathematics course at this institution. The findings of the study did support similar findings from other studies in other subject areas. A better understanding of what the students at this institution found helpful allows the institution to build on these resources and
provide more opportunities for students to engage in activities such as peer tutoring and lab time, which were repeatedly described as contributing to their success. The study also highlights the importance of the faculty who teach remedial mathematics. It is important to find faculty who have a passion and commitment to helping students with basic mathematics.

A large percentage of each incoming class at this institution, and nationally, requires remedial coursework in mathematics. For a variety of reasons, it is important that once first-year students arrive on campus, the institution be able to support these students. These reasons range from supporting the students in reaching their goals, improving their pass rates so that they can matriculate into other courses and programs/majors of study, and improving the institutions’ retention and graduation rates.

Career programs such as those in medical imaging and nursing rely on foundation courses such as mathematics to prepare students for the professional programs. Mathematics, like the sciences, is considered high stakes because certain grades must be achieved in order to progress. Providing students, the resources they need, and addressing the factors described here, might allow more of them to be successful in remedial mathematics, and facilitate their matriculation into their program of choice.

Finally, as the researcher for this study, I have been able to generate evidence to support changes at the college that were in process at the conclusion of this study. I now recognize the value and the significance of research in providing the evidence that is necessary to solve a problem of practice or answer a question, when evidence can’t be found in the literature, or the setting changes. As a scholar-practitioner, in conducting this study, I have also gained the skills and knowledge required to identify a problem of practice, develop the methodology to study the
problem, and most important, report my findings and conclusions within the context of the literature.
References


APPENDIX A: INFORMED CONSENT

Signed Informed Consent Document

| Northeastern University, College of Professional Studies |
| Name of Investigator(s): Elisabeth E. Bennett, PhD and David Gilmore |
| Title of Project: Exploring Student Success Factors in a Remedial Mathematics Course: A Qualitative Study of Medical Imaging and Nursing Students at a Small, Private College |

| Informed Consent to Participate in a Research Study |
| We are inviting you to take part in a research study. This form will tell you about the study, but the student researcher will explain it to you first. You may ask this person any questions that you have. When you are ready to make a decision, you may tell the student researcher if you want to participate or not. You do not have to participate if you do not want to. Your decision will not affect your status here at the college regardless if you decide to participate or not. If you decide to participate, the student researcher will ask you to sign this statement and will give you a copy to keep. |

| Why am I being asked to take part in this research study? |
| You are being asked to be in a research study of QR 101A (Remedial Mathematics) and your success in that course. You were selected to be in this study because were required to take QR 101A your first semester here at the college and successfully passed the course and you gained acceptance into your program of study. You are not eligible to participate if you are no longer in the medical imaging or nursing program. Please ask any questions you may have before you agree to be in the study. |

| Why is this research study being done? |
| The student researcher is a doctoral student at Northeastern University completing his dissertation. The purpose of this study is to explore the elements that you believed helped you pass QR 101A and move forward into other math and science courses. |

| What will I be asked to do? |
| If you decide to take part in this study, we will ask you to participate in a one-hour interview with the student researcher. During the interview, the student researcher will ask questions to you in which you can answer them anyway you wish. If there are questions you do not wish to answer, just say that you do not wish to answer. The student researcher will record the interview to ensure he captures your responses correctly; however, no identifiable information will be recorded. After the study is complete, the student researcher may provide you with the interpretation of the interview to determine if it is accurate and reflects your answers and thoughts. |

| Where will this take place and how much of my time will it take? |
| You will be interviewed in a private place on the Regis campus that you select to protect your privacy. The interview will take approximately one hour. |

| Will there be any risk or discomfort to me? |
| The study has no expected risks. If there are any questions asked that you are not comfortable answering, you do not have to answer the question(s) and the student researcher will move to the next question. |

| Will I benefit by being in this research? |
There are no direct benefits to you in this study. However, the information learned in this study may assist additional students in the future to pass the QR 101A course and be accepted into the program of their choice—medical imaging or nursing programs.

**Who will see the information about me?**

Your part in this study will be confidential. Only the researchers on this study will see the information about you. No reports or publications will use information that can identify you in any way or any individual as being of this project.

The records of this study will be kept private. Research records will be kept in an electronic format that will be coded and secured using a password-protected file. Only the researchers will have access to the study records and the recorded transcripts. The written records will be destroyed (deleted electronically from all storage spaces) once the study is completed and submitted as a written document and approved for publication except for the consent forms, which will be kept for three (3) years. The audiotapes and transcripts may be kept, but do not identify you in any way. Responses from the transcriptions are anonymous when the researcher is identifying information about who wrote them. A list of the participants will be kept and identified with a pseudonym name. This information will also be protected electronically and stored similar to the transcripts; however, this information will not be part of the data analysis. No published reports will include any information that will make it possible to identify you.

**What will happen if I suffer any harm from this research?**

This study does not have any expected risks.

**Can I stop my participation in this study?**

Your participation in this research is completely voluntary. You do not have to participate if you do not wish to do so and you can refuse to answer any question(s). Even if you begin the study, you may quit at any time, until the data is entered into the research record. Again, you are not identifiable as you are given a pseudonym name. If you do not participate or if you decide to quit, you will not lose any rights, benefits, or services that you would otherwise have as a student at Regis College. There is no impact on your academic status.

**Who can I contact if I have questions or problems?**

If you have any questions about this study, please feel free to contact David Gilmore, the person mainly responsible for the research, at gilmore.c@husky.neu.edu or 617-312-1402. You can also contact Dr. Elisabeth E. Bennett, the Principal Investigator, at el.bennett@neu.edu or 617-390-4335.

**Who can I contact about my rights as a participant?**

If you have any questions about your rights in this research, you may contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

**Will I be paid for my participation?**

There is no payment for being in this research study.

**Will it cost me anything to participate?**

There is no cost to you for being in this research study.

**Is there anything else I need to know?**

There is no additional information for this study that has not already been explained above.

**I agree to take part in this research.**
Signature of person agreeing to take part

Date

Printed name of person above

Signature of person who explained the study to the participant above and obtained consent

Date

Printed name of person above
APPENDIX B: CALL FOR PARTICIPATION LETTER

Dear _____________________________:

Congratulations on your progression in the medical imaging or nursing program. I am inviting you to participate in a research study that I am conducting to gain insight into the factors that contributed to the successful completion of QR 101A (Quantitative Reasoning with Lab) of medical imaging and nursing students. In order to participate, you must:

- Have completed QR 101A (Quantitative Reasoning with Lab) during your first year at this college.
- Have progressed to the second year at XXX College and in your first or second year in either the medical imaging or nursing program.
- Be able to recall your experience(s) in QR 101A (Quantitative Reasoning with Lab).

This study consists of a face-to-face interview will be no longer than 60 minutes with the possibility of a follow up face-to-face interview if information needs to be clarified. The study is completely voluntary and confidentiality will be maintained. If you are interested in participating in the study, please email me at gilmore.c@husky.neu.edu. I will send you a link to the survey.

Sincerely,

David Gilmore
Student Researcher
gilmore.c@husky.neu.edu
APPENDIX C: UNSIGNED CONSENT FOR WEBBASED SURVEYS AND SURVEY MONKEY QUESTIONS

UNSIGNED CONSENT DOCUMENT FOR WEB-BASED ONLINE SURVEYS

45 CFR 46.117(c) In certain instances, an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects. In cases in which the documentation requirement is waived, the IRB may require the investigator to provide subjects with a written statement regarding the research. Only the IRB can waive or modify the consent process. Researchers are not authorized to make this decision. Please modify the following information as necessary.

Northeastern University, College of Professional Studies
Name of Investigator(s): Elisabeth E. Bennett, PhD and David Gilmore
Title of Project: Exploring Student Success Factors in a Remedial Mathematics Course: A Qualitative Study of Medical Imaging and Nursing Students at a Small, Private College

Request to Participate in Research
We would like to invite you to participate in a web-based online survey. The survey is part of a research study whose purpose is explore the factors that helped you pass QR 101A and to enter either the medical imaging or nursing program. This survey should take about 20 minutes to complete.

We are asking you to participate in this study because you passed the QR 101A course and gained acceptance into the medical imaging or nursing program. You must be at least 18 years old to take this survey.

The decision to participate in this research project is voluntary. You do not have to participate and you can refuse to answer any question. Even if you begin the web-based online survey, you can stop at any time.

There are no foreseeable risks or discomforts to you for taking part in this study.

There are no direct benefits to you from participating in this study. However, your responses may help us learn more about what may help more students successfully pass the QR 101A course.

You will not be paid for your participation in this study.

Your part in this study is anonymous to the researcher(s). However, because of the nature of web based surveys, it is possible that respondents could be identified by the IP address or other electronic record associated with the response. Neither the researcher nor anyone involved with this survey will be capturing those data. Any reports or publications based on this research will use only group data and will not identify you or any individual as being affiliated with this project.

If you have any questions regarding electronic privacy, please feel free to contact Mark Nardone, NU’s Director of Information Security via phone at 617-373-7901, or via email at privacy@neu.edu.

If you have any questions about this study, please feel free to contact David Gilmore, the person mainly responsible for the research, at gilmore.c@husky.neu.edu or 617-312-1402. You can also contact Dr. Elisabeth Bennett, the Principal Investigator, at el.bennett@neu.edu or 617-390-4335.

If you have any questions regarding your rights as a research participant, please contact Nan C. Regina, Director, Human Subject Research Protection, 960 Renaissance Park, Northeastern University, Boston, MA 02115. Tel: 617.373.4588, Email: n.regina@neu.edu. You may call anonymously if you wish.

By clicking on the survey link below you are indicating that you consent to participate in this study. Please print out a copy of this consent form for your records.

http://___ (this will be the survey link generated from Survey Monkey). Questions are found in the attached documents.
Thank you for your time.
David Gilmore
Doctoral Student, Northeastern University

SURVEY MONKEY QUESTIONS:

1. Please enter your name so that the researcher may be able to reach out to you via the college email.

_______________________________________________

2. Did you take QR 101A (Quantitative Reasoning with Lab) your first year here at this college?
   __ YES
   __ NO

3. Did you pass QR 101A (Quantitative Reasoning with Lab) the first time you took the course?
   __ YES
   __ NO

4. Which program are you in?
   __ Medical Imaging
   __ Nuclear Medicine
   __ Radiography
   __ Ultrasound
   __ Nursing

5. Can you recall specific details about the QR 101A (Quantitative Reasoning with Lab) course?
   __ YES
   __ NO

   IF you answered YES, please provide some of the specific details.

6. Can you provide a short description of your experience in the QR 101A (Quantitative Reasoning with Lab) course?

Thank you for completing the survey. The researcher will contact you about your eligibility for the study.
APPENDIX D: INTERVIEW OUTLINE AND QUESTIONS

DATE: ______________________________

LOCATION: ______________________________

INTERVIEWEE: ______________________________

Introduction

The purpose of this interview is to gain a better understanding of how you would describe your successfully completion of QR 101A (Quantitative Reasoning with Lab). You have been selected based on three criteria. The criteria are that you successfully passed QR 101A (Quantitative Reasoning with Lab), you were able to progress to your second year here at the college and in the first year of the program in either the medical imaging or nursing program, and you completed the survey monkey questionnaire and meet the qualifications to be in the study. I am interested in what you believed helped you successfully pass QR 101A. There are no right or wrong answers and feel free to express any idea or though you have about the course. I will be recording our interview so that I may transcribe the answers. I will share that information with you for accuracy.

Interview Questions

1. Tell me about your experience with math prior to college? Tell me anything you would like about math prior to college. Did you like it? Why or why not?

2. What did you want to major in when you got to college? Why? What did you think the job (i.e. medical imaging or nursing) entailed?
3. So, fast forward. You got to college and you passed the QR 101A course. Tell me about this class. This can be anything you remember. You can even describe how you felt in the course. You can discuss anything from the faculty member to homework to tests.

4. What helped you pass the class (QR 101A)?

5. Tell me a story about a barrier to success in the course and how you overcame it.

6. What is your experience with math now (after QR 101A)?

   Extra questions if the participant can’t think of answers/comments: Maybe you can include things like how do you study? When do you study? If the material is new and you have never seen it before, how do you study for that versus material you have seen before?

7. What are your own beliefs in your ability to do math now?

8. What advice would you have for students who are just starting to take the class now?

9. Do you have any other thoughts, ideas, or talking points about QR 101A that you believe I did not ask you about and which you would like to share?

At the conclusion of this study, I will share my interpretation of this interview with you to review and determine if it captured your answers and thoughts accurately. Thank you for your time!
Dear _____________________:

I am inviting you to participate in a research study that I am conducting as part of my doctoral program to gain insight into the factors that contribute to the successful completion of QR 101A (Quantitative Reasoning with Lab) of first year medical imaging and nursing students.

As a faculty member of QR 101A, I would be interested in gaining your insight into what you believe successful students do in your remedial mathematics class to succeed; and what, if any, positive or negative impacts they report as a result of their being in your remedial mathematics course.

This study consists of a small focus group session with the faculty who teach QR 101A that will be no longer than 60 minutes.

The study is completely voluntary and confidentiality will be maintained. If you are interested in participating in the study, please email me at gilmore.c@husky.neu.edu with your interest. Once I hear from the group of interested faculty members, I will schedule a time that is convenient to all and find a place that is private in the STEM department, such as a conference room.

Sincerely,

David Gilmore
Doctoral Student, Northeastern University
gilmore.c@husky.neu.edu
APPENDIX F: FOCUS GROUP OUTLINE QUESTIONS

DATE: ______________________________

LOCATION: ______________________________

Introduction

The purpose of this focus group is to gain a better understanding of how you, as faculty members of remedial math describe students who successfully complete QR 101A (Quantitative Reasoning with Lab). As a group, I would like to understand your experience with the students who are required to take the remedial mathematics course. Your answers, as faculty, are another source of data that I can use in my research study as a doctoral student in determining what are the factors that help students be successful in passing the remedial mathematics and able to move into either the medical imaging or nursing program.

Focus Group Questions

1. I’m interested in what you observe about students in QR 101A. Based on your observations of these students, how would you describe them?

   Probing: Are they the same as other students? If they differ, how so? Tell me how you teach your QR 101A class. What does a typical in-class day look like? What activities do you include? Is there outside classroom work and if so, can you describe it for me? Are there any tools you use either inside or outside of the classroom to help with learning mathematics?

2. Do you vary your teaching methods to help students who might have barriers to learning math? If so, how?
3. How do you think the students approach QR 101A regarding their learning? Do you mean: How do you think students approach their learning in QR 101A?

4. What do you see the successful students doing that the non-successful students are not doing?

5. What do you think contributes to some students passing QR 101A, and to others not passing?

6. Do you have any other thoughts, ideas, or things you would like to say about QR 101A that you believe I haven’t asked about, and which you would like to share?

   Thank you so much for taking the time to discuss QR 101A with me and your colleagues. I will be sharing my interpretation of this focus group session with you so that you can validate that I documented and captured your thoughts and observations correctly. I would appreciate your feedback and comments on the document that I send you. Your feedback will help to assure the trustworthiness of my data. Thank you for your time!