COURSE PLACEMENT, COURSE MODALITY, AND STUDENT SUCCESS: DEVELOPMENTAL MATHEMATICS AT A PUBLIC TWO-YEAR COLLEGE IN THE NORTHEAST

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by

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DEDICATION

I must begin by thanking my husband for supporting all my crazy ideas, including buying a 150-year-old home to renovate and traveling abroad for two weeks, just to see what else the world has to offer. Most importantly, I am grateful for his understanding that this degree was my long-time goal, once I began college. You are my best friend.

ABSTRACT

Counterman, Celisa Y., Course Placement, Course Modality, and Student Success: Developmental Mathematics at a Public Two-Year College in the Northeast. Doctor of Education (Developmental Education Administration), August 2020, Sam Houston State University, Huntsville, Texas.

Changing how we present information to students has been standard discourse from as early as the 5th century BC, when Quintilian stated that teachers needed to reach students with different learning styles at different points in their education (Corno, 2008). There are varied methods for reaching students with learning disabilities, language or cultural differences, and content-related struggles, but no singular method has proven to be the "best" choice for all learners. This research study examined archival data of developmental mathematics students from fall 2015 through spring 2019 at Northampton Community College (N.C.C.).

Purpose

The purposes of this journal-ready dissertation were to look for differences in student success and persistence in developmental mathematics based on three factors: placement, students' perceptions of their motivation and anxiety, and the course modality they chose. The first purpose was to analyze the success and persistence of students in mathematics, based on the college's placement policy of utilizing high school transcripts and ACCUPLACER exam. The second purpose was to determine if developmental students' perceptions of their motivation and anxiety levels impacted their final course grade or persistence in mathematics at the college. Finally, the third purpose was to examine the differences between final exam grades, final course grades, and persistence to the next mathematics courses at the college, based on developmental mathematics course modality. The first and third research study involved an analysis of four years of data from a suburban community college in Northeastern Pennsylvania. The second study involved the survey of developmental mathematics students in the spring of 2019.

Method

This study was a causal-comparative research design using archival data from Northampton Community College Institutional Review Board for fall 2015 through spring 2019 school years. Statistical data were analyzed to determine whether differences existed in final exams, final course grades, persistence in mathematics, and motivation and anxiety levels for students enrolled in developmental mathematics in either emporium, face-to-face, or online courses during this timeframe.

Findings

In the first study, chi-square analysis revealed that placement by high school transcripts appeared to result in higher success and persistence in mathematics for students. The second study examined how students' perceptions of their intrinsic and extrinsic motivation and anxiety levels affected their course grades in these courses, based on their modality using MANOVA and *t*-test analysis. Regardless of student success or course modality, students who responded to the survey were more worried and extrinsically motivated than had negative affection reactions (NAR) or were intrinsically motivated. In the third study, chi-square analysis revealed that, overall, students in emporium and face-to-face courses performed equally as well, but online students struggled more with final course grades and persistence in mathematics at the college. The conclusion of this journal-style dissertation includes connections with literature and theoretical frameworks and suggestions for practice and future research.

KEYWORDS: Developmental math, Online courses, Redesigning math, Face-to-face mathematics, Emporium model, Persistence, Anxiety, Motivation

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CHAPTER I: INTRODUCTION

Students who attend community college face many challenges and often have no goal in mind for their future (Rose, 2012). Of the more than 10 million community-college students, the majority are "from low- to modest-income backgrounds" with some students living in poverty (Rose, 2012, p. 9). Many incoming community-college students do not have the academic skills needed for them to succeed in college, particularly in mathematics courses. Thus, they have been required to complete remedial education courses (Schak, Metzger, Bass, McCann, & English, 2017), designed to focus on specific academic skills deficiencies in order to effectively prepare students for more rigorous college-level courses. (Arendale, 2005). Sometimes educators refer to developmental education as remedial education. Regardless of what it is called, finding ways to remediate students' academics in more efficient, substantive ways has been, and continues to be a challenge, particularly, in mathematics courses where failure rates continue to remain high. Developmental education has often been associated with the idea of a more comprehensive model for learning rather than focusing on a specific topic or subject (Arendale, 2005).

Enrollment numbers in developmental education courses have been higher at community colleges than at universities, and more students have needed remediation in mathematics than in English and writing (Schak et al., 2017). Low completion rates in remedial mathematics and subsequent college-level mathematics courses at community colleges require the need for more large-scale comprehensive studies in developmental mathematics, which have been sparse in the literature. Bahr (2007) conducted a large-scale study and found that only one of every four students successfully completed both their remedial and first college-level mathematics course.

In community-college mathematics classrooms, teachers have predominantly utilized lecture as their primary teaching method. (Mesa, Celis, & Lande, 2014). Low success rates, along with students being required to often complete several developmental mathematics courses, has led post-secondary educators and policymakers to search for new ways to modify their existing programs. The desire is to decrease the costs of serving underprepared students while increasing the success rates at the institution (Lucas & McCormick, 2007). For many colleges, courses have been redesigned and implemented in multiple delivery modes to increase the success of students in these courses while decreasing the costs associated with them (Twigg, 2003).

Traditionally, in mathematics, developmental education has been divided into multiple courses, which serve as pre-requisites for gateway courses such as college algebra and statistics. The traditional sequence of developmental mathematics courses seems to hinder the ability of students to complete their college-level course because of high failure rates and requirement of additional semesters to enter them (Bailey, Jeong, & Cho, 2010; Edgecombe, 2011). A challenge of traditional lectures has been that students often work alone, at home, on problems, potentially on a computer-aided system, with little to no interaction with instructors. Historically, students have been further limited in developing critical thinking, problem-solving, and reasoning skills as they follow the procedural steps demonstrated in class using memory strategies (Patterson & Sallee, 1986; Teeguarden, 2013), albeit a push for a change has occurred within the mathematics education community.

The community college in this study instituted a multitude of changes in their developmental mathematics programs, such as supplemental instruction (in-class tutors to aide in instruction), hybrid courses (courses meet face-to-face one day a week and students worked independently the other day), and eventually, moving some of the mathematics courses to on online-delivery format. In fall 2015, the college added emporium style courses to speed up student progress through developmental mathematics and increase both success and retention. For the emporium model at the community college in this study, students worked on the computer with an instructor in the classroom to assist in their learning. In these classrooms, there were also one to two professional or student tutors to assist with learning.

One might argue that there are similarities between the emporium model at this college and K-8 education in the 1800s farming communities. In the 1800s, a one-room schoolhouse focused teaching in mathematics, reading, and writing on what students had on hand at home. Most children could read prior to entering formal education in New England, having learned the necessary skills from their mothers (Peterson, 1983). Skills were refined based on a family's expectations about their child's future occupation, and students learned concepts with their peers at their own pace. Because of a large age discrepancy in the classroom, the teacher served as more of a coach or facilitator than a professor of knowledge. Today's emporium model works much the same way. The main difference is that in emporium courses, many students may have seen the materials before and simply need a refresher or to relearn a subset of the materials.

Today, students' future expectations drive the coursework that students complete, although a core set of courses are required for all degrees. Even though post-secondary educators today seek to limit the range of academic skills in a course through placement criteria, similar to the 1800s, developmental mathematics classrooms include a diverse level of academic skills and socio-cognitive beliefs (Boylan, 1995; Boylan, Bonham, & Bliss, 1994; Saxon, Sullivan, Boylan, & Forrest, 2005). With developmental education, what seems to work best for multiple learning challenges has been a varied instructional program to reach as many students as possible (Boylan, 2002).

Conceptual Framework

Tinto's Model of Student Resistance and Engagement Retention

All colleges strive to decrease attrition rates while, simultaneously, increasing degree completion rates (Draper, 2008). Higher rates of attrition are not just for the fiscal responsibility of the college, but also serve as a symbol of failure for these institutions. While colleges strive to increase retention rates and student success rates, many students in higher education choose to leave college before completion for a variety of reasons, including failures, family challenges, employment issues, and socioeconomic factors. Tinto's theory of retention has been a commonly referenced source (Aljohani, 2016; Karp, Hughes, & O'Gara, 2008; Tinto, 1975, 1993, 1997, 2005) and focuses on the integration of academic and social networks. Tinto's (1975) model theorized that the integration of students into their college community through interaction with faculty members, staff members, and other peers would increase the likelihood that students would persist in their coursework and completed their degree as compared to students who make no connections. Students' reasons for departing college present challenges that have been difficult for colleges. The importance of integrating students into their academic courses, as well as, into social groups on campus has administrators and researchers searching for an effective formula to guarantee engagement and, consequently, increase persistence and retention rates.

Attrition is related not just to the formal and informal academic experience that a student has but is also related to the student's social integration while on campus. In 2016, Vincent Tinto clarified the difference between a student's desire to persist to a degree, regardless of the institution, while institutions focus on student retention regardless of the degree. Over the last 40 years, Tinto's own model of student integration has evolved to include student motivation and goal commitments (Demetriou & Schmitz-Sciborski, 2011).

Tinto (2002) claimed that five factors can increase the persistence of students at a college: (a) expectation, (b) advice, (c) support, (d) involvement, and (e) learning. Expectations need to be clear, not just from the college staff, but from faculty members, as well. Students who understand the expectations and requirements of a course, will be more likely to persist and graduate. Setting goals and receiving solid advice about courses and degree programs is another key to helping students achieve success and persist. At the community college in this study, Success Navigators (advising faculty who work with students in specific disciplines) were implemented in fall 2018 to facilitate the guidance of students through registration and placement into degree programs and courses. These Success Navigators used Guided Pathways, beginning in fall 2018, to direct students into specific general education courses for each program of study. Faculty members began using Starfish, a computer program designed to flag potentially failing students, for further outreach by the Success Navigators. This network of faculty and staff helped students integrate into the college campus and obtain academic and social support, while giving them information about college and local resources to increase their persistence and retention.

Student integration with a college campus can occur in one of two ways: social and academic (Karp et al., 2008). Students integrate into the college, socially, by forming relationships and connections outside of the classroom. Initially, students integrate, intellectually, into academics by attending classes. Class attendance has been identified as a predictor of course grade in developmental classrooms (Albert, Zientek, & Manage, 2018; Zientek, Ozel, Fong, & Griffin, 2013). Tinto (1993, 1997, 2005) noted that colleges encourage integration, both formally and informally, to increase persistence. Integrating socially and academically on college campuses has been inherently easier with resident populations than with commuter populations; however, community colleges can encourage the integration of commuter students (Tinto, 1993).

Socio-Cognitive Factors: Mathematics Self-Efficacy

In addition to students who struggle to integrate into their college campus, many students often experience additional struggles with motivation, attendance, attitudes, confidence, and anxiety as numerous research studies report (Andrews & Brown, 2015; Ashcraft, 2002; Benken, Ramirez, LI, & Wetendorf, 2015). Zientek, Schneider, & Onwuegbuzie (2014) found that dispositional factors were one of three themes that developmental mathematics faculty members believed hindered student success, including motivation levels, attitudes, confidence/self-esteem, and mathematics anxiety. Across multiple studies and samples, researchers have found that self-efficacy is an important predictor of mathematical achievement (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1994; Zientek & Thompson, 2010).

Bandura (1986) broadly defined self-efficacy as an individuals' confidence in their ability to succeed. Mathematics self-efficacy pertains to the confidence to succeed in mathematics.

Bandura (1997) hypothesized that mathematics anxiety could be reduced by addressing self-efficacy. Developmental mathematics students at community colleges, on average, manifest levels of mathematics anxiety that are higher than the general adult population (Zientek, Yetkiner, & Thompson, 2010). Mathematics anxiety is a physiological state, the latter of which is a source of self-efficacy. The other three sources are social persuasions, vicarious experiences, and mastery experiences (Usher & Pajares, 2009). Thus, the research on self-efficacy also supports the need to cultivate classroom experiences that address non-cognitive factors.

Changes in Developmental Mathematics

Remediation at the post-secondary level has been an area of substantial "controversy on educational policy agendas, and a subject of increasing focus among researchers" (Bahr, 2007, p.1). The interest in determining how to move students to and through the developmental mathematics sequence has led to legislative policies (Park, Woods, Hu, Jones, & Tandberg, 2018; Rodriguez, 2014; Whinnery, 2018), the creation of alternative curricular pathways (Rutschow, Diamond, & Serna-Wallender, 2017) and changes in institutional degree requirements (Joselow, 2016; Long & Boatman, 2013). In 2017, 25 states introduced legislation to reform, amend, or assess developmental education (Whinnery, 2018). Systems, such as those in Florida, are looking to remove developmental mathematics from the curriculum (Hu, Park, Wood, Richards, Tandberg, & Jones, 2016). In June 2017, "Texas Governor Greg Abbott signed into law the use of corequisite remediation as the model for students in developmental education courses" (Smith, 2017, July 12, p. 1). Recently, Michigan State University and Wayne State University dropped college algebra from their general education requirements and replaced it with mathematics quantitative literacy courses (Joselow, 2016), which is an example of what is sometimes referred to as an alternative pathway. The American Mathematical Association of Two-Year Colleges (2014) further supported the creation of alternative pathways by adopting the position statement "The Appropriate Use of Intermediate Algebra as a Prerequisite Course" which reads as follows:

> WHEREAS, The prerequisites of a mathematics course should be those appropriate to providing a foundation for student success in that course;
>
> WHEREAS, The course description and learning outcomes of a mathematics course determine the level of mathematical literacy, skills, and knowledge necessary for successful completion of the course;
>
> WHEREAS, The equivalent content in intermediate algebra courses is generally required to master the content of algebra-based courses that lead to calculus;
>
> WHEREAS, The equivalent content in intermediate algebra courses is not required to master the content for most college-level mathematics courses that do not lead to calculus;
>
> NOW, THEREFORE, It is the position of AMATYC that:
>
> Prerequisite courses other than intermediate algebra can adequately prepare students for courses of study that do not lead to calculus. (p. 1)

While the position statement was specific to Intermediate Algebra, the first two statements could transfer to all mathematics courses. Regardless of the curricular pathway, policy decisions made by institutions and state policymakers must address the academic needs of the approximately 60% of students who historically have tested into developmental mathematics every year (Bailey & Cho, 2010).

The costs for remediation have also been of concern. Some experts place the national costs of remedial education at one to two billion dollars, annually. (Bahr, 2007). To reach these diverse and underprepared students, more mathematics departments must provide instructional-delivery models beyond the traditional face-to-face models. With the introduction of a new learning environment, the review process should be iterative and consist of empirically testing the effectiveness in seeking ways for improvement. Two non-traditional environments discussed in this study are the emporium and online-teaching models, designed to increase student success and persistence.

Characteristics of Developmental Students

Typically, students in developmental mathematics courses must improve their academic skills. Chen and Simone (2016) tracked remedial course-taking practices of students over a six-year period. The nationally represented sample consisted of students who enrolled in higher education in 2003-04. They found that the highest enrollment rates were in mathematics courses. Bailey, Jaggars, and Jenkins (2015) found that the majority incoming community-college students (approximately 67%) arrive unprepared for their college's standards of college readiness. In addition to high enrollment numbers in remedial courses, completion rates have been low and failure rates high. Of the students who required remediation in mathematics, 49% of students at public two-year colleges completed all required courses, with 35% completing some and 16% completing no courses (Chen & Simone, 2016, p. 22). Of the students who required remediation in mathematics at public four-year colleges, 59% completed all their required remedial coursework, with 25% completing some and 15% completing no courses (Chen & Simone, 2016, p. 23).

Attewell, Lavin, Domina, & Levey (2016) conducted a longitudinal study from a national sample that followed students from 8th grade. However, their sample did not include non-traditional students (those who do not come right after high school) and was "representative of a single nationwide cohort of high school students who went on to college during the roughly 8 years following high school" (Attewell, 2006, p. 893). Attewell (2006) found that lower-economic students needed remediation at rates around 52%, with the majority of Black (66%) and Hispanic (53%) students needing more remediation than those who identified as White (36%). Both Attewell et al. (2016) and Chen and Simone (2016) found evidence that first-generation students typically needed more developmental courses than non-first-generation students. They also found that returning adult students, typically, needed more developmental courses than students who were under the age of 24.

Students taking developmental mathematics courses have tended to fit into one of three categories: (a) returning adults, away from formal education for more than five years, (b) students with significant K-12 placement in special education courses, and (c) students who were recent high school graduates less than 24 years of age (Krzemien, 2004). Students in the first group have generally tended to exhibit higher levels of anxiety due to being away from formal education for so long, but they have also beenwere far more motivated to succeed. (Meeks, 1989). Regardless of the group a student belongs, in general, developmental mathematics students tend to have mathematics anxiety at a level higher than the general adult population (Zientek, Yetkiner, & Thompson, 2010). This study will investigate course modality, placement, and student perceptions of motivation and anxiety as they pertain to student success and persistence for a population of developmental mathematics students.

Setting

This study was conducted at Northampton Community College (N.C.C.), which began in 1967 in Bethlehem, Pennsylvania. N.C.C. is in Northeastern Pennsylvania, a commonwealth state, which means that all 14 community colleges have an individual board of trustees who govern their campuses. Funding for each of the 14 community colleges comes through local support, as well as, through tuition and state funding. The sponsoring areas, therefore, determine the program course offerings and needs of the community. Community colleges in Pennsylvania offer the bulk of remedial education, workforce development, and public safety training for the state (Pennsylvania Department of Education, 2018).

Northampton Community College is a public, two-year college with specialized diplomas, community education and workforce development programs, and over 70 associate degree programs. Northampton Community College has served the Lehigh Valley community since 1967 and the Monroe County community since 1988. The first class was comprised of 846 students, specialized mostly, in career and transfer degree options (Northampton Community College, n.d.).

The college's student population has been diverse. The Lehigh Valley campus in Bethlehem is surrounded by several four-year private and public colleges and an additional community college in the region. The student population was and continues to be a diverse mix of ethnic and racial groups, including White, Black, Hispanic, and those of Eastern European and Caribbean descent. Students at the Bethlehem campus were a mix of on-campus residential, international, and commuter students. There were some international students, but most of them attended the main campus of the college due to a lack of housing. Public transportation for areas surrounding the Bethlehem campus has been more reliable and varied and has included bus, taxi, shuttle, and walking.

The population on the Bethlehem or Main Campus has been different from the Monroe Campus. The Pennsylvania region of the Poconos in Monroe County has been home to thousands of residents who commute to New York City, daily, which is about an hour and a half away. Because N.C.C. is a community college, most of the student population lives off-campus in communities or developments. Students at the Monroe campus can only commute via car, bus, or taxi as there are no other modes of transportation available. The students served in the developmental mathematics courses are indicative of the student population on the Pocono campus. According to DataUSA (2016), approximately 50% of people living in Mount Pocono, Monroe County, considered themselves White, while approximately 28% were Black and 19% were Latino. This data mimics the Monroe Campus data with approximately 50% identifying as White, 19% Black, and 23% Latino. A fall 2017 student enrollment report stated that 49.8% of the students at the Monroe Campus identified as minorities compared to 35.2% of students at the main campus of the college (Northampton Community College Fact Book, n.d.). See Table 1 for specific breakdowns of ethnicity based on the Fall 2018 student population.

Developmental mathematics program. Developmental mathematics has been a part of the curriculum at N.C.C. nearly since the inception of the college (Denise Ebersole, personal communication, May 17, 2018). N.C.C. developmental mathematics was designed to help students, deficient in basic mathematics or algebra skills, to meet minimum college-ready standards for Statistics, College Algebra, Mathematics for Elementary Teachers, or Natures of Mathematics, a quantitative literacy course. At N.C.C., students place into one of three levels of developmental mathematics; thus, some students have been required to complete several semesters of courses before entering a college-level course.

Course offerings began with just elementary mathematics (Math 022) and intermediate algebra (Math 026), both three credit courses. Over time, the addition of pre-algebra (Math 020) as the third level of developmental mathematics addressed the lowest levels of students who continued to struggle (Elizabeth Bughaigis, personal communication, July 7, 2016). In 2004, the elementary algebra course went through a curriculum design change to become a four-credit course to allow faculty to begin teaching it using project-based learning ideas. While the mathematics faculty did not permanently adopt that teaching method, the course remained at four credits. The mathematics courses have been offered either online, face-to-face, or as an emporium model since Fall 2015. Students placed into mathematics courses based on high school transcript grades, placement test scores, or in some cases, SAT scores. At this college, the SAT scores are used only for placing the student into college-algebra.

In 2013, some of the Northampton faculty members attended presentations that focused on course redesigns and modalities in developmental mathematics at both regional and national conferences. Faculty also attended a company-sponsored conference that focused on course redesigns to introduce them to commercial products for course redesign utilization. During this time, discussions about potential ways to improve low student success rates began at the department level. Several faculty formed a subcommittee to investigate potential course redesigns and how best to streamline courses in the curriculum. This committee determined that many of the adjunct faculty members were not adhering to the course outlines or structures. The institution collected data about course success, but there were no common assessments administered in any of the courses. An outcome of the committee was the creation of common final exams across all developmental courses and the implementation of emporium-model courses as another alternative for students.

Statement of the Problem

Low completion rates in developmental mathematics classes have been costly for many students completing remediation and the post-secondary institutions they attend, and this is true at N.C.C. These low rates are problematic because passing developmental mathematics courses is a prerequisite to enrolling in college-level mathematics courses and, ultimately, a prerequisite to attaining a college degree. Furthermore, students with the weakest academic backgrounds have been the least likely to successfully complete the developmental mathematics course sequence (Attewell et al., 2006; Chen & Simone, 2016). Therefore, placement into developmental courses and then failing to complete that course sequence has inhibited many students from attaining their college or vocational goals. A score on one test, typically, has determined placement policies (Gerlaugh, Thompson, Boylan & Davis, 2007). Post-secondary institutions often decide to set these test score criteria without empirical evidence. Research has been lacking on the effectiveness of such placement policies, particularly, in the presence of other factors that impact study success such as high school grade-point average (Belfield & Crosta, 2012; Camara, 2013), mathematics anxiety (Hembree, 1990; Ma, 1999), and mathematics self-efficacy (Bandura, 1997; Usher & Pajares, 2009; Zientek, et al., 2013). The fact that students enrolled in developmental mathematics courses tend to exhibit mathematics anxiety (Zientek et al., 2010) combined with findings that mathematics anxiety hinders student success (Hembree, 1990; Ma, 1999) collectively suggests that mathematics anxiety is a physiological state that presents a problem for developmental mathematics student success. Moreover, mathematics anxiety is related to self-efficacy (Usher & Pajares, 2009), and self-efficacy is the predictor of academic achievement (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1994; Zientek & Thompson, 2010).

From the early 2000s until the present, research began to highlight the failure of developmental students (Bahr, 2007; Bailey, Jaggars, & Scott-Clayton, 2015; Bailey, Jeong, & Cho, 2010; Chen & Simone, 2016). The realization that the existing developmental process has not served many students has led to the creation of alternative pathways by the Carnegie Foundation and the Charles A. Dana Center (Rutschow et al., 2017). The passing of an AMATYC (2014) position statement that recognized courses other than Intermediate Algebra might better serve some students, provided support for alternative pathways as a viable option to the traditional sequence. However, there has been little to no research on the changes in mathematics anxiety, based on various developmental instructional environments, even though this population has heightened levels of anxiety. This study seeks to add to the growing research by examining the extent to which the implementation of an emporium model, an analysis of placement policies, and students' perception of their motivation and mathematics anxiety related to student success and persistence in developmental mathematics.

Purpose of the Study

A score on one test, primarily, has established placement in developmental mathematics courses (Gerlaugh et al., 2007). Students have often taken a standardized, multiple-choice test that places them into college courses based on grammar, mathematics, and reading comprehension (Rose, 2012). This placement practice has occurred, even though many factors or predictors of success, impact whether a student is ready to or will be able to succeed in mathematics or college, in general. These predictors of success include a variety of factors such as financial burdens, family needs, new jobs, and new work hours (Rose, 2012). In a survey of nationwide community colleges (Gerlaugh et al., 2007), over 90% of institutions have mandated a placement assessment. Of those surveyed, 97% of them were using ACCUPLACER® created by the Educational Testing Service, and the majority used Standardized Assessment Test or SAT as another method of prescreening (Gerlaugh et al., 2007).

A benefit of conducting the study at Northampton Community College was the multiple criteria utilized to determine mathematics placement. There exists a need to ascertain a relationship between (a) the college's placement system, mathematics motivation and anxiety, and developmental mathematics course structure , and (b) student success and persistence in mathematics. Three studies were conducted. The first study examined to what extent did developmental mathematics course grade, persistence in mathematics at the college, and subsequent mathematics course grade differ by the placement criteria (i.e., high school math background or ACCUPLACER® test). A second study investigated to what extent did students' perceptions of their self-efficacy (intrinsic motivation and extrinsic motivation) and mathematics anxiety differed by course modality. The third study investigated to what extent differences existed in the final exam and course grades by modality in developmental mathematics courses, and persistence at the college by developmental mathematics modality. Each semester, students had an opportunity to choose to take their remedial mathematics course in an emporium, face-to-face, or online modality. Descriptive statistics and comparisons of course grades, common final exam grades, and persistence rates for each type of learning modality provided insight about student success at N.C.C.

Significance of the Study

The National Center for Education Statistics (NCES; 2011) found that students in 8th grade had average mathematics scores at a basic achievement level (The Nation's Report Card, 2012). This lowest level of achievement means that students have only partial mastery of the work required for that grade. Four years later, many 8th-grade students were still not ready for college-level mathematics courses when they graduated high school. In a study of Achieving the Dream Schools, the percentage of recent high school graduates that were enrolled in developmental education courses was approximately 54% (Complete College America, 2012). Achieving the Dream Schools were a collection of community colleges involved in a national movement to increase student success. Furthermore, community colleges have had higher enrollment in developmental mathematics than universities, (Complete College America, 2012) and many of those students have failed their developmental mathematics course (Bahr, 2007).

Increasing graduation rates will require institutions of higher learning to determine how to increase success rates in mathematics. Empirical evidence provides support for educators and enables them to make evidence-based decisions that can bridge the gap between placement policies, students' persistence, and completion rates. Investigating the importance of mathematics anxiety can help determine if the incorporation of different classroom practices, such as the emporium-model delivery format can affect anxiety levels. Ultimately, finding relationships between placement policies, mathematics anxiety, and the emporium model might result in higher persistence rates and higher graduation rates. The findings in this journal-style dissertation may help faculty members and higher education administrators improve success and persistence rates of developmental students through placement and course modality and understanding of their students' levels of mathematics anxiety.

Definitions of Terms

Important terms for the three research studies in this journal-ready dissertation are provided below for the reader.

College Readiness

Conley (2007) defined college readiness as "the level of preparation to enroll and succeed – without remediation – in a credit-bearing general education course at a postsecondary institution that offers a baccalaureate degree or transfer to a baccalaureate program" (p. 5).

Persistence in Mathematics

Persistence was defined as a student continuing at the college and enrolling in their next subsequent mathematics course.

Student Success

Student success was defined as any student who achieved a mathematics course grade of 73% or a C or higher.

Emporium Model

Emporium courses are held in math labs with a professor and one or two professional or student tutors to assist students. All students work independently towards specific due dates by filling in note packets and starting each course at the beginning. Students could test out of materials at the beginning of each module/chapter.

Online-Delivery Format

Students could elect to complete courses via Blackboard, which provides an online-delivery format without physically being on campus. Students complete all assignments and exams via commercial software, which may or may not include any professor-led instruction.

Placement Criteria

Placement criteria into mathematics courses at N.C.C. include high school transcripts, SAT scores created by the College Board, prior mathematics courses, or a score set by the mathematics department based on the ACCUPLACER exam. SAT scores placed students into college-algebra only. Math 020 Pre-Algebra was the only course that students could self-place without any other criteria. High school transcript evaluations were completed by the Office of Student Services, with the advising director. Based on criteria set forth by a formally made committee, high school courses and final grades placed students into their respective mathematics course. A committee determined the score based on each student's transcript. The committee was comprised of various faculty and staff members, the advising director, and subsequent advisors. Only one mathematics representative was on the committee. When students arrived on campus with their transcripts, members of the student services team for placement analyzed the transcripts. This team includes both full-time and part-time advisors and counselors.

Mastery Learning

Mastery learning is a threshold set for students before they are ready for a new assignment to open, used exclusively in emporium courses. Students needed to obtain minimum grades of 85% on their homework, 73% on quizzes and 73% on examinations before the next material would open to complete. Students could test out of the materials by completing a Skills Check to 85% mastery level or higher.

Success Navigators

Success Navigators are faculty advisors who are the assigned students based on potential degrees in their first semester on campus. After successful completion of the semester, students are assigned to specific faculty in a degree program if possible. If not, students continue with their success navigator throughout their degree at N.C.C.

Developmental Education Course

The National Association for Student Success (n.d.) defined developmental education as “a comprehensive process that focuses on intellectual, social, and emotional growth and development of all students” (p. 1) as it relates to mathematics proficiency. Sometimes referred to as remedial education courses, the purposeful design of these courses was to teach students fundamental content to help them be more successful in college-credit courses.

Course Redesign

For this study, course redesign refers to the changing of the curriculum and standardization of syllabi, final exams, homework, quizzes, and other common exams. Prior to this redesign, not all courses were addressing the learning outcomes in the same manner.

Delivery or Instructional Mode

In this study, there were three different delivery modes consequent to the course redesign: emporium, face-to-face, and online. The emporium courses were designed with mastery-based learning objectives for each homework, quiz, and exam. Face-to-face and online courses were given the same standardized homework, quizzes and final exam as the emporium courses. In the last year of the study, the face-to-face and online courses were given standardized exams based on compilations of the emporium exams for specific chapters.

Limitations

This study was limited to an autonomous community college in Pennsylvania. There was a lack of control over the students' background before they enrolled in the developmental courses. There was no control of the external influences, which might have limited a students' progress throughout the program and/or influenced their decision to continue, semester to semester. There was no consideration for socio-economic factors, which might have unduly influenced students' grades in their course. Also, because all students in the developmental program were included, there was no comparison group. Finally, there was an assumption that faculty members' grading was similar due to the common course shells, but no guarantees existed that faculty members did not curve final exam grades or final course grades.

Delimitations

This study took place at a mid-sized, suburban community college in Northeastern Pennsylvania that has both a branch campus and online course presence. Participants in the study were in either Pre-Algebra (Math 020), Elementary Algebra (Math 022), or Intermediate Algebra (Math 026), and all were represented as either emporium, face-to-face, or online. None of these courses counted towards a student's graduation requirements but were pre-requisites to college-level mathematics courses numbered over 100. Students in these courses are considered to have successfully completed if they have 73% (C) or higher. Students were a mix of recently graduated high school students and adult learners.

Assumptions

For this dissertation, it was assumed that the Office of Institutional Research at Northampton Community College accurately reported the data. There also was an assumption that the received data included all possible values with none removed for this study. It was also assumed that student-recorded surveys were of the actual student registered for a course at Northampton Community College. Finally, it was assumed that all faculty treated the courses the same by not curving final exam grades or final course grades.

Organization of the Study

There were three purposes for this journal-style dissertation. The first purpose was to examine to what extent was course grade and persistence in mathematics at the college predicted by the placement criteria (i.e., high school math background or ACCUPLACER test). For the students who persisted in the subsequent mathematics course at the college, to what extent was that persistence predicted by the placement criteria. A second purpose was to investigate to what extent did students' perceptions of their intrinsic motivation, extrinsic motivation, and mathematics anxiety differ by course modality. The third purpose was to investigate to what extent persistence in college and the subsequent mathematics college-course differs by course modality. Descriptive statistics will provide insight, as will comparisons of course grades, common final exam grades, and persistence rates for each type of learning modality at N.C.C. With lower enrollment numbers over the last few years, there exists a need to ascertain a relationship between placement, anxiety, and course structure in the developmental mathematics courses and student success and persistence.

There are five chapters in this journal-style dissertation. Chapter 1 is the background of the study, statement of the overreaching problem, purpose, and significance of the study, as well as limitations and delimitations. Each study overlaps in some respects in terms of participants and literature. Chapter 2 offers a retrospective look at the placement of students in mathematics courses and their overall success in the courses. Chapter 3 is a comparative study of students' perceived levels of mathematics anxiety and motivation, and their ultimate continuation and success in a course. Chapter 4 presents a quantitative study of success for developmental mathematics students at N.C.C. in Northeastern Pennsylvania. This college has two satellite campuses and an online presence, serving over 10,000 students annually. Data were collected from the Office of Institutional Research on the campus and was retrospective in nature. Chapter

5 is a review of the study and data results, along with implications for further policy decisions and research. References are included at the end of each chapter along with a cumulative resource at the end of the journal.

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Table 1

Demographics of Students by Race and Campus (Fall 2018)

	NRA	H/L	AI/AN	A	B/AA	NH/PI	W	2+	U
Bethlehem	8	1246	9	149	469	5	3395	168	68
		(22.5%)		(3%)	(8.5%)		(61.5%)	(3%)	(1%)
Monroe	4	550	8	55	439	12	1188	68	39
		(23%)		(2%)	(18.5%)		(50%)	(3%)	(2%)

Note: Bethlehem *N* = 5,517; Monroe *N* = 2,363; NRA = Non-resident alien; H/L = Hispanic or Latino; AI/AN = American Indian or Alaska Native; A = Asian; B/AA = Black or African American; NH/PI = Native Hawaiian or Pacific Islander; W = White; 2+ = 2 or more races; U = Unknown (categories from institution)

CHAPTER II: AN INVESTIGATION OF DIFFERENCES IN SUCCESS AND PERSISTENCE BASED ON PLACEMENT POLICIES

This dissertation follows the style and format of *Research in the Schools (RITS)*.

Abstract

The purpose of this study was to investigate if differences existed in the success and persistence rates of students relative to the placement policies at a suburban community college in Northeastern Pennsylvania. A non-experimental, quantitative, retrospective research study was conducted with archival data from fall 2015 through spring 2019 of students who took mathematics during this time. Traditionally, students tested into one or more sections of developmental mathematics. Findings indicated that differences existed in success across all developmental mathematics courses when placement was by high school transcripts. There were also differences in the categorical persistence category and placement with high school transcripts and ACCUPLACER for two levels of developmental mathematics. Creating a placement policy for students who do not have a recent high school transcript will remain a challenge for community-college advisors.

Keywords: *mathematics placement, high school transcripts, ACCUPLACER, multiple measures, high school GPA, success, persistence*

An Investigation of Differences in Success and Persistence Based on Placement Policies

Students' navigation of college often begins with course placement. Historically, institutions of higher education have used placement tests to determine students' eligibility to enroll in specific courses in grammar, mathematics, and reading comprehension (Gerlaugh, Thompson, Boylan, & Davis, 2007; Rose, 2012). These tests have tended to be either standardized multiple-choice tests from a commercial software developer or non-standardized tests developed by faculty members. In the latter case, faculty develop tests based on student learning outcomes courses. Placement tests are considered high-stake assessments because scores can alter students' path to college completion; yet students often take these high-stakes assessments without warning or preparation (Fay, Bickerstaff, & Hodara, 2013). To increase persistence and retention at the college level and consider tests as a placement option, multiple research studies have explored outcomes of placement tests (Abraham, Slate, Saxon, & Barnes, 2014; Camara, 2013; Safran & Visher, 2010; Scott-Clayton, 2012).

Placement tests measure students' current content knowledge but do not take into consideration other factors that hinder student success in higher education, which includes a variety of situational factors such as financial burdens, family needs, new jobs, and long working hours (Rose, 2012; Zientek, Scheider, & Onwuegbuzie, 2014). Holistic approaches to college placement provide an alternative to focusing on one particular test score and, instead, allow institutions to administer a comprehensive placement approach that considers all aspects of a student's educational career, including high school transcripts, placement test scores, and non-cognitive assessments (Gerlaugh et al., 2007; Conley, 2010). These multiple measures collect more information about a student, which can help educators make evidence-based decisions about placement. In some instances, these multiple measures might boost the student into higher-level courses (Ngo & Kwon, 2014).

Background of the study

The predictive validity of placement scores has come under scrutiny, particularly as readiness has been defined differently at individual colleges. One college might find that a particular test score indicates college readiness while another may not. Furthermore, when other student variables are considered, the predictive validity of placement test scores as an indicator of college-readiness remains unproven. For example, Belfield and Crosta (2012) found empirical evidence that placement by high school grade point average (GPA) was a better placement measure than placement by test scores. Evaluating high school transcripts can take more time for college administrators than evaluating one test score; however, high school transcripts provide a picture of a student's academic work that may indicate a broader range of knowledge in multiple attributes (Belfield & Crosta, 2012). Several studies found that using high school transcripts and GPAs placed students into college-level courses with strong academic success (Ngo & Kwon, 2014; Scott-Clayton, 2012).

Because placement is important and researchers have advocated for the use of more than one placement measure, Northampton Community College (N.C.C.) in Northeastern Pennsylvania adopted and implemented a multiple criteria placement in mathematics. This study was conducted at N.C.C., which is a public two-year college with specialized diplomas, over 70 associate degree programs, and community education and workforce development programs. While N.C.C. does not follow a purely holistic-placement approach, the benefit of conducting the study at this college was the college's utilization of multiple measures when placing students into mathematics courses. To place recent high school graduates (i.e., five years or less) in the highest possible college-level mathematics course, the college, in this study, encouraged students to submit high school transcripts prior to registration and at the start of their first semester. Students who had been out of high school for greater than five years or did not have their high school transcripts were encouraged to take the ACCUPLACER exam. The mathematics department faculty established placement criteria to place students from the lowest level of remediation (Math 020) up to and including Calculus I. Advisors evaluated students' mathematics course placement at the time of registration. Placement decisions were made on the criterion that placed students in the highest mathematics course. In addition, to streamline the intake process, N.C.C. utilized mathematics course coordinators along with a math lab manager to field questions about developmental mathematics placement from students, faculty, and advisors. With varied measurements, questions remained unanswered for N.C.C. that centered on student success and persistence by course level and placement policy, particularly regarding developmental mathematics. This study sought to explore further the placement policies at N.C.C.

Statement of the Problem

In 2011, Hughes and Scott-Clayton reported that "placement exam scores are commonly used not merely as a measure of skills but rather as a high-stakes determinant of students' access to college-level courses" (p. 1). For many community college students, the exam is taken during orientation, and they are placed directly into a series of developmental education courses. The purpose of the placement test is to determine students' abilities and readiness to enroll in reading, English, and mathematics courses. Yet, students might arrive at orientation unprepared to take a test. Even when students schedule a test, they might not review the subject matter prior to taking the placement exam. Thus, students might not always understand the placement consequences of the test (Safran & Visher, 2010).

While many educators believe that the design of standardized exams should help place students in a course that optimizes their probability of success, those tests might not, in reality, always align with state or college-learning outcomes. For example, a generalized ACCUPLACER test may not address specific learning outcomes of a course, if the college has not tailored questions to meet those learning outcomes (College Board, 2018, p. 1; Saxon & Morante, 2015). Safran and Visher (2010) found that many students in their study took placement tests with little understanding of the importance those scores have at the college, nor did faculty members at the school use data from the exams for instructional purposes. Other placement policies have included evaluation of high school transcripts that paint a broad picture of a student, but those practices have been used less often and little research exists on the effectiveness of such placement practices.

Purpose of the study

The purpose of this study was to determine the effectiveness of a new placement policy at one community college in Northeastern Pennsylvania. The community college changed from solely relying on placement by commercial products to also including high school transcript evaluations. With multiple research studies beginning to focus on multiple measurements (Ngo & Kwan, 2014; Scott-Clayton, 2012; Hodara et al., 2012;

Rutschow & Mayer, 2018), there is a need for examining the relationship between course placement, student success, and mathematics persistence.

Prior to this study, reporting of statistical findings regarding placement practices and students' success at the participating community college was not provided to faculty members. Instead, reporting was limited to total success in developmental courses (i.e., pass or not pass) with withdrawals not distinguished from failures; data were further disaggregated by ethnicity. One hypothesis for not previously delving further into the data is a lack of utmost importance in placement outcomes when the institution primarily relied on commercial placement products. Today, faculty members have been involved in developing policies and course redesigns, and data needs to drive the evidence-based decision-making process to determine what has been effective and what still needs to change.

Five years ago, the college redesigned their developmental mathematics courses, which included creating common assessments, syllabi, and grading scales. This initiative has resulted in the ability to streamline data collection and an assurance that learning objectives are being met. A goal of this study was to help administrators and educators make well-informed decisions. To fulfill this goal, student success rates and persistence in developmental mathematics were compared to their course placement by placement policy. Student success was parsed out, accordingly, with withdrawals tracked separately from failures. At the end of this study, suggestions and recommendations were made for the overall goal of improving the program further.

Significance of the study

Developmental education studies have continued to be a topic of interest in dissertations (Anonymous, 2017; Anonymous, 2018). The interest in these courses has been driven by the need to increase graduation rates at colleges where many students are placed into and required to complete developmental mathematics courses. If failure rates in mathematics courses remain high, and time to degree completion is lengthened because multiple developmental courses are needed before enrolling in a college-level mathematics course (Bahr, 2008), those degree completion rates will not increase, and developmental mathematics will remain a barrier for many students.

Placement policies are important because they determine the point of entry in the mathematics course sequence and provide a measure for content-readiness. There has been a need to examine the relationship between college placement and success measures such as course grade and persistence. These studies should consider multiple measures instead of one placement test score. Holistic approaches to placement consider students' overall academic background rather than focusing on one high-stakes placement exam. However, not all colleges are using multiple measures (Gerlaugh et al., 2007). This study adds to the growing research on multiple placement measures by investigating a somewhat holistic placement approach for developmental mathematics and the corresponding success and persistence of those students.

Conceptual Framework

Retention and persistence are somewhat related terms. Retention refers to an institution keeping a student enrolled, or the educational system keeps them retained, whereas persistence refers to students' individual ability to continue towards a goal (The

Myers-Briggs Company, n.d.). Both are important because, for students to attain their degree, they must persist towards their goals and, in order to do that, institutions must retain them. When students do not persist towards their educational goals, the high rates of attrition become, a symbol of failure for institutions of higher education and the students they serve.

Student retention can be affected by several factors (Tinto, 1982). Tinto (2002) claimed that five factors can increase the persistence of students at a college: (a) expectation, (b) advice, (c) support, (d) involvement, and (e) learning. Accordingly, persistence will be more likely if expectations are clear at all levels including college staff, advisors, and faculty members. When students are aware of the course expectations, then they will be more likely to persist and graduate. Setting goals and receiving solid advice about courses and degree programs is another key component to helping students achieve success and persist.

While those factors are important, Tinto (1975, 1982) believed the most important factor was the ability for students to integrate academically and socially in the first semester. Tinto (1975) theorized, in his model of retention, that the integration of students into their college community through interactions with faculty, staff, and other students would more likely encourage students to stay and complete their coursework through to graduation compared to students who did not make those connections. Over the last 40 years, Tinto's own model of student integration has evolved to include student motivation and goal commitments (Demetriou & Schmitz-Sciborski, 2011). Tinto posited (2002) that access to college itself might be more fundamental to completion than a student's persistence.

Accurate placement into coursework might also help students to succeed and, thus, persist. One of the ways colleges can increase the effectiveness of their placement policy is to give students responsibility for their level of preparation for their placement (Goeller, 2013; Koch, Slate, & Moore, 2012). The involvement of both the college and student implies an action must occur. Astin's (1999) theory of involvement has also been relevant to student placement and success. While Astin (1999) has five postulates of involvement, the fifth focuses on policies and practices of an institution as a way to increase student involvement and states that "the effectiveness by any educational policy or practice is directly related to the capacity of that policy or practice to increase student involvement" (p. 519). By increasing communication about the placement policy at an institution, both student satisfaction and retention can be increased along with efficiency. The success of developmental education programs, based on placement policies, can affect college retention rates (Goeller, 2013).

Placement in Mathematics Courses at Community Colleges

Admission policies into community colleges are open-access; thus, the academic preparation of the population of students coming to the campus is diverse and lends itself to a need for varied and accurate placement. Many students from well-to-do families choose to attend community colleges because these courses provide savings that can be applied to education beyond the bachelor's degree (Rose, 2012). For some students from lower economic status or rural areas, they might have been less likely to have "benefited from high-performing schools or quality educational resources" (Rose, 2012, p. 9). Many community-college students have needed an academic boost in their content knowledge (Attewell, et al., 2006; Boylan, Bonham, & Bliss, 1994; Chen & Simone, 2016), which is why accurate placement has been necessary. In fact, some have touted that one of the characteristics of a successful remediation program is the mandatory and early assessment and placement of students (Roueche & Baker, 1987; Roueche & Roueche, 1994). Determining placement into courses has been a standard part of the enrollment process (Gerlaugh et al., 2007). The academic course level a student may take depends on highly-valued placement options (Hughes & Scott-Clayton, 2011; Bailey, Jeong, & Cho, 2010). While colleges frequently use measures like placement exams and SATs, high school transcripts have been used less often to make decisions about student course placement (Gerlaugh et al., 2007). Research has been emerging about the effectiveness of multiple measures of prior mathematics, along with placement test scores, for accurate placement (Ngo & Kwon, 2014). Saxon and Morante (2015) suggested a comprehensive model of assessment and placement would create a more accurate and refined process.

Placement exams. Oftentimes, students choose to take one attempt at a computerized, commercial placement exam that will determine (a) if they will be required to enroll in developmental education courses and (b) how many developmental education courses they need to complete. In a survey of nationwide community colleges conducted by Gerlaugh et al. (2007), over 90% of institutions have mandated placement assessment. Of those surveyed, 97% were using ACCUPLACER created by the Educational Testing Service, and the majority used the SAT (Standardized Assessment Test) as another method of prescreening (Gerlaugh et al., 2007). Hughes and Scott-Clayton (2011) reported that ACCUPLACER and COMPASS were among the most popular placement options, which allow assessment of multiple students at the same time and produces results more quickly (Ngo & Kwon, 2014). There has been no uniformity on how each college determines the validity of the score and how it aligns with their learning outcomes. Only a handful of states around the country even conduct validity testing before using tests (Fulton, 2012). In a recent study in North Carolina, Hilgoe, Brinkley, Hattingh, and Bernhardt (2016) found the North Carolina Early Mathematics Placement Test was a useful tool to for assessing college algebra readiness of high school students. Students who passed the placement test finished with significantly higher GPAs than those students who failed the exam (Hilgoe et al., 2016).

When a test is the only criterion used for course placement, cutoff scores for each student are considered definitive; if a student is one point or 10 points above or below a cutoff score, the interpretation means the same in terms of placement (Belfield & Crosta, 2012). Validity of placement becomes more complicated when many students take placement exams without proper and adequate preparation (Fay et al., 2013). The reasons for the lack of preparation vary and include late enrollment, not knowing about the exam, or being unaware of the preparation materials available to them. (Fay et al., 2013). Camara (2013) noted the “in determining whether students are prepared or ready to succeed in college or career-training programs, direct evidence between test scores and performance in post-secondary education may provide the strongest form of evidence” (p. 16). Placement tests serve each college in one of three ways: (1) identifies deficiencies in content and preparation, (2) certifies students as college ready, and (3) identifies the correct course a student needs to enroll in (Camara, 2013). Morante (2013) argued that placement exams could not predict a student’s future success potential. Recent studies have shown some evidence that the predictive validity of these exams is low, with a weak correlation between students’ pass rates and their placement scores (Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012). These exams are only valid for the proper placement of students in their respective courses.

High school transcripts. According to Venezia, Bracco, and Nodine, (2010), when there is a connection between the curriculum of the high school and community-college expectations, the evaluation of high school transcripts should be part of a holistic placement approach. A high school transcript provides information regarding students' academic ability, prior effort, and readiness for a college course that a single exam score cannot. As noted by Scott-Clayton (2012), high school transcripts might be more helpful at lower achievement scores because "they capture non-cognitive factors such as motivation and academic engagement that are particularly important in the lower tail of the grade distribution" (p. 16). Belfield and Crosta's (2012) results indicated that high school GPA "can reveal not only cognitive competence but also student effort and college-level readiness" (p. 3).

A challenge to the validity of the high school transcript for course placement occurs when high schools call a course the same name but covers different content. For example, a course called Pre-Calculus might not include trigonometry at one school but might extensively cover it in another. Another validity challenge occurs when high school transcripts are not available. When Scott-Clayton (2012) analyzed the placement of students, she found that 30% of the students did not have high school transcript information available. Regardless of those challenges, high school transcripts hold promise for placement of recent high school graduates. Scott-Clayton (2012) went on to find that with further research, high school transcripts might more accurately predict student success at the college level.

Some colleges have used high school transcripts for placement purposes. For students who fail to achieve the required scores on SATs or ACCUPLACER exams, college officials at Montgomery College and Fredrick Community College in Maryland look to high school transcripts (Matthews, 2015). If students achieved at least a B or higher in specific courses, they could enroll directly into the required college-level mathematics course (Matthews, 2015). In North Carolina's community college system, students with a high school GPA of 2.6 or higher and a minimum number of high school courses could bypass the placement exam altogether (Zinshteyn, 2016).

Placement policy of the participating college. This study was conducted at a suburban community college in Northeastern Pennsylvania that had a placement policy that has varied over time. For most of the history of the college, course placement occurred with a commercial software product called ACCUPLACER® created by the Educational Testing Service. Alignment of the college-learning outcomes with the commercial software never occurred; instead, scoring of student exams came from the publisher's recommendations (Jeannie Galick, personal communication, August 17, 2018). Students could also place into College Algebra based on their SAT scores, if submitted on time.

In 2015, the college moved to a placement policy that included utilizing high school transcripts criteria. The first step in creating the criteria was the formation of a committee. They analyzed a variety of transcripts and then determined what the criteria would be for placement into a college-level course or one of the three developmental courses. The committee understood that courses across high schools might not be equivalent. While Pennsylvania high schools follow a common core curriculum, there has been no oversight on what content is covered for each course in high school. Only Algebra I at each high school follows the outcomes presented in the Keystone algebra exam, which all students must take and pass to graduate in Pennsylvania. Content in courses after Algebra I can differ by each high school (Shelli Bird, personal communication, March 31, 2019).

Research Questions

Placement of students into college always has been a varied process. The current study takes place at a Northampton Community College in Northeastern Pennsylvania. Many variations in placement occur within the state at all institutions of higher education. For example, Bucknell University in central Pennsylvania recently decided to remove the barriers of SAT scores or other placement policies to increase access to students from all socioeconomic statuses; the test is now an optional part of the admissions process (Ferlazzo, 2019). In this study, I sought to determine if there were differences in students' success and persistence rates by the courses they were placed in, with consideration given to the placement policy. This study seeks to answer the following questions about course eligibility, success rates and persistence.

1. For students enrolled in developmental mathematics courses, to what extent did differences exist between student success rates by course placement, more specifically, when disaggregated by:
    i. high school mathematics score or
    ii. ACCUPLACER scores?

2. For students enrolled in Math 020 and Math 026, to what extent did differences exist between persistence rates in mathematics by course placement criteria, more specifically, when disaggregated by:
    i. high school transcripts or
    ii. ACCUPLACER scores?

Method

This study examined the placement policies at Northampton Community College (N.C.C.) in Northeastern Pennsylvania to determine if differences existed in success and persistence rates by placement practices. This was a retrospective, nonexperimental study that used quantitative methods. The criterion for student placement at this community college placed students into the highest-level course, even if multiple placement criteria were available. Student mathematics placement was by (1) ACCUPLACER scores, (2) high school mathematics courses, grades, and GPA less than five years old, (3) prior college credits, (4) self-placement, or (5) SAT scores. Scores on the SAT only applied for College Algebra placement and, thus, were not included in this study. Once students began a developmental mathematics course, they completed a diagnostic exam to confirm their placement. If a student scored an 80% or higher on this diagnostic, they met with their faculty member to discuss potentially moving ahead in the course sequence. Diagnostic exam scores were not tracked. Only two courses did not require a prerequisite: Math 020 Pre-Algebra and Math 103 Applications in Mathematics. While all developmental course grades count towards a student's GPA, course credits did not fulfill degree requirements, except for Math 103 that fulfilled math requirements for a terminal associate degree.

Selection of Participants

This community college was the researcher's home institution in Northeastern Pennsylvania. The diversity, in terms of course structure and the student population, were a benefit of conducting the study at this college. Data about the student population came from the Office of Institutional Research at the college. The sample included all full-time and part-time students who were enrolled in a mathematics course during the last five years and were currently still enrolled as students. The sampling strategy included all the students who were registered for any mathematics course in spring, summer, or fall semesters from fall 2015 through spring 2019 and enrolled in the course that they placed into (i.e., not a lower-level course). Table 2 illustrates the diversity of students at this college during the years the data were collected across courses.

Course structure. Three levels of developmental mathematics were offered during the 2015-2019 academic years. Each level of developmental mathematics could be taken as an emporium course, face-to-face course, or an online course. Beginning in spring 2019, two sections of each level of mathematics were offered online, which was a decrease from the fall semester where three sections of each course were offered online. Also, two sections of Intermediate Algebra (Math 026) were not included in this study as they were offered in spring 2019 as co-requisite courses with College Algebra (Math 140) and did not adhere to the same course structure or assessments. Table 3 provides a breakdown of the number and types of courses offered at this college from fall 2015 through spring 2019.

Each developmental mathematics course used the same textbook and online homework platform throughout the study. The only common assessments in all course modalities included homework and quizzes that were delivered via a commercial internet program. The final exams were also common for all modalities, but some semesters had technical issues at final exam time. Exams were either completed via the commercial internet program or a Scan-Tron paper version so that question data could be tracked. On all common assessments, each problem was randomly selected from a set pool of items. This ensured that, while not all final exams, homework, or quizzes were identical, common learning objectives were tested. Starting in fall 2018, all exams became standardized and were utilized for online and face-to-face courses and were comprised of problems that came from the common chapter exams in the emporium classroom.

The courses were taught by both full-time and adjunct faculty with no one person teaching the same schedule from semester to semester. The emporium courses met in a lab-style classroom, where the instructor and two to three tutors worked in the designated course time, guiding students. Face-to-face courses consisted of one instructor, who may or may not have been in a computer classroom. As not all faculty had a computer room, students generally worked outside of the classroom on the course assignments. Those with computers took exams online and others took Scan-Tron paper exams in the classroom. Online students worked solely outside of a classroom environment. All online exams were mandated to be proctored, regardless of paper or computer format. Students in all modalities had limitations on testing aides. Students in the Pre-Algebra course were not allowed to use calculators but could utilize the common formula sheet. Students in Elementary and Intermediate Algebra also could utilize the common formula sheet but were only allowed basic calculators for each exam.

Procedures and Research Design

Prior to collecting any data, an IRB (institutional review board) form was generated and approved by the home institutions' IRB committee. Before receiving data, the home institution generated new identification numbers for each student to protect their identity. The researcher collected the data, downloaded it to a computer in a locked office, created persistence data, and converted the file into Statistical Package for the Social Sciences version 25. The file was password protected on the desktop of the password-protected computer of the researcher in a locked office.

With the newly generated identification numbers, the persistence of Math 020 and Math 026 students to their subsequent mathematics course could be tracked. Because not all Math 022 (Elementary Algebra) students were required to complete a mathematics course, the analysis for persistence was limited to students enrolled in the first and last developmental mathematics courses (i.e., Math 020 and 026). I coded the success rate based on their initial placement at the college. As not all students continued to their next course immediately or at all, cross-identification was necessary to see who persisted and who did not. It was also necessary to ascertain who started in which course along with their placement at the college. After merging the data, I removed all student identifications from the data file. The data file remained on the intranet of the researcher and was password protected and encrypted.

This quantitative research study used a causal-comparative design, as data were archival. A causal-comparative research design seeks to examine differences between variables after an event has already occurred (Salkind, 2010). As the data set for my study was archival, the effect could not be manipulated, nor were there distinct treatment or control groups. This study was a retrospective design, as I chose to compare the placement and success of students in developmental mathematics courses after they occurred.

Instrumentation

For this study, student data retrieved from the Office of Institutional Research included: (a) student ID, (b) gender, (c) race, (d) mathematics course name, (e) mathematics course section, (f) semester, (g) year, (h) mathematics course grade, (i) ACCUPLACER score, (j) SAT score, and (k) high school transcript code. Persistence was coded by the researcher as a dichotomous variable. Persistence data was generated by matching repeated student identification numbers. Further persistence was coded by the researcher as a categorical variable to determine who persisted based on whether they passed the course or not. Student success in developmental mathematics courses requires a grade of C (73%) or higher.

Students were placed into their respective mathematics course based on one of four criteria: high school transcript evaluation, ACCUPLACER scores, SAT scores, or previous college mathematics course. Students' high school transcripts were coded by a member of the student services division and uploaded into the Learning Management System. Student's placement by ACCUPLACER and SAT scores were coded accordingly and uploaded into the Learning Management System. Students were placed into the highest-level course possible based on four criteria. When evaluating SAT scores, students who received a score higher than 500 in mathematics were placed into College Algebra. If SAT placed a student into College Algebra, then no other criteria were reviewed. For students who earned 500 or less on the SAT, placement was based on the other criteria such as previous college enrollment, high school transcript, and ACCUPLACER scores. Students who had enrolled or completed a college mathematics course within the last five years were placed into the next respective college mathematics course, accordingly. For example, a student who took Math 020 at the college in spring 2015 would be placed in Math 022 in spring 2019. Table 4 lists the placement coding policies and Figure 1 shows the progression through courses.

Students who applied to the college and submitted their high school transcript had their transcripts evaluated by staff in the student services division. Transcripts were evaluated based on the mathematics courses the students completed along with their course grade and overall GPA. A student whose highest high school course was Algebra I and who passed with a grade of C (73%) was placed in the lowest-level mathematics course, Math 020, Pre-Algebra. A student who completed Pre-calculus or Algebra III with Trigonometry with a C or higher was given a score of 100 for GPA and 402 for math class. This designation placed them into college algebra at the community college. A challenge to the high school transcript was the completion of the ACCUPLACER exam. In spring 2019, the criteria for the ACCUPLACER exam changed as the exam was revamped to the Next-Generation ACCUPLACER. Cutoff scores were updated, accordingly, and were used on a small percentage of students prior to the start of spring 2019. Table 4 compares the placement scoring for the high school transcript, ACCUPLACER, and SAT coding. Table 5 has the frequency distribution of placement for ACCUPLACER and high school transcripts only because no SAT score could place a student in developmental courses.

Data Analysis

Table 6 contains the variables, data type, and analysis for the two research questions disaggregated by placement criteria. For all research questions, chi-square tests were conducted to test the null hypothesis that no differences existed for success and persistence by course level. Analyses were disaggregated by placement policy. The $p_{calculated}$ was compared to an alpha of .05 to determine statistical significance. In order to conduct the chi-square test, all variables needed to be categorical, the sample needed to be randomly selected with equal probability and with each observation appearing only once, and all expected cell values had to be at least five (Dodge, 2008).

Coding of student success. Students could not continue to the next mathematics courses until they earned at least a C (73%) in their current developmental mathematics course. Any grade less than a C required the student to repeat all or part of the course. Students could withdraw from any course at the college up to the end of the 14th week of the semester. Students who were withdrawn for lack of attendance were not differentiated in the college's system, and any "W" received by those students was considered a failure by the college, regardless of when that student received it.

Grades were grouped as passing (A through C), failing (C- through F), and withdrawn (W). Students who had an "I" on their transcript for an incomplete were considered failures because a change of grade was necessary to override a failing grade. Students who were labeled "IP" for In Progress were counted for persistence, but then were removed as the current courses were not yet completed by the students; an IP only showed a willingness to continue to the next course. Because not all students received plus (+) or minus (-) grades, letter grades were collapsed. For example, a letter grade of B consisted of students who earned a B+, B, or B-. For the analyses, course placement for both High School Transcript and ACCUPLACER was coded as the following: “1” = Math 020, “2” = Math 022, and “3” = Math 026. Course success were in reference to the final remedial course grades and were coded as the following: “0” = Pass, “1” = Fail, and “2” = Withdraw. Students who arrived at the college with no high school transcript scores were removed from the analysis.

Coding of persistence. Persistence was first coded as a dichotomous variable and then coded as a categorical variable. The dichotomous coding was “0” equals persisting and “1” equals not persisting. The categorical coding for persistence was as follows: “1” = passed the course and persisted to the next math course, “2” = failed or withdrew but retook the mathematics course, “3” = passed their course but did not take another mathematics course, and “4” failed or withdrew from their course and did not retake the course.

Other data considerations. For the placement test and persistence analyses, only students who were enrolled in the course they were placed in were considered in the data. In other words, students who opted to take a lower-level course than their placement suggested were not included. Because enrollment in the respective developmental course was not required, students who took the placement test but then did not take the required mathematics course were not accounted for in the data. Another aspect of the data was that some students had both a High School Transcript and ACCUPLACER scores and those criteria placed them into the same developmental mathematics course. Because those students were then adhering to both placement policies and, thus, in both the High School Transcript and the ACCUPLACER groups, analyses were conducted separately for those two groups. College-level courses were not included because of small cell counts for some courses and there was no way to know which mathematics course was a student's terminal mathematics course.

Results

Research Question 1: Course-Level Placement and Student Success

1A: High school transcript. As seen in Table 7, 1,604 of the 5,612 (28%) who were placed into a specific level of developmental mathematics by their high school transcript chose to adhere to High School Transcript placement requirements by enrolling in their designated course placement. Chi-square results indicated sufficient evidence to suggest differences existed between (a) course placement by the High School Transcript criteria and (b) pass, fail or withdraw grades for developmental mathematics students, $\chi^2(6) = 41.993, p < .001$, with no cells having an expected count of less than five. A somewhat noteworthy Cramer's V effect size was .077. Students in all three courses passed their course after high school transcript placement between 46% and 58% overall with less than 20% of withdrawing and approximately 30% failing.

1B: ACCUPLACER. As seen in Table 7, 917 of the 2,568 (35%) who were placed into a specific level of developmental mathematics by their ACCUPLACER placement criteria adhered to those placement requirements by enrolling in their designated course placement. Results indicated that there was not sufficient evidence to suggest differences existed between (a) course-level placement by ACCUPLACER scores and (b) pass, fail or withdraw grades for all developmental mathematics, $\chi^2(4) = 3.311, p = .507$, with three cells having an expected count of less than five. Cramer's V effect size was .031. Students placed into developmental mathematics based on

ACCUPLACER scores appeared to pass, fail, or withdraw from their course between 21% and 43% of the time.

Research Question 2: Course-Level Placement and Persistence

For several degrees, Math 022 could fulfill the mathematics requirement. As degree information was not tracked, it was not possible to ascertain which Math 022 students required more mathematics courses. All students enrolled in Math 020 and Math 026 were required to complete an additional mathematics course. Therefore, analysis of persistence rates in this study was limited to students who placed into either Math 020 or Math 026.

2A: High school transcript. For research question 2A results indicated that there was not sufficient evidence to suggest differences existed between (a) course-level placement by High School criteria into MATH 020 or MATH 026 and (b) persistence as measured by the dichotomous variable at the *p* =.05 level, $\chi^2(3) = 7.626, p = .054$, albeit the Cramer's V effect size of .060 suggests small differences might exist within the population. Students placed into Math 026 persisted 83% compared to almost 76% for Math 020 students. There was sufficient evidence to suggest differences existed between (a) course-level placement by High School criteria into MATH 020 or MATH 026 and (b) persistence as measured by the categorical variable at the *p* =.05 level, $\chi^2(9) = 46.436, p < .001$, with a somewhat noteworthy Cramer's V effect size of .085. Students in Math 026 who persisted, did so at the same rate (41.5%) regardless of their pass, fail, or withdraw status. Those in Math 020 passed and persisted higher than if they failed or withdrew, which was 20-30% higher than not persisting at all.

2B: ACCUPLACER. For research question 2B results indicated sufficient evidence to suggest differences existed between (a) course-level placement by ACCUPLACER scores into MATH 020 or MATH 026 and (b) persistence as measured by the dichotomous variable at the *p* =.05 level, $\chi^2(3) = 2264.473, p < .001$, with a very noteworthy Cramer's V effect size of .670. Students by and large did not persist to the next math course after ACCULACER for both classes between 85% and 93% of the time. There was also sufficient evidence to suggest differences existed between (a) course-level placement by ACCUPLACER criteria into MATH 020 or MATH 026 and (b) persistence as measured by the categorical variable at the *p* =.05 level, $\chi^2(9) = 2293.819, p < .001$, with one cell having a count less than five and with a very noteworthy Cramer's V effect size of .389. The largest percentage (66.6%) of students not persisting after failing or withdrawing was in the lowest level course (Math 020).

Quantitative Comparisons of Placement Policies

Comparisons of percentages across placement policy in Tables 7 and 8 suggest that the placement by High School Transcript policy developed at the participating community college resulted in higher success and persistence rates compared to placement by ACCUPLACER scores. The sample size for ACCUPLACER in the upper-level course was relatively small in comparison to the MATH 020 and MATH 022 sample; thus, generalizing to the college population should be cautioned. Regardless, of the smaller sample size, the results were similar for ACCUPLACER across courses as was shown above in 2B.

Discussion

Increasing success and persistence in mathematics is important because most students need to complete a mathematics course to attain their post-secondary educational goals. Because success rates have been low in developmental courses, institutions of higher education sought methods for increasing student success. Placement policies is an area that has been explored (Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012). Accurate placement of students is important to success and can save students money and time.

In this study, results indicated that success rates differed by course level when students were placed into the course by evaluations of their high school transcripts, but differences did not exist across courses when placed by ACCUPLACER scores. Persistence rates also differed by course level based on placement criteria. Students were more likely to persist, regardless of passing or failing/withdrawing from a course when they were placed with their high school transcripts, and those differences were quite striking. This research is consistent with that done by both Scott-Clayton (2012) and Belfield and Crosta (2012) where they found that high school GPAs gave a greater picture of students' efforts and college readiness, as well as, their motivation and engagement with academics.

Placement Policies

Community colleges are open-access institutions that enroll students of various academic backgrounds. Determining college readiness must be addressed before students can choose a course schedule. Historically, placement exams like the SAT or ACCUPLACER have been employed by colleges to determine whether remediation is required before college-level courses (Barnett et al., 2018; Gerlaugh, Thompson, Boylan, & Davis, 2007). However, many problems occur when determining college readiness based on one placement test score, including students' lack of mental preparation to take the course and anxiety that arises from one score determining their academic trajectory (Cassady & Johnson, 2001; Fulton, 2016) ,as well as, an inability to capture motivation and engagement (Scott-Clayton, 2012).

The efficacy of placement exams has been under scrutiny because of the high-stakes outcomes that can be costly to students who are required to complete additional coursework. Placing into lower-level developmental coursework will prolong students' path towards their college degree and will increase their investment of time and money (Barnett et al., 2018). Encouragingly, since 2011 there has been an increase in the number of higher education institutions seeking to improve the placement of students using multiple measures rather than a single standardized exam (Rutschow & Mayer, 2018).

Student success. Research from this study supports claims from other studies that achievement in high school and prior mathematics enrollment might serve as a better placement alternative to a standardized exam (see Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012). In this study, high school transcript evaluations were based on previous high school mathematics, grades in those courses, and overall GPA instead of limiting the evaluations based on an overall GPA. For placement based on high school transcript evaluations, chi-square tests indicated that differences existed in success rates by course level with the highest success rates in the middle-level developmental mathematics courses. Maybe those results should not be surprising, considering Scott-

Clayton’s (2012) notion that high school transcripts might be even more effective on the lower tail because the transcripts capture engagement and motivation over time. While this notion was true for our study, caution should be exercised regarding inferences to the highest-level developmental mathematics course when placed by ACCUPLACER because of the small sample size.

While no statistically significant differences existed across course level when ACCUPLACER scores were used to place students, regardless of course level, comparisons of percentages indicate that ACCUPLACER placement resulted in lower pass rates and greater withdrawal rates compared to students placed by their high school course evaluations. As seen in Table 7, across classes, students adhering to ACCUPLACER policies were less likely to pass and more likely to drop compared to students who adhered to the High School Transcript placement policy. Pass rates fared slightly better for ACCUPLACER placement in MATH 026 (38.3%) but the sample size was small, and the rates were still lower than the High School Transcript policy (46.6%).

Persistence in mathematics. When persistence in mathematics was coded as persisted or did not persist, no statistically significant differences existed on persistence rates by course level when high school evaluations were utilized, but differences did exist when ACCUPLACER scores were used. As noted earlier, caution should be used in regards to ACCUPLACER interpretations for the highest-level course because of the small sample size. Like student success, regardless of placement policy, some consistencies existed across the highest and lowest developmental courses in regard to persistence in mathematics. As seen in Table 8, students that adhered to their placement by high school transcript evaluations tended to persist in mathematics (i.e., 75.7% in

Math 020 and 83% in Math 026), but the same was not true for placement by ACCUPLACER scores (i.e., 6.9% in Math 020 and 14.9% in Math 026). Those findings suggest that the high school transcripts were capturing a snapshot of students' abilities and motivations to succeed over time that was not captured by one test score. Thus, an argument can be made that student success is based on more than mathematical knowledge. When persistence was disaggregated further, the largest percentage of students who did not persist, either failed or withdrew from Math 020, after placement by their ACCUPLACER score.

A challenge. While a review of high school transcripts was beneficial, this study also identified the challenge of utilizing high school transcripts, which was also noted by Scott-Clayton (2012). The question that remains unanswered is "what would you do with students who do not have a high school transcript or who are returning after many years away from an educational setting?" Scott-Clayton (2012) found that 30% in her study did not have high school transcript information on file. In this study at a public two-year college, only 46.4% of the total student population entered college with high school transcripts available that were less than five years old. Of this total, 28.0% required Math 020, 19.2% required Math 022, and 22.4% required Math 026 or were non-STEM college ready. Therefore, alternative measures would need to be in place for non-traditional returning students or for students who attained their GED.

Limitations

This study had multiple limitations. As this study was based at a single institution, the results might not be generalizable to other community colleges. This study was limited in its scope in that random assignment of students by placement was not possible. Furthermore, tracking of students' degree track was another limitation. This meant that persistence could not be measured for students enrolled in Math 022 (Elementary Algebra) because it was not possible to delineate the students in Math 022 who did not require additional mathematics requirements. For example, students who take Math 022 (Elementary Algebra) while pursuing a degree in the Licensed Practical Nursing degree program do not need additional mathematics. If included in the analysis, those students would have been categorized as not persisted when, in fact, they had completed their requirements and were a success by other measures. Another limitation was that students did not always adhere to the placement policy, resulting in some students being deleted in the study. If a student had multiple placement categories, they could take either the highest course they were placed into or any course lower than that course or, in some cases, students decided to delay their enrollment in mathematics.

Implications and Future Research

Due to an open-door policy, community colleges have been comprised of a large population of academically underprepared students, and those students will continue to need assistance with learning deficiencies as they pursue their college dreams. As Boatman and Long (2018) found in their recent study, "more attention must be paid to determining how to assess which students truly need remedial instruction before pursuing college-level work" (p. 54). Thus, placement policies will continue to be an area that needs to be researched. This study contributes to the growing research on the success and persistence of students in developmental mathematics courses based on high school placement evaluations. Evidence from this study suggests that multiple measures from high school transcripts are a more comprehensive approach to accurately place students into their respective courses because the information gathered captures a snapshot of the student over time versus information gathered from one test. More research comparing placement policies and student success and persistence needs to be conducted to determine what the best placement practices are for different types off colleges. Researchers need to be diligent in finding colleges that adhere to similar formats and cut off scores to compare student results. Information from this study can help advisors and instructors at this participating college continue to improve their placement practices. Educators will need to explore alternative assessment measures for non-traditional students or students without high school transcripts.

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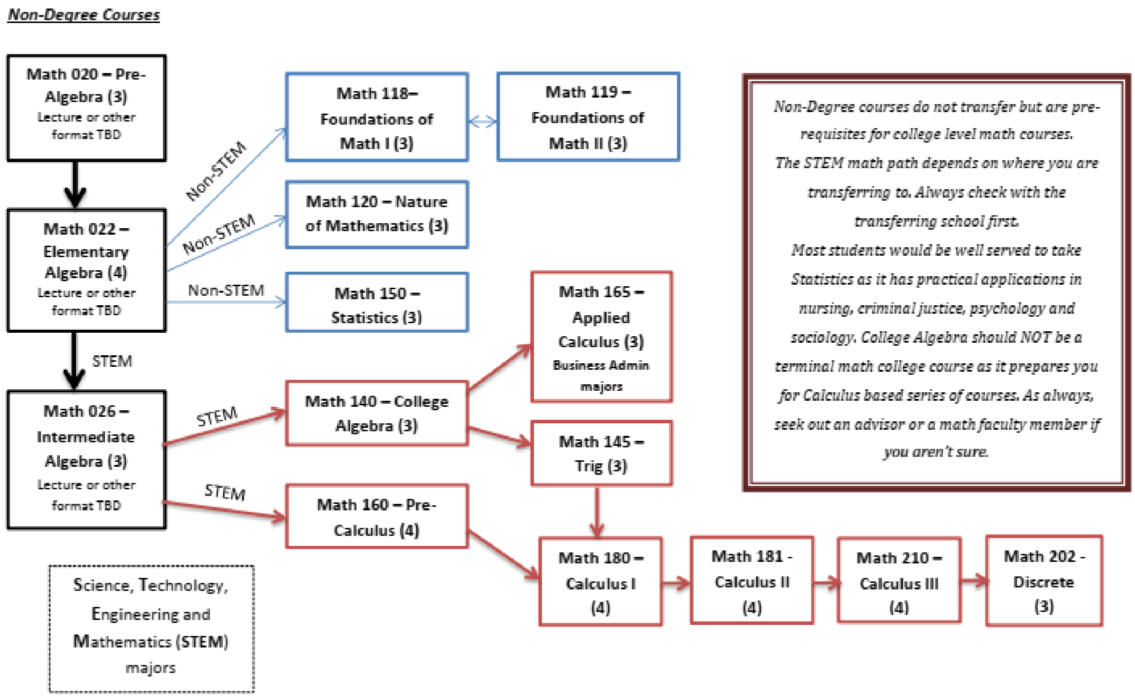

Figure 1: Mathematics Placement Chart at Northampton Community College

Table 2

Diversity of Developmental Mathematics Students by Course, Fall 2015 – Spring 2019

Ethnicity	Math 020		Math 022		Math 026		Math 028	
	N	%	*n*	%	*n*	%	*n*	%
American Indian	7	20.6	13	38.2	14	41.2	0	0.0
Asian	38	27.0	35	24.8	68	48.2	0	0.0
Black	666	34.7	733	38.2	509	26.5	10	0.5
Hispanic	771	29.7	1010	38.9	805	31.0	11	0.4
Multi-Racial	103	32.8	120	38.2	91	29.0	0	0.0
Non-Resident Alien	24	42.9	18	32.1	14	25.0	0	0.0
Pacific Islander	7	25.9	14	51.9	6	22.2	0	0.0
Undeclared	46	37.1	46	37.1	31	25.0	1	0.8
White	1071	24.1	1828	41.1	1524	34.3	24	0.5

Note: The total student population is 9658. Students in Math 028 had both Math 022 and Math 026 in the same semester.

Table 3

Types and Number of Developmental Mathematics Courses

	Math 020			Math 022			Math 026		
Semester	E	O	FtF	E	O	FtF	E	O	FtF
FA15	11	3	4	10	4	4	5	2	4
SP16	7	3	4	10	4	5	7	2	4
SU16	0	1	1	1	2	1	2	2	1
FA16	10	3	4	10	4	3	6	3	4
SP17	6	3	4	10	4	5	7	3	4
SU17	0	2	1	1	2	1	2	2	2
FA17	8	3	5	10	4	5	6	3	5
SP18	6	3	4	10	5	5	7	3	4
SU18	1	1	1	1	2	1	2	2	2
FA18	9	3	4	10	4	4	6	3	4
SP19	8	1	4	10	2	5	7	2	2

Note: E = Emporium, O = Online, FtF= Face-to-face, SP = Spring, SU = Summer, FA = Fall

Table 4

Placement Coding Policies per Mathematics Course

	Math 020	Math 022	Math 026 or Liberal Arts Math	Math 026 but requires College Algebra	College Algebra and above
High School Transcript (HST)					
HST Label 1 (GPA)	0	0	0 (GPA < 3.0) 100 (GPA≥ 3.0)	100	100
HST Label 2 (math course)	20	221	261/262	261/262	401/402 601/602 801
ACCUPLACER	A < 65	A ≥ 65 EA ≥ 50	A ≥ 65 EA > 60	EA > 61 CL > 0	CL > 0
SAT score					≥ 500

Note: A = Arithmetic, EA = Elementary Algebra, CL = College Level, QAS = Quantitative Reasoning, Algebra, and Statistics Exam

Table 5

Frequency Distribution of Placement Coding

	N	*M*	*SD*	*s*	020	022	026	CR
HST	9,398	3.21	1.897	3.599	2,217	2,142	1,253	3,786
ACCUPLACER	17,527	3.68	.852	.725	1,411	216	941*	14,959

Note: M = Mean; *SD* = Standard deviation; *s* = Variance. Any coding = 0 was removed for no data. CR = College Ready and above; * includes some students who could take a liberal arts math course.

Table 6

Research Questions for Study One

Research Question	DV	Data Type	IV	Defined	Data Type	Analysis
1A) To what extent did differences exist between student success rates by course placement for students placed by the HST criteria?	Dev Math Course Grade (A to C (pass), C- to F (fail), W)	Cat	Course Level	“1” = 020; “2” = 022; “3” = 026; “4” = College Ready (STEM & non-STEM) “1” = Math 020, “2” = Math 022, “3” = Math 026	Cat Cat	Chi-Square
1B) To what extent did differences exist between student success rates by course placement for students placed by the ACCUPLACER scores?	Dev Math Course Grade (A to C (pass), C- to F (fail), W)	Cat	Course Level	“1” = 020; “2” = 022; “3” = 026; “4” = College Ready (STEM & non-STEM) “1” = Math 020, “2” = Math 022, “3” = Math 026	Cat Cat	Chi-Square
2A) To what extent did differences exist between persistence rates by course placement for students placed by the HST criteria?	Persistence (“0” passed & persisted, “1” persisted & failed/withdrew “2” not persisted & passed, “3” not persisted & failed/withdrew)	Cat	Course Level	“1” = Math 020 & “3” = Math 026	Cat	Chi-Square
2B) To what extent did differences exist between persistence rates by course placement for students placed by the ACCUPLACER scores?	Persistence (“0” persisted & passed, “1” failed/withdrew but persisted “2” passed but not persisted, “3” failed/withdrew but not persisted)	Cat	Course Level	“1” = Math 020 & “3” = Math 026	Cat	Chi-Square

Note. DV = dependent variable; Cat = Categorical; W = Withdrawal; HST = High School Transcript

Table 7

Student Success and Course Placement Level Disaggregated by Placement Policy

	High School Transcript			ACCUPLACER		
Success Measures	MATH 020 *n* = 626	MATH 022 *n* = 643	MATH 026 *n* =335	MATH 020 *n* =734	MATH 022 *n* =136	MATH 026 *n* = 47
Passed	335 53.5%	373 58.0%	156 46.6%	215 29.3%	36 26.5%	18 38.3%
Failed	208 33.2%	180 28.0%	117 34.9%	203 27.7%	46 33.8%	10 21.3%
Withdrew	83 13.3%	90 14.0%	62 18.5%	316 43.0%	54 39.7%	19 40.4%

Note: ACCUPLACER and High School Transcript were conducted in separate analyses.

Table 8

Persistence in Mathematics Disaggregated by Placement Policy and Course Level

	High School Transcript		ACCUPLACER	
Persistence Measures	MATH 020 *n* = 626	MATH 026 *n* = 335	MATH 020 *n* = 734	MATH 026 *n* = 47
Dichotomous				
Persisted	474 75.7%	278 83.0%	51 6.9%	7 14.9%
Not Persisted	152 24.3%	57 17.0%	683 93.1%	40 85.1%
Categorical				
Passed & Persisted	269 43.1%	139 41.5%	21 2.9%	4 8.5%
Failed/Withdrew but Persisted	205 32.7%	139 41.5%	30 4.1%	3 6.4%
Passed but Not Persisted	66 10.5%	17 5.1%	194 26.4%	14 29.8%
Failed/Withdrew but Not Persisted	86 13.7%	40 11.9%	489 66.6%	26 55.3%

CHAPTER III: AN INVESTIGATION OF STUDENT INTRINSIC AND EXTRINSIC MOTIVATIONAL FACTORS AND PERCEIVED ANXIETY

This dissertation follows the style and format of *Research in the Schools (RITS)*.

Abstract

Community-college students are often not prepared for the mathematical work in their program and are placed into one or several developmental mathematics courses. One of the issues that may affect students' success is their perception of their negative affective reactions, worry, intrinsic and extrinsic motivational factors. The extent to which intrinsic and extrinsic motivation and anxiety differed by course modality and course grade at a suburban community college in Northeastern Pennsylvania was analyzed. The dataset comes from a post-survey given to all students in developmental mathematics in the spring of 2019, when students completed a total of 19 questions taken from the Motivational Anxiety Questionnaire and the Motivational Strategies for Learning Questionnaire (MSLQ). The sample size was small, but the results show that, regardless of the course modality, in general, developmental mathematics students were more worried about succeeding in mathematics and were extrinsically motivated.

Keywords: *course modality, emporium, face-to-face, online, developmental mathematics, remedial mathematics, instructional methods, extrinsic motivation, intrinsic motivation, worry, anxiety*

An investigation of student intrinsic and extrinsic motivational factors and perceived anxiety

In 1982, Pat Benatar released her album, *Get Nervous*. The lyrics focused on a person feeling anxious, nervous, and unable to breathe or talk. For many students, mathematics classrooms have the same effect (Hembree, 1990; Zientek, Yetkiner, & Thompson, 2010) and their success is impcated by mathematics anxiety (Ma, 1999). In a meta-analysis, Ma (1999) concluded that “when students' characteristics are diverse and unique, so are the relationships: Mathematics anxiety can facilitate mathematics performance, can debilitate mathematics performance, or can be unassociated with mathematics performance” (p. 536), but, generally, high levels of mathematics anxiety tend to debilitate mathematics performance. For many students, their expectations about their performance can be tied to intrinsic and extrinsic motivational factors. Intrinsic motivation is a person’s inclination to do a specific activity for its inherent satisfaction, while extrinsic motivation is when a person does an activity specifically for a particular outcome (Ryan & Deci, 2000). Pintrich and Schunk (1996) defined extrinsic motivation as wanting a reward to avoid punishment as opposed to wanting to learn the materials. The purpose of this study was to examine the differences in persistence and success rates of students in developmental mathematics courses based on a surveyed response by students on their perceived levels of anxiety, worry, extrinsic and intrinsic motivation.

Statement of the Problem

In 1999, Ma conducted a meta-analysis on mathematics achievement and anxiety from 26 studies primarily centered on elementary and secondary students. However, at the college level, studies of groups of developmental mathematics courses at community-colleges have been sparse. Low success rates, measured by passing grades, in developmental courses (i.e., remedial courses) along with a long progression through the course sequence has impeded progress for many remedial students towards a college degree (see Bahr, 2008; Bailey, Jeong, & Cho, 2010; Parsad, Lewis, & Greene 2003). Students often are required to complete several developmental mathematics courses, which adds additional costs for both students and institutions. Thus, post-secondary educators and policymakers have sought reformations to existing programs to decrease the costs of serving underprepared students while increasing the success rates at the institution (Lucas & McCormick, 2007). For many colleges, courses are now implemented in multiple delivery modes to increase student success in these courses, while decreasing the costs associated with them (Twigg, 2003).

The need for academic remediation is not a new phenomenon. Attewell, Lavin, Domina, and Levey (2006) found, in their analysis of data from the National Educational Longitudinal Study, that 58% of the high school graduating class of 1992 were required to take at least one remedial course for those who attended a two-year college. Of those students, "most took only one or two such courses, and most passed those courses successfully, usually in the first year" (p. 914). In 2016, Chen and Simone reported that of the students who began two-year post-secondary education in 2003-04, 59% of them were enrolled in at least one remedial mathematics course between 2003 and 2009. Moreover, they reported that only 50% of those remedial students completed their required developmental mathematics sequence. The Public Policy Institute of California (2016) disclosed that 80% of students in their community-colleges needed to take at least one remedial course, and 65% of them required remedial mathematics. Of the students that took remedial mathematics, only 27% successfully finished a college mathematics course with a C or higher. Despite the fact that failure rates in developmental mathematics courses have continued to be high, Bahr (2008) concluded that successful students in developmental mathematics courses had comparable success as students who were not required to complete those courses. However, most students who needed remediation did not complete their college-level mathematics course.

Mathematics anxiety might be impeding success in developmental mathematics, and, as such, it needs to be researched further. Research has indicated that mathematics anxiety levels for students enrolled in community-college developmental mathematics tend to be higher than for the general population (see Zientek et al., 2010). As noted by Rosin (2012), many developmental mathematics students enter those courses with increased mathematics anxiety, often as a consequence of repeated failures. Mathematics anxiety is not a new phenomenon at the college level. To some extent, “it seems socially acceptable to be anxious about math” (Beilock & Willingham, 2014, p. 29). The prospect of even engaging in mathematics can cause panic, fear, and trepidation for some. Furthermore, students’ motivation and persistence in mathematics can be tied to their beliefs and attitudes about their anxiety, knowledge, and confidence (Benken, Ramirez, Li, & Wetnedorf, 2015). Hembree (1990) did not find that poor performance *caused* mathematics anxiety but did find a relationship between the two. According to Hembree (1990), at mathematics anxiety at high levels is an emotional response that adversely affects a student’s ability to be successful. High anxiety levels may affect students in one of two ways: (1) avoidance of all math courses or subjects that rely on math or (2) negative influence on their attitude about mathematics (Kargar, Tarmizi, & Bayat, 2010).

Multiple research studies have found that potential success in a mathematics course can be traced to a students' mathematics anxiety (Ashcraft, 2002; Hembree, 1990; Kargar et al., 2010; Skaalvik, Federici, & Klassen, 2015). However, motivation is also important. In two different studies, Wang, et al. (2015) found that mathematics anxiety, itself, might not equate to poor math performance. Whereas students with low mathematical motivation and low performance tended to suffer from high mathematics anxiety, some students with high math motivation and high performance also experienced high mathematics anxiety.

Purpose of the Study

Developmental mathematics courses provide students an opportunity to remediate their skills upon entry to a college. The courses typically are non-credit to prepare students for college-credit mathematics courses. Because most degrees require a mathematics component, determining measures that can increase developmental mathematics students' success in college-credit mathematics courses is important. However, developmental mathematics students often need to complete multiple academic remediation courses prior to college-credit mathematics courses, and failure rates in the developmental courses has often been high (Bahr, 2008). Reformations to accelerate students through the developmental sequence have focused on different course modalities, such as emporium models where students remediate only on their weaker mathematics skills. Thus, more needs to be learned about the relationship between (a) motivation and anxiety and (b) student success in these courses. Understanding these relationships is a prerequisite to finding effective ways to shift the beliefs of students in a more positive manner in these learning experiences (Bonham & Boylan, 2012; Howard &

Whitaker, 2011).

Developmental mathematics courses offer a unique group to study because they share a tendency to contain students highly anxious about mathematics (Zientek et al., 2010) who come from very diverse backgrounds (Chen & Simone, 2016). The present study sought to determine developmental mathematics students' perceptions of their motivation and mathematics anxiety levels and the extent to which those perceptions differed by successful course completion levels relative to course modality. I examined students' perceived mathematics anxiety and their motivational factors and compared those data points to their actual course grade. Measures that were collected near the end of the semester were analyzed. The sample consisted of students enrolled in a developmental mathematics course at a community college in Northeastern Pennsylvania during spring 2019.

Conceptual Framework

Mathematical thinking is a key factor in helping people increase their chances of employment in an array of fields such as the military, education, and government (Hendijani, Bischak, Arvai, & Dugar, 2016; Tobias, 1978). However, to succeed in any endeavor, one must be motivated (Pintrich, Smith, Garcia, & McKeachie, 1991) and have the confidence to succeed (Bandura, 1997). The focus of this study was the extent to which community-college students' motivation and perceived mathematics anxiety levels differed by their success in developmental mathematics courses relative to course modality. This study was based on socio-cognitive theory and the interplay between anxiety and motivation. Given that many developmental mathematics students enter their mathematics classroom with high mathematics anxiety, this study assumes that two existing hypotheses were true: (a) mathematics anxiety began at a young age due to struggling with numbers and (b) mathematics anxiety was the result of social situations, which may affect peoples' belief about their ability to do math (Sokolowski & Ansari, 2017). Furthermore, there was an assumption of interplay between anxiety, motivation, success, and course modality. Similar to Hendijani et al. (2016), overall motivation was a conglomeration of extrinsic and intrinsic motivation.

Social Cognitive Theory

Social cognitive theory is the grounding theoretical framework for self-regulated learning and self-efficacy. Social cognitive theory tells us that achievement is based on the interactions between peoples' beliefs or thoughts, their behaviors, and their environment (Bandura, 1997). A supposition of social cognitive theory is that people who are motivated, based on their self-efficacy beliefs, will be more purposeful and goal-oriented individuals (Erlich & Russ-Eft, 2011).

While I did not measure mathematics self-efficacy, the importance of self-efficacy is relevant to this study, given that mathematics anxiety is a physiological state that has been identified as one of the four sources of self-efficacy (see Bandura, 1997; Usher & Pajares, 2009; Zientek, Fong, & Phelps, 2019). In fact, Bandura (1997) suggested that reducing anxiety should occur by addressing self-efficacy. Furthermore, Bandura (1986) characterized self-efficacy as peoples' perception of their capability to do what is required to obtain an outcome or particular goal. People with lower degrees of self-efficacy tend to have higher degrees of mathematics anxiety (Ma & Xu, 2004, Wigfield & Meece, 1988).

Mathematics self-efficacy has been identified as one of the best predictors of mathematical achievement (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1994; Zientek & Thompson, 2010) and can have either a negative or positive effect on an individual. Students with increased self-efficacy often persist longer, have more problem-solving strategies, and have been willing to attempt more difficult work (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995). Research has shown that behaviors about engagement, perseverance, and accomplishment can be predicted by peoples' self-efficacy (Bandura, 1997; Pajares, 1996). Multiple research studies have validated that a persons' opinion about their ability predicts their actual abilities (Ayotola & Adedeji, 2009; Pajares, 1996; Hoffman, 2010; Pajares, 2002). Furthermore, the achievement of students, academically, based on self-efficacy, has been evident in multiple research studies (Chen & Zimmerman, 2007; Hoffman, 2010; Karasel, Ayda, & Tezer, 2010; Usher & Pajares, 2009). These studies show that self-efficacy has been related to students' success. In addition, these self-efficacy beliefs held by students could be used in academic planning behavior as a predictor of change (Erlich & Russ-Eft, 2011).

Mathematics anxiety. For this study, social cognitive theory offers anxiety as a variable to rationalize potential differences in student success rates by course modality. Ashcraft (2002) defined mathematics anxiety as a "feeling of tension, apprehension, or fear that interferes with math performance" (p. 181). An adverse relationship exists between mathematics anxiety and mathematical performance (Andrews & Brown, 2015; Ashcraft & Kirk, 2001; Achcraft & Moore, 2009). People who have higher levels of mathematics anxiety often have lower levels of mathematics self-efficacy (Ma & Xu, 2004; Wigfield & Meece, 1988). According to Ho et al. (2000), effective mathematics anxiety was a more debilitating factor in student success than a cognitive one.

Hembree (1990) reported that researchers hypothesized that students who had poor achievement in mathematics would have the greatest negative feelings about the subject and, thus, would avoid mathematics as often as possible in their future. Furthermore, multiple studies have shown that students will avoid situations or activities that involve mathematics for those with high anxiety levels (Ashcraft, 2002; Dowker, Sarkar, & Looi, 2016). Further avoidance would cause their performance to continue to decline and, thus, reinforce their negativity about mathematics and increase their anxiety levels. Dowker et al. (2016) concluded that some mathematics anxiety may be due to cognitive learning disabilities; furthermore, most studies agree that the attitudes towards mathematics tend to change during adolescence.

Dislike of the subject has been identified as a negative reaction associated with mathematics anxiety. In a study by Howard and Whitaker (2011), developmental mathematics college students were interviewed, and results indicated that some "students expressed dislike and even hatred towards learning mathematics" (p. 5). Students in their study could remember what grade they were in or which teacher they had when they began to struggle with math and have negative feelings about it. Disliking mathematics, however, is not synonymous with mathematics anxiety. While students may claim to *dislike* math, this dislike does not necessarily mean they have mathematics anxiety. Even so, Hembree (1990) found that students who did not enjoy or have confidence in their mathematics tended to exhibit higher levels of anxiety. In other words, if someone does not like mathematics, they tended to be more anxious about doing math.

Addressing anxiety is important because students who exhibit more positive attitudes are often more motivated to embrace mathematical reasoning, logic, and content (Kargar et al., 2010). Cognitive-behavioral theory, which consists of restructuring beliefs that were faulty and building confidence in mathematics, has had some success in lowering mathematics anxiety. Behavioral treatments, particularly systematic desensitization, also helped lower anxiety (Chang & Beilock, 2016; Hembree, 1990; Zettle, 2003). As noted by Zettle (2003), "given the clinical status of mathematics anxiety as a type of specific phobia, it is not surprising that systematic desensitization … has been shown to be one of the most efficacious treatments for math anxiety" (p. 200). Classroom interventions, which included the use of classroom work on computers, allowing calculators, or presentation of material in different modalities such as "tutorial, small-group, and self-paced" did not tend to lessen mathematics anxiety (Hembree, 1990, p. 43). Addressing mathematics anxiety might differ by gender as Ma and Xu (2004) concluded that the origins of mathematics anxiety contrasted by girls and boys and suggested "that male mathematics anxiety comes from consistent poor mathematics performance in the past, whereas female mathematics anxiety becomes sensitive to poor mathematics performance only when girls are in critical transition periods" (p. 176). Ma and Xu (2004) proposed that reducing mathematics anxiety in boys requires increases in mathematics achievement, but for girls "one of the most effective ways to reduce mathematics anxiety is to prevent it from taking shape (because, for girls, mathematics anxiety has the tendency to last in a stable manner over time once it takes shape)" (p. 176).

Self-regulated learning. Given the relation between self-regulated learning, self-efficacy, and anxiety (Jain & Dowson, 2009) and the linkage between self-regulated learning and motivation (Zimmerman, 2002), a brief discussion about self-regulation is warranted. Jain and Dowson (2009) confirmed a model that mathematics anxiety was a function of both self-efficacy and self-regulation, and in order to reduce mathematics anxiety, both should be addressed. Furthermore, Jain and Dowson (2009) confirmed self-regulation had a direct impact on self-efficacy, which then had an impact on reducing mathematics anxiety levels. Self-regulated learning is when a student is proactively engaging their behaviors, emotions, and thoughts in an environment to fulfill a specific objective (Zimmerman, 2002). According to Zimmerman (2002), the “learner displays personal initiative, perseverance, and adaptive skills in pursuing [a goal]” (p.1). Students will actively participate in their learning, generating their own “thoughts, feelings, and actions to attain learning goals” (Zimmerman, 2002, p. 5). The responsibility for learning comes from the student taking active control (Erlich & Russ-Eft, 2011). Higher retention rates come from an increased desire to persist from students (Tinto, 1982). This desire to persist comes from internal student motivation. As the value component of self-regulated learning, how information is disseminated to students can affect both their motivation and anxiety levels.

Motivation: Intrinsic and Extrinsic

There are several theories associated with the motivation of people in the workplace, at home, and in the classroom. In addition to socio-cognitive factors, motivation is important to student success. Howard and Whitaker (2011) found that when students moved into a growth mindset, their attitudes positively correlated with motivation in mathematics. Behavioral theorists have dominated literature regarding motivation since the beginning of the 1900s (Middleton & Spanias, 1999). Multiple studies have shown that student motivation plays a central role in mathematics education (Middle & Spanias, 1999; Singh, Granville, & Dika, 2002). A person's motivation is the outcome expectation of one's self-efficacy or self-regulated learning. For many students, this proactive behavior (motivation), is the determining factor in whether or not they complete a course. Ryan and Deci (2000) define a motivated person as one "… who is energized or activated toward an end" (p. 54). Generally, motivation has been divided into two basic types: intrinsic and extrinsic.

These two terms first showed up in psychology by Woodworth in 1918 when he defined intrinsic motivation as some internal drive for an activity, while extrinsic motivation focused more on the reward (Locke & Schattke, 2018). Intrinsic motivation has often been called the value component of self-regulated learning because it looks to improve learning in some way. For example, students may be more motivated to complete a course if it is tied to their degree program. Those activities that are considered intrinsic motivators are enjoyable or purposeful (Pink, 2011).

Other students may be motivated by an extrinsic factor, such as pleasing their parents or receiving a bonus at work. Only the students, themselves, can determine what is a "reward" for motivating them to be successful. Students who are extrinsically motivated rely on accolade and feedback from their parents, peers, and teachers, to continue in a course (Middleton & Spanias, 1999), or to avoid an undesired outcome such as punishment (Ryan & Deci, 2000). According to Pintrich et al. (1991), "Intrinsic goal orientation concerns the degree to which the student perceives herself to be participating in a task for reasons such as challenge, curiosity, mastery" (p. 9). Extrinsic motivation complements intrinsic motivation, but the primary concern is not the task, rather, outcomes, such as course grades and perceived success in a course.

The meta-analysis of 128 studies conducted by Deci, Koestner, and Ryan (1999) provided “a means of quantifying effect sizes and combining them across studies” (p. 631). One of the major outcomes of their study was that receiving a verbal award resulted in enhanced intrinsic motivation for colleges students. However, when a task was interesting to the student, a tangible reward had a significantly negative effect on intrinsic motivation.

Course Modality

Course modalities were introduced at the participating college to accelerate students through the remedial process and provide them with an opportunity to receive instruction in different formats, such as in traditional, online, hybrid (i.e., combination of traditional and online), and emporium models. Acceleration is provided in emporium models where students work in a computer lab with assistance of tutors and instructors and remediate only on the topics in which they lack skills. Thus, they can cover more than one course in a given semester. However, students are required to master the concepts before moving to the next topic, where mastery is met by reaching a benchmark score on a test. Several studies and reviews of research have been conducted in the last few years focused on developmental mathematics courses and course redesigns (Arvich & Walker, 2014; Bassett & Frost, 2010; Bickerstaff, Fay, & Trimble, 2016; Hodara, 2013; Taylor, 2008). One study by Taylor (2008) found evidence that students who were enrolled in an emporium-style class, using the diagnostic ALEKS software system, performed on the same level as students in a traditional classroom, but the students using the ALEKS software exhibited a decrease in their anxiety levels. However, there has been a lack of research on different course modalities and students' motivation and anxiety levels at a time when online and emporium-style courses are being implemented. Thus, investigating students' mathematics anxiety and motivation in relation to course grades in different course modalities adds to the existing research.

A hypothesis that I had was that students in emporium models would exhibit higher levels of intrinsic and extrinsic motivation and lower levels of anxiety through their mastery experiences compared to those students in the online and face-to-face courses. Bandura (1997) found that mastery experiences were the strongest way to enhance a person's self-efficacy and self-regulated learning. Mastery learning ensures that a student cannot continue without reaching a threshold of success. At the community college in this study, mastery had to be reached before moving to the next section in the emporium sections. Before moving to the next section, students had to earn at least a 73% on their quizzes, 73% on their exam, and 85% on their homework. Students in emporium courses worked to meet deadlines, but at their own pace, thereby increasing their motivation to work harder and either finish a course early or complete a second course for free.

Research Questions

Dispositional factors such as "motivation, attitude in general, confidence/self-esteem, anxiety, persistence, and interest" have been identified by faculty members as a hindrance to student success (Zientek, Schneider, & Onwuegbuzie, 2014, p. 75). Most of the research on students' attitudes have been conducted in K12, traditional, face-to-face classrooms (Hembree, 1990; Ma, 199). However, advances in technology have led to changes in course formats (i.e. modalities) and developmental mathematics classrooms are comprised of many highly anxious students. This study contributes to knowledge about mathematics anxiety and motivation by focusing research on course modalities with a population that has been identified as highly anxious in mathematics.

Students enrolled in developmental mathematics courses in the emporium, face-to-face, or online modalities at a mid-sized, suburban community college in Northeastern Pennsylvania during the spring 2019 semester were surveyed. A hypothesis was that, regardless of course modality, students who were successful in their mathematics course would report high motivation factors and lower mathematics anxiety levels. The following research questions were investigated:

1. To what extent does post-intrinsic motivation, post-extrinsic motivation, and post-mathematics anxiety differ by course modality (i.e., among students who take online, traditional, or emporium courses)?
2. To what extent does course grade depend on post-intrinsic motivation, post-extrinsic motivation, and post-mathematics anxiety?

Method

This study used both a causal-comparative and correlational design. All students in developmental mathematics were asked to complete pre- and post-surveys that focused on mathematics anxiety and motivation. Statistical analyses were conducted to compare results for students in the emporium, face-to-face, and online sections across each level of developmental mathematics.

Selection of Participants

The population consisted of 735 students enrolled in developmental mathematics at a community college in Northeastern Pennsylvania. This setting was selected because it was the researcher's home institution and emporium courses were added in 2015. The three levels of developmental mathematics (Math 020, Math 022, and Math 026) were all surveyed, regardless of modality (face-to-face, online, or emporium). Two sections of Intermediate Algebra (Math 026) were not considered for survey or data collection as they were newly offered co-requisite courses for the spring 2019 semester only.

In the spring 2019 semester, 41 developmental mathematics courses were offered at this college. A total of 109 students responded to the pre-survey and 96 students responded to the post-survey. Table 9 contains the response rates for the pre- and post-surveys disaggregated by the number of sections per course and the number of students per section. Responses rates for the pre-survey were (a) 11.7% (24/206) for Math 020, (b) 21.4% (67/313) for Math 022, and (c) 8.3% (18/216) for Math 026. Responses rates for the post-survey were (a) 22.1% (25/113) for Math 020, (b) 24.4% (49/201) for Math 022, and (c) 19.3% (22/114) for Math 026. All post-survey total numbers are based on the number of students who took the final exam. There were 89 female students compared to 20 male students who responded to the pre-survey and 68 female students compared to 22 male students who responded to the post-survey. Two students did not respond as either male or female. Response rates by course type for students who completed both surveys were 3.27% (13/98) for emporium, 24% (12/50) for face-to-face, and 14.04% (8/57) for online. Because of low response rates, all analyses were limited to post-survey responses.

Students who completed the post-survey passed their remedial course at 83% for the Emporium, 86% for the Face-to-face, and 67% for the Online courses. Pass rates of those students surveyed were higher than the total population as seen in Table 10.

Students who completed the post-survey were predominately White (52.2%) followed by Hispanic (21.7%) and Black (8.7%) students. The characteristics of the post-survey sample are reported in Table 11.

Procedures and Research Design

Students were chosen using a purposeful convenience sampling strategy. Only students who were currently registered in a developmental mathematics course were asked to participate. As the data was collected at the researcher's home institution, Sam Houston State University's Institutional Review Board allowed the research to fall under the guidance and direction of the researcher's home institution (see Appendix A). After approval from the Northampton Community College Office of Institutional Research Board, the survey link was emailed to students. The letter of request for consent and survey can be found in Appendix B. Data were collected using Survey Monkey, which is a commercial product. The participating community college purchases a subscription to Survey Monkey (2019), which is an international company used by 650 employers every day, and they have security protocol practices in place.

All students were emailed a link to the mathematics anxiety and motivation survey on an external website by their professors during weeks five through seven and again during weeks 12 through 15 of the spring 2019 semester. Students were given three weeks to complete the survey during the first iteration and three weeks to complete the survey during the second iteration. Faculty were asked to take ten minutes out of class time to allow students to participate in the survey. Participation was voluntary, and students could opt-out at any time. Faculty members did not know which students completed or did not complete the survey. Participants had to give consent before they could access the survey instrument. For course completers in emporium courses, the post-survey could be taken any time after they completed the course. For face-to-face and online students, this could only be completed at the end of the semester.

A causal-comparative research design was employed to compare multiple groups in terms of the course that was already chosen (Creswell, 2014). This design was chosen, given there was no way to randomize the students taking developmental mathematics courses, and it allowed the researcher to determine a relationship between success rates and the modality of the developmental mathematics course. There was a need to determine what differences existed, if any, between the groups to determine if students in emporium courses differed in their motivational and anxiety compared to those in traditional or face-to-face courses, and whether those factors influenced students' course grades at the college. Manipulation of the independent variable (i.e., course modality) in this nonexperimental design cannot occur as students self-selected into their respective developmental mathematics courses (Johnson & Christensen, 2014). The independent variable was course modality, which was identified by the course and section number. Passing the course was the dependent variable. A student had to earn a C or higher to continue to the next course. Course grades were manually retrieved from the college's database of student information, and the researcher inputted the grades into the data file.

Instrumentation

Students completed two instruments on motivation and mathematics anxiety that were merged into one cohesive questionnaire, consisting of eight questions about motivation and eleven questions about mathematics anxiety. Additional questions asked about student ID, gender, ethnicity, and course modality. Survey items are in Appendix C.

Intrinsic and extrinsic motivation. Students responded to eight questions from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991). Four questions focused on intrinsic motivation and four questions focused on extrinsic motivation (Pintrich et al., 1991). Students rated their motivation beliefs in their developmental mathematics course on a 7-point Likert scale ("1" = not at all and "7" = very much).

Intrinsic and extrinsic goal orientation items were chosen to determine a student's general goals in a course. For intrinsic goal orientation, Pintrich et al. (1991) reported a Cronbach alpha score reliability of .74 with a correlation with final grades to be an r = .25. Holland et al. (2018) found that across 112 studies, alpha ranged from .37 to .88 with a 95% confidence interval of the mean having a lower bound of .703 and an upper bound of .719. In this study, Cronbach's alpha score reliability for intrinsic goal orientation was .822 for the post-survey.

The extrinsic goal orientation subscale was used to measure students' perception of why they participated for a specific reason such as grades, competition, or degree program. For extrinsic goal orientation, Pintrich et al. (1991) reported a Cronbach alpha score reliability of .62. Holland et al. (2018) found that across 82 studies, alpha ranged from .48 to .92 with a 95% confidence interval of the mean having a lower bound of .685 and an upper bound of .703. In this study, Cronbach's alpha score reliability for extrinsic goal orientation was .785 for the post-survey.

Mathematics anxiety. Following the book published by Liebert and Morris (1967) that focused on test anxiety, Wigfield and Meece (1988) developed an instrument with 22 items that measured six dimensions of negative reactions to math or anxiety: (a) dislike, (b) lack of confidence, (c) worry, (d) confusion/frustration, (e) fear and dread, and (f) discomfort. Wigfield and Meece (1988) focused on 11 items related to students' concerns about their mathematics anxieties. For this study, the items were Fear and Dread (see items 1 - 7 in Appendix C), which I refer to from now on as the negative affective reaction (NAR), and Worry (see items 8 - 11 in Appendix C). Permission to use this instrument can be found in Appendix D. The MAQ was used because 11 items were easier to implement in the period than other existing mathematics anxiety instruments. Responses to each item were on a Likert scale from 1 (not at all) to 7 (very much). In this study, Cronbach's alpha score reliability for the MAQ was .923 for the post-survey.

Mathematics course grades. Final course grade was the dependent variable for research question two and was used to measure success. Course grades were given to all developmental mathematics students as an indicator of readiness for the next math course at this community college. Successful completion of a mathematics course consists of 73% (C) or higher. In the present study, regardless of course or modality, all students who did not pass could earn a D, F or I.

Emporium students who received an "I" grade had to sign a contract to finish the course prior to the start of the next term. If they refused to sign the contract, they were given a "D". The purpose of awarding the D was for tracking students who came close to finishing the course (within one module) but did not complete the course for a variety of reasons that cannot be quantified. This was different than a "D" received in a face-to-face or online course, which was earned based on the entirety of the coursework. Emporium students also could receive an "F" for not completing enough of the course and not taking a "W". Regardless, no one could take the next math course without a “C” or higher. Historically, it is a rarity that faculty members ever record a grade of "I" for a student because the “I” gives students five months to complete a course and they cannot take the next course while that one is incomplete.

All faculty should report a "C-" for a grade below 73, but no accountability exists to determine adherence to this policy. In other words, there is a possibility an instructor passed a student who earned a 70-72, but we will assume that almost all the instructors adhered to the college grading policy and did not pass those students. Students who received a C- were grouped with those students who earned an “F” as that is considered a non-successful completion. Students who received a “W” at the end of the semester were also grouped with the “F” grades as Northampton equates a withdrawal late in the semester as a failure. Earning a grade of C- or less or withdrawing from the course was coded as not passing.

Course grades were determined by weighting the homework (15%), quizzes (10%), exams (50%), final exam (20%), and participation in the course (5%). All instructors administered a common final exam in all course modalities. Emporium courses have common exams after each module, and online and face-to-face courses have common exams after a set number of modules. Students in the online and face-to-face course had only one attempt on any given exam. Except for the final, students in emporium courses can retake any exam multiple times.

Data Analysis

Table 12 contains the independent and dependent variables and data type. The modality of the developmental courses was independent of each other, as students could self-select which instructional method they would prefer in each semester. A multivariate analysis of variance (MANOVA) was conducted to answer the first research question: To what extent does post-intrinsic motivation, post-extrinsic motivation, post-NAR, and post-Worry differ by course modality (i.e. among students who attend online, traditional, and emporium courses)? A MANOVA simultaneously considers the variables in the analysis and assumes that the observations are independent of one another and that the independent variable is categorical (Nimon, Zientek, & Kraha, 2016). A MANOVA was conducted, as there were several dependent variables (i.e., intervalscaled motivation and mathematics anxiety) and a categorical independent variable (i.e., course modality). The latter was coded as “0” for Emporium, “1” for Face-to-face, and “2” for online. The null hypothesis was that no relationship existed between the dependent variable and the independent variables.

The original intent was to conduct a binary logistic regression to answer research question two: To what extent does course grade depend on post-intrinsic motivation, post-extrinsic motivation, and post-mathematics anxiety? However, the sample size was too small. Therefore, *t*-tests were conducted to determine the extent to which the constructs of motivation and mathematics anxiety differed by success in the course. Incompletes were removed from the data because the final score could not be ascertained.

Results

Because of the low response rate, based on the initial 735 students who registered for the courses, results were limited to post-survey responses. Table 13 contains the 96 students who completed the post-survey disaggregated by course modality. Four students did not take the final; thus, analyses with grades were limited to 21.5% (*n* = 92) of the 428 students who completed the final exam and post-survey.

Research Question 1. For the MANOVA, the dependent variables were Post-Negative Affective Reaction (NAR), Post-Worry, Post-Intrinsic Motivation, and Post-Extrinsic Motivation. Multivariate normality was tested before running the MANOVA. The graph of the Mahalanobis D^2 versus chi-square plots was approximately linear (see Figure 2) indicating that, overall, the multivariate normality was not violated on measures of Motivation, NAR, and Worry. Only one person appeared to be an outlier, categorizing himself or herself as both low intrinsically and high extrinsically motivated. This person was not removed from the data. Box's M for the post-test indicated that the assumption of homogeneity of covariance matrices was met ($p = .222$) with an alpha level of $\alpha = .05$. No statistically significant differences existed in anxiety and motivation measures by modality (F (8, 180) = .61481 Wilk's $\lambda = .94751$, $p = .765$) with a small effect size (1- λ = .05249) and a power of .28.

Table 13 contains the descriptive statistics and confidence intervals of the means. Across modalities, similarities existed in students' responses. On average, responses to Worry and Extrinsic Motivation were higher across all modalities than NAR or Intrinsic Motivation. Thus, students were more likely to be worried about their performance in the class than they were to have NAR about mathematics. As seen in Figure 3, confidence intervals overlapped across course types for all variables. Although the mean NAR scores were slightly less for the emporium model, overlapping confidence intervals in Figure 3 further supported that no noteworthy differences existed. Future research should be conducted with larger samples to explore this phenomenon further.

Research Question 2. Table 14 contains the post-survey results of students' perceptions of their NAR, Worry, Intrinsic motivation, and Extrinsic motivation based on course success (i.e.., passed vs. failed). Because multiple *t*-tests were conducted, a Bonferroni's correction was applied; p values less than .05/4 = .0125 were considered statistically significant. Levene's test for equality of variance assumption was met. Results from *t*-tests displayed in Table 15 indicated that no statistically significant differences existed on motivation and anxiety measures by course success. Boxplot comparisons provided in Figure 4 further support that finding. Because of low power, it is suggested that this study be repeated with a larger sample size as part of future research. Because reporting correlation matrices and matrix summaries enable interpretations of relationships between variables as well as encourage meta-analytic thinking (Zientek & Thompson, 2009), correlations disaggregated by passing the course are provided in Table 16. Worry was correlated at a noteworthy level with both Intrinsic and Extrinsic Motivation.

Discussion

Research supports my assumption that mathematics anxiety hinders a student's success (Hembree, 1990; Ma, 1999). Given the adoption of various course modalities that have the potential of increasing success rates through mastery experiences, a hypothesis can be posited that different learning modalities can result in differing levels of Negative Affective Reactions (NAR), Worry, and motivation to learn mathematics. While the results of this study were limited in scope, location, and sample size, a profound finding was that, regardless of course modality, this sample of developmental mathematics students (a) tended to be worried about their overall success in doing mathematics and (b) were more likely to be extrinsically motivated than intrinsically motivated. The ability to make claims about modality differences were hampered by low power.

Comparison of Groups

Based on the data collected, statistically significant differences did not exist in students' perceptions of their NAR, Worry, Extrinsic Motivation, and Intrinsic Motivation by course modality or by course success. Even though power was insufficient because of the small sample, results add to the existing literature.

Course modality. Reward is one of the key factors of motivation and is used in a variety of forms throughout our lives such as pay raises, gold stars and merit pay (Hendijani et al., 2016). The adoption of emporium courses was meant to increase student success, which means an extrinsic reward would be the completion of the developmental sequence in a shorter timeframe than a traditional course sequence. However, results of this study suggest that emporium and online developmental mathematics courses were not more successful in creating intrinsically motivated students than traditional face-to-face courses. Students' extrinsic motivation was high across all modalities. Results from this study support the notion by Deci et al. (1999) that, while increased success in courses might improve student engagement, it does not always improve intrinsic motivation or the desire to learn and do mathematics. Ryan and Deci

(2000) found that extrinsic motivation required less effort to produce immediate results than intrinsic motivational factors. Several studies have illustrated that students' intrinsic motivation could be negatively impacted by the extrinsic motivational factors (Deci & Ryan, 1980; Bain, 2004; Biehler & Snowman, 1990). Thus, when emporium models focus only on the reward outcome of passing quickly through the sequence instead of changing curriculum that will help students' value mathematics, intrinsic motivation might not be increased. Regardless of course modalities, benefits of learning mathematics need to be linked with the value of learning mathematics, rather than just the successful passing of the course.

It was hypothesized that emporium students would rate their mathematics anxiety constructs low (i.e., NAR and worry levels) because their ability to proceed was contingent on success measures built into the course that required exhibiting mastery regularly throughout the semester. In regard to NAR, no statistically significant differences existed, and non-overlapping confidence intervals suggests that, even in the presence of low power, no differences existed by course modality. However, a simple comparison of mean ratings suggests the possibility that students in emporium courses could be slightly lower but not detectable. That fact combined with Taylor's (2008) findings that students in emporium models ended the course with less NAR suggest more research should be conducted on anxiety by course modality with larger sample sizes.

Course success. Research suggests that those students with lower achievement in mathematics have higher levels of mathematics anxiety (Ma, 1999). This study looked at two constructs of mathematics anxiety: NAR and worry. Even though statistically significant differences were not found on NAR by course success, comparisons of boxplots and means suggest that differences did exist on the NAR of mathematics anxiety. Comparisons of means in Table 14 suggest that post-anxiety means were higher for the 20 students who failed the course compared to the 72 students who passed the course. Boxplots in Figure 4 provide a valuable illustration of the spread of data by dividing the data into four intervals (i.e., 25% of data in each interval) and identification of median scores. Boxplots provide further information about Worry, mainly, that both groups worried about their ability to do well in mathematics, but the distribution of scores was narrower for the students who failed the course. Boxplots in Figure 4 indicated that, of the students who did not pass the course, at least 75% rated their Worry at about a 5.5 or higher on a 7-point scale and, except for a couple of outliers, all rated their Worry at about a 4.5 or higher. Thus, students tended to worry about their success in mathematics. Of the students who passed the course, Worry ranged from 1 to 5 and at least 50% rated their Worry levels at least a 5 on a scale from 1 to 7. In other words, students who failed almost all tended to exhibit a measure of worry at the end of the course, but the passing students' ratings were more dispersed.

Across Groups

Worry. Students' responses in this study suggest that developmental mathematics instructors need to understand that worrying about doing mathematics is a real phenomenon that might be occurring with their students, regardless of success. Thus, students were more worried about their mathematics than having NARs. The magnitude of Pearson's r indicated that Worry was positively correlated at a noteworthy level with both negative affective reactions and extrinsic motivation and, at a somewhat lesser level, with intrinsic motivation.

Intrinsic and extrinsic motivation. Mean motivation scores in Table 14 and boxplot comparisons in Figure 4 illustrate that, regardless of course success, on average students were more extrinsically than intrinsically motivated. The medians in the boxplots were almost identical and just above a 4 for both the passing and non-passing group, although the not passing group had scores that were slightly skewed in the direction of more worry. Thus, students were choosing values of intrinsic motivation near the middle and not necessarily exhibiting low or high intrinsic motivation levels. Regarding extrinsic motivation, boxplot comparisons indicated students tended to be extrinsically motivated.

Limitations

All studies have some limitations. A limitation of this study was the lack of student participation, and therefore, lack of data collected from the entire population. While there was a mix of survey responses from all modalities, only about 92 of the post-surveys were collected. The number of Black students who responded was lower than the college demographics, which might be biased by a certain population, i.e. White students. This study also did not use longitudinal data because of the small response rate. A final limitation is the inability to capture the beliefs of students who did not pass the course.

Implications and Future Research

When adopting various course modalities, colleges should understand the students they serve. In this study, an attempt was made to understand students' beliefs and, more specifically, the extent to which students' perceptions of their NAR, worry, intrinsic, and extrinsic motivation levels differed by course modality. Negative affective reactions and worry about doing mathematics are important to because those students who are more confident and less anxious tend to be more successful (Phan, 2012; Zakaria, Zain, Ahmad, & Erlina, 2012). Claims of differences by modality on the affective measures could not be made because of the low power. However, evidence suggests that more research needs to be conducted on worry by course modality for possible effects that emporium students might exhibit less anxiety at the end of the course (Taylor, 2008).

Regardless of course modality or student success in a developmental mathematics course, many students worried about their academic performance and reported themselves as extrinsically motivated. Reasons for exhibiting high levels of extrinsic motivation and worry might be incited by a desire to meet transferability and degree requirements that require specific GPAs. Post-secondary institutions should encourage their instructors to receive training on alleviating worry and anxiety and helping students become intrinsically motivated (Posamentier, 2017). This training would provide instructors with techniques to increase intrinsic motivation, including revealing gaps in knowledge, providing opportunities for challenges, and relating mathematics applications to the real world (see Posamentier & Krulik, 2016). A follow-up study could determine the effects of these methods on increasing intrinsic motivation. Given the study limitations, future studies should include larger samples, as well as, take a longitudinal view of the data. Furthermore, determining if initiatives can reduce withdrawal rates might result in students that have higher levels of self-efficacy, are less worried, and seek to learn for the sake of learning, and, thus, might result in higher persistence rates.

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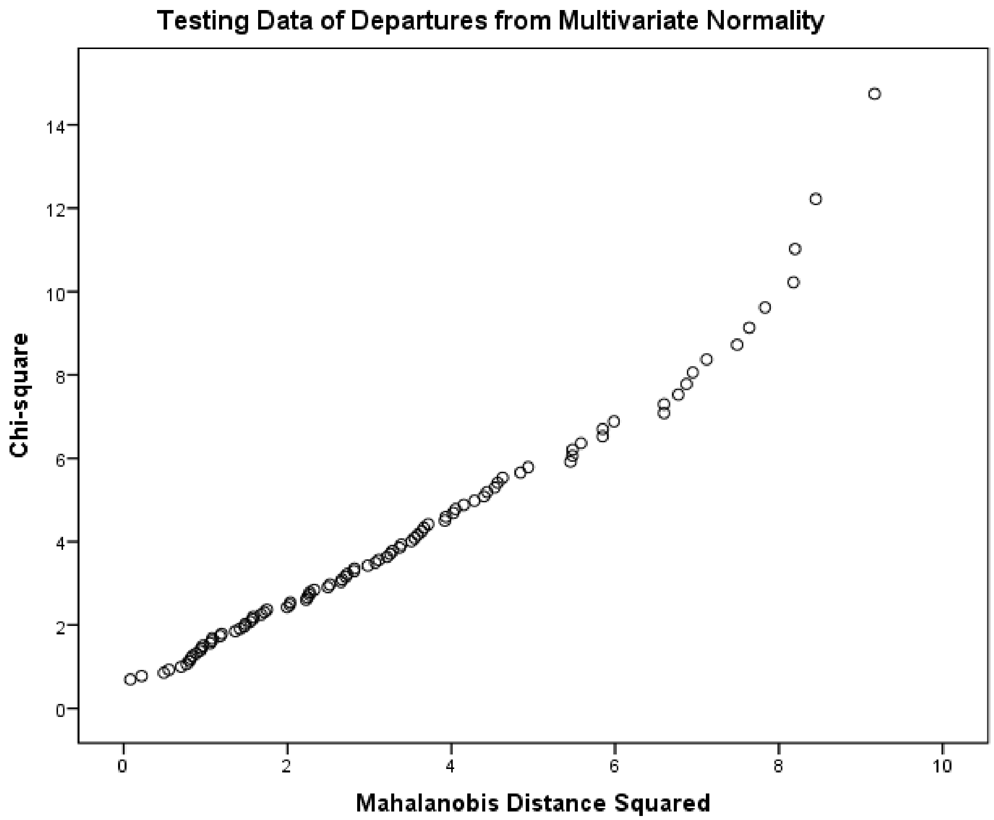

Figure 2: Investigations of normality for NAR, worry, intrinsic motivation, and extrinsic motivation.

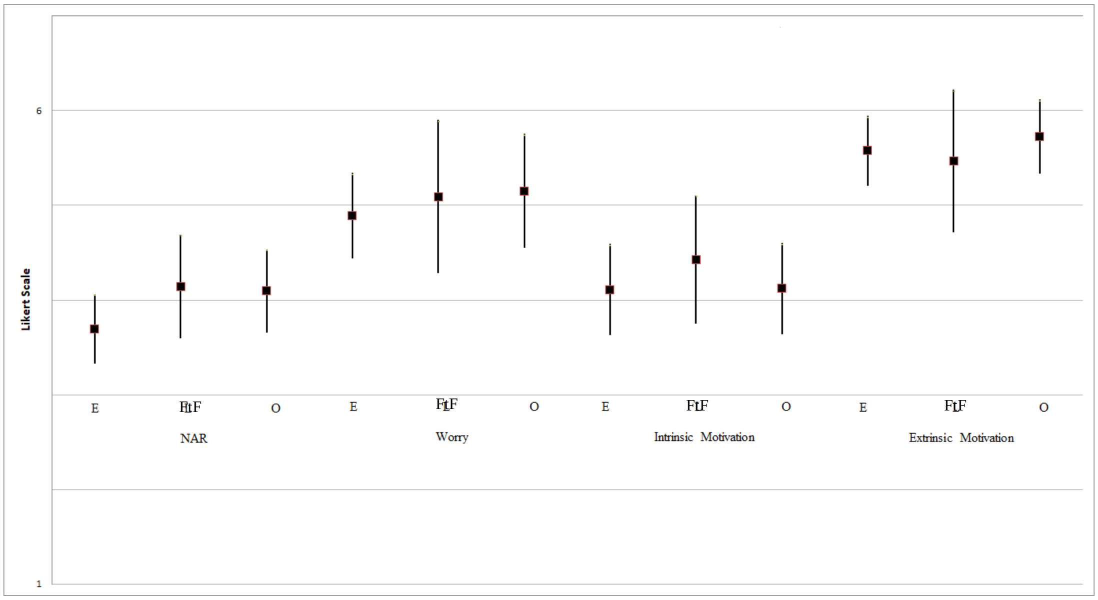

Figure 3: Confidence intervals of mean ratings on negative affective reaction (NAR), worry, intrinsic motivation, and extrinsic motivation.
Note. E = Emporium; FtF = Face-to-face O = Online.

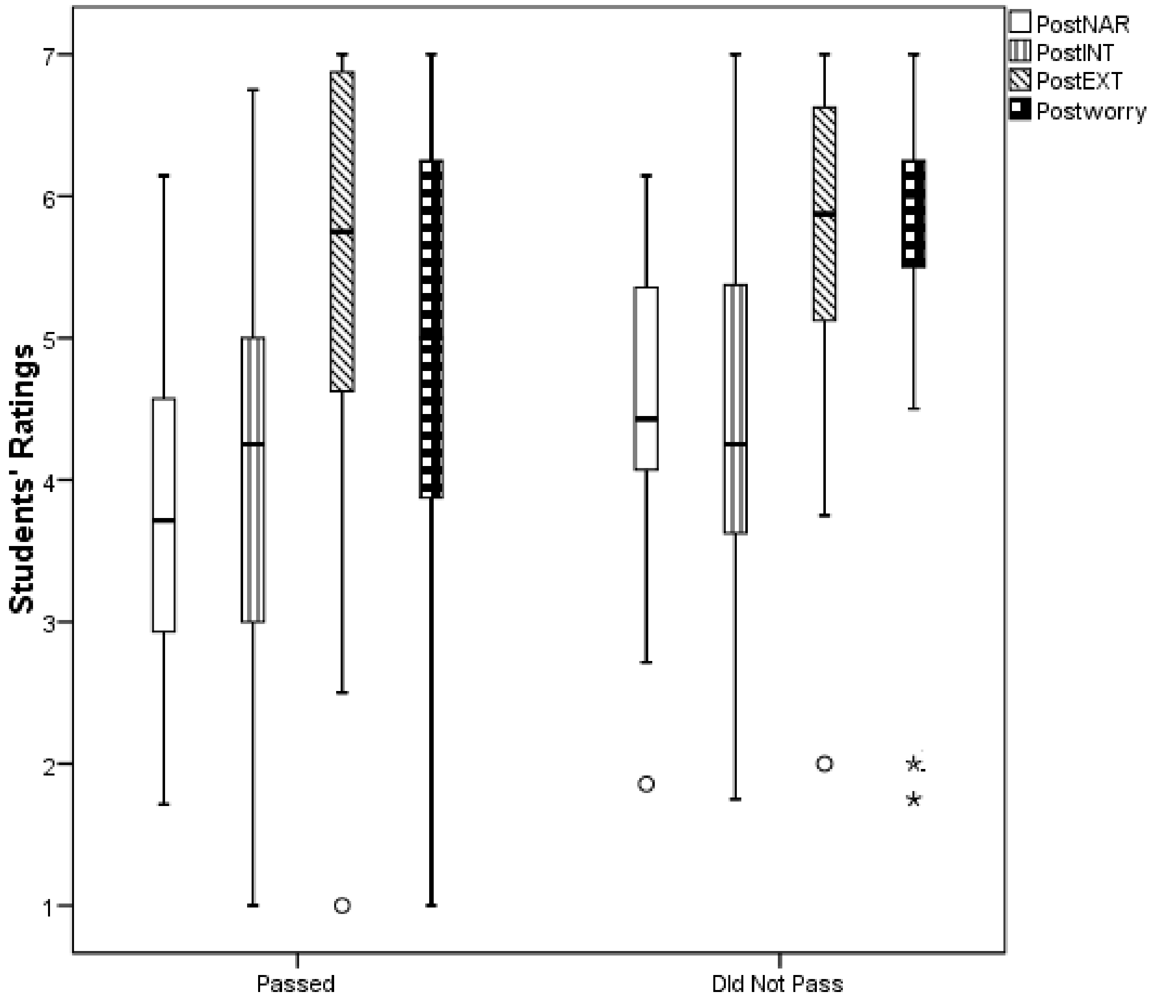

Figure 14: Boxplot comparisons of students' responses to post-survey items disaggregated by passing or not passing the course.
Note. Circles and asterisks are outliers. PostNAR = Post-Negative Affective Reactions; PostINT = Post-Intrinsic Motivation; PostEXT = Post-Extrinsic Motivation; PostWorry = Post-Worry.

Table 9

Developmental Mathematics Course Enrollment, *Spring 2019*, and *Student Response Rates by Course Modality Based on Enrolled Numbers*

	Math 020	Math 022	Math 026
Enrollment			
Emporium	111[a] (S = 8)	180[a] (S = 10)	140[a] (S = 7)
	47[b] (S = 8)	107[b] (S = 4)	74[b] (S = 1)
Face-to-Face	70[a] (S = 4)	85[a] (S = 5)	39[a] (S = 2)
	51[b] (S = 4)	68[b] (S = 5)	25[b] (S = 2)
Online	25[a] (S = 1)	48[a] (S = 2)	37[a] (S = 2)
	15[b] (S = 1)	26[b] (S = 2)	15[b] (S = 2)
Pre-Survey			
Emporium	15 (13.5%)	33 (18.3%)	11 (7.9%)
Face-to-Face	7 (10.0%)	15 (17.6%)	4 (10.3%)
Online	2 (8.0%)	19 (39.6%)	3 (8.1%)
Post-Survey			
Emporium	7 (14.9%)	25 (23.4%)	7 (9.5%)
Face-to-Face	9 (17.6%)	11 (16.2%)	4 (1.6%)
Online	9 (60.0%)	13 (50.0%)	11 (73.3%)

Note. S = Number of sections.

[a] These numbers are the original values for those registered for each course.
[b] These numbers correlated with those who took each final for each course.

Table 10

Percentage of Successful Students, Spring 2019

	Post-Survey Results		College Data	
	Passed	Failed/Withdrew	Passed	Failed/Withdrew
Emporium	83%	17%	47%	53%
Face-to-Face	86%	14%	49%	51%
Online	67%	33%	32%	68%

Note: The *N* = 96 for the survey was only a small proportion of the total of students who completed the courses. College Data from Math Lab Manager, personal communication, June 6, 2019.

Table 11

Demographic Characteristics of Participants Post-Survey (N = 92)

Characteristic	*N*	%
Gender		
Male	22	23.9
Female	68	73.9
Not Answered	2	2.2
Course Name[a]		
Math 020	24	26.1
Math 022	46	50.0
Math 026	21	22.8
Course Modality[a]		
Emporium	36	39.1
Face-to-Face	22	23.9
Online	33	35.9
Course Grade		
A	17	18.5
B	35	38.0
C	20	21.7
D	9	9.8
F/W/C-	11	12.0

Note: Total of percentages are not 100 for every characteristic
because of missing data.

[a] One piece of data is missing

Table 12

Research Questions for Study Two

RQ	DVs	Type	IV	Type	Test
(1) To what extent does post-intrinsic motivation, post-extrinsic motivation, and post-mathematics anxiety differ by course modality (i.e., among students who attend online, face-to-face, and emporium courses)?	Motivation and Math Anxiety	Interval scale (1 to 7)	Course Modality	Categorical ("0" = E, "1" = FtF, "2" = O)	MANOVA
(2) To what extent did post-intrinsic motivation, post-extrinsic motivation, and post-mathematics anxiety differ by success in the course?	Motivation and Math Anxiety	Interval scale (1 to 7)	Success	Dichotomous (Pass or Fail/W)	*t*-tests

Note. RQ = Research question; DV = dependent variable; IV = independent variable; E = Emporium, FtF = Face-to-face; O = Online

Table 13

Student Perceptions of Anxiety, Worry, Intrinsic, and Extrinsic Motivational Factors by Course Modality

				95% Confidence Interval for Mean	
Students' Perceptions	*n*	Mean	*SD*	Lower Bound	Upper Bound
Emporium					
NAR	39	3.696	1.110	3.336	4.056
Worry	39	4.891	1.369	4.447	5.335
Intrinsic	39	4.109	1.458	3.637	4.581
Extrinsic	39	5.577	1.109	5.217	5.937
Face-to-Face					
NAR	24	4.143	1.280	3.602	4.683
Worry	24	5.094	1.891	4.295	5.892
Intrinsic	24	4.427	1.587	3.757	5.097
Extrinsic	24	5.469	1.756	4.727	6.210
Online					
NAR	33	4.095	1.217	3.664	4.527
Worry	33	5.152	1.680	4.556	5.747
Intrinsic	33	4.121	1.327	3.651	4.592
Extrinsic	33	5.727	1.080	5.344	6.110
TOTAL					
NAR	96	3.945	1.196	3.703	4.187
Worry	96	5.031	1.606	4.706	5.357
Intrinsic	96	4.193	1.439	3.901	4.484
Extrinsic	96	5.602	1.281	5.342	5.861

Note. NAR = Negative Affective Reaction.

Table 14

Student Perceptions of Anxiety, Worry, Intrinsic, and Extrinsic Motivational Factors by Course Grade

				95% Confidence Interval for Mean	
Student Perceptions	*n*	Mean	*SD*	Lower Bound	Upper Bound
Pass (A, B, C)					
NAR	72	3.79	1.15	3.52	4.06
Worry	72	4.78	1.70	4.38	5.18
Intrinsic Motivation	72	4.05	1.45	3.71	4.39
Extrinsic Motivation	72	5.57	1.30	5.27	5.88
Fail (C-, D, F, and W)					
NAR	20	4.45	1.15	3.91	4.99
Worry	20	5.56	1.44	4.89	6.23
Intrinsic Motivation	20	4.41	1.47	3.72	5.10
Extrinsic Motivation	20	5.61	1.26	5.02	6.20
TOTAL					
NAR	92	3.93	1.17	3.69	4.17
Worry	92	4.94	1.67	4.60	5.29
Intrinsic Motivation	92	4.13	1.45	3.83	4.43
Extrinsic Motivation	92	5.58	1.29	5.32	5.85

Note: NAR = Negative Affective Reaction. There were 4 students whose grades were not collected due to inaccurate student IDs.

Table 15

T-Test Results for Differences in Perceptions by Passing or Not Passing the Course

				95% CI	
Variables	*t*	*p*	Mean Difference	Lower	Upper
PostNAR	–2.295	.024	–.66429	–1.23930	–.08927
PostWorry	–1.887	.062	–.78472	–1.61079	.04135
PostINT	– .992	.324	–.36389	–1.09252	.36475
PostEXT	– .121	.904	–.03958	– .68946	.61029

Note: df = 90; PostNAR = Post-Negative Affective Reactions; PostINT = Post-Intrinsic Motivation; PostEXT = Post-Extrinsic Motivation; PostWorry = Post-Worry.

Table 16

Correlations of Success, Affective Measures, and Motivation by Post-Survey Results

	PassFail	PostNAR	PostINT	PostEXT	Postworry
PassFail	–				
PostNAR	.235*	–			
PostINT	.104	.167	–		
PostEXT	.013	.268**	.261*	–	
Postworry	.195	.675**	.331**	.453**	–

Note: Significant correlations are marked with asterisks (*$p < .05$ and **$p < .01$)

CHAPTER IV: AN INVESTIGATION ON COURSE MODALITIES: DIFFERENCES IN STUDENT PERSISTENCE AND SUCCESS

This dissertation follows the style and format of *Research in the Schools (RITS)*.

Abstract

This study investigated the extent to which differences were present in the final exam score, course grades and persistence in mathematics by course modality for students enrolled in developmental mathematics at a suburban community college in Northeastern Pennsylvania from fall 2015 through spring 2019. Statistically significant differences were revealed in final exam score and course grades by course level. Results from the dichotomous persistence variable varied by course, but statistically significant differences existed by categorical persistence. Results indicated that emporium models, designed to provide a semi-structured schedule, prompt feedback, and frequent interactions with tutors and faculty are viable options for middle- and upper-level courses with comparable success to face-to-face courses, but not for pre-algebra courses. Success rates in that modality were lower than the other modalities. Results of this study may have implications for post-secondary institutions that want to begin offering developmental mathematics courses in multiple modalities.

Keywords: *course redesign, persistence, success, developmental mathematics, course modality*

An investigation on course modalities and differences in student persistence and success

Low success rates, along with requirements of completing multiple developmental mathematics courses for many students, has created a movement to redesign existing developmental education programs. Conversations continue between and among post-secondary educators, administrators, and policymakers as they seek to decrease the costs of serving underprepared students (Lucas & McCormick, 2007). Many colleges have attempted to decrease students' time and costs associated with placement in developmental education courses by offering multiple delivery modes (Twigg, 2003). Online and emporium are two such modes, but emporium modes offer students an opportunity to accelerate through the program and, thus, save time and money. This counters the traditional introductory-level mathematics course offerings at community colleges that were primarily taught in a face-to-face format. This study seeks to add to the growing research by examining the extent to which the implementation of an emporium-model approach for developmental mathematics was successful compared to online and face-to-face courses, in regard to student success and persistence rates.

Statement of the Problem

The open-door policy at community colleges helps promote a population that is diverse with respect to age, reasons for attending, and academic preparations. Today, many students in community-colleges are 24-years old or older, and some need to improve or change their job skills (Center, 2016). However, the discussion about how to help more students in this diverse population attain their post-secondary goals has centered on bettering success rates in developmental education courses, particularly mathematics. A higher percentage of students who require academic remediation enroll at community colleges than four-year public institutions (Chen & Simone, 2016).

Developmental education was devised to help students gain the academic competence necessary for a college-level course (Bailey, 2008). Reasons for requiring remediation vary. In a study by Molina and Morse (2015), some students who enter college underprepared might not have completed a college preparatory mathematics course, and many veterans returning to civilian life did not complete high school courses in Algebra II or higher. In particular, students receiving remediation in developmental mathematics courses might also need to rebuild lost skills, learn new skills, or work on strengthening existing skills (Attewell, Lavin, Domina, & Levey, 2006).

Yet, the achievement of these developmental education programs has been called into question. In 2010, Bailey and Cho found that, within eight years of enrolling, the percentage of developmental education students who completed their certificate programs or degrees was less than a quarter. Chen and Simone (2016) reported that 59% of students who began their post-secondary education in 2003-04 at a public two-year institution enrolled in a developmental mathematics course, with only 50% ever completing the sequence. These higher enrollment numbers in developmental mathematics compared to reading and writing has often targeted mathematics as a degree barrier. The percentage of freshmen enrolled in developmental mathematics has been double that of those placing into developmental reading (Parsad, Lewis, & Greene, 2003). For some students, prior to entering a college-level mathematics course, upwards of three semesters of remedial mathematics courses have been required. As the quantity of students entering colleges across the country has grown, the need to accelerate the successful completion of developmental mathematics to improve college retention and graduation rates has also grown (Rutschow & Schneider, 2011). Accelerated course options, such as emporium courses, have been adopted as a traditional face-to-face course alternative. Emporium courses help students focus their remediation only on the basic mathematics skills they are deficient in, instead of completing an entire course. Often, emporium courses are modularized, and students only focus on content that they have not previously mastered, based on their placement testing. That means students only complete modules of materials they have not tested out of (Northern Virginia Community College, 2020). Thus far, the institution in this study has not explored the success of emporium courses. Analyzing data can provide educators with evidence to inform existing and future reforms.

Educational Significance

Beginning with the turn of the 21st century, the number of developmental education studies has continued to increase (Anonymous, 2017; Anonymous, 2018). Reasons for an interest in developmental mathematics have included high enrollment numbers and high failure rates in those courses, along with the requirement of multiple courses to reach college-level mathematics (Bahr, 2008). Because institutions and policymakers recognized a significant need to increase success rates, many states mandated that students have an option to accelerate through the developmental program (Rutschow & Schnieder, 2011). To answer this call, colleges began offering alternate delivery modalities that allowed students to spend less time in developmental courses and colleges to spend fewer resources on this remediation (Bragg & Barnett, 2009). This study adds to the growing research by examining success and persistence rates by multiple course modality offerings at one community college in Northeastern Pennsylvania.

Purpose of the Study

Many course redesigns have been developed to help students accelerate through development courses. They include (a) paired or compressed courses, (b) curriculum redesign, (c) basic skills integration, and (d) mainstreaming with supplemental support (Edgecombe, 2011). Emporium courses focus on changes to a modularized curriculum and delivery mode. With a modularized curriculum, emporium modalities have become a popular delivery option for acceleration in developmental mathematics courses. In many colleges, students who have enrolled in emporium courses place into a set of modules and complete the modules for their specific degree. In the college in this study, emporium students placed into a traditional course number (i.e., Math 020, Math 022, or Math 026), but then they could accelerate through the course by (a) testing out of modules and (b) completing the remaining modules. The emporium course structure was based on mastery learning that required students to achieve a specific mastery before moving to the next module. Because the delivery of emporium courses has been recent, rigorous research has been lacking, in terms of the effects these reforms have had on student achievement (Rutschow & Schneider, 2011). The purpose of this study was to help fill that research void by comparing the success and persistence rates of students who completed an emporium developmental mathematics course sequence with those students who completed a mathematics course with the same content in a traditional face-to-face or online setting. The setting was at a mid-sized, suburban community college in Northeastern Pennsylvania. A final course grade of a C (73%) or higher was considered a success for this study. Quantitative data were collected from fall 2015 through spring 2019. Like other research studies on course modalities conducted by Twigg (2011) and the National Center for Academic Transformation (2014) this study was conducted in a retrospective manner.

Conceptual Framework

Colleges strive to decrease dropout rates, while simultaneously decreasing time to degree completion rates (Draper, 2008). Some institutions have abandoned all placement testing to allow students to take college-level courses directly to achieve maximum efficiency and increase these completion rates (Jaggars & Hodara, 2011; Cafarella, 2016), while other colleges have moved to compression or acceleration models to increase student success and retention (Cafarella, 2016). For some students, the need to complete multiple remedial courses for no credit seems insurmountable. An accelerated path might increase motivation to persist when the goal seems unachievable. One such accelerated structure is the emporium model that allows students to test out of some content and complete the remaining content, covered in multiple courses, in one semester.

The conceptual framework of this study focused on the premise that emporium models might increase students' success and persistence in mathematics through the acquisition of mastery experiences, use of self-regulatory strategies, and interaction with faculty and tutors, all while students receive prompt feedback in the online system and from tutors. In the emporium structure, a computer-assisted instructional component is used in the classroom, and students are required to work in a lab for a specific number of hours a week so that their progress is monitored by the faculty member. In a well-designed course, there are multiple formative assessments and prompt feedback from the instructor or tutors help the students' progress at an accelerated rate in contrast to traditional courses (Twigg, 2003). The expectation for this modality is high, as students with the most deficits in mathematical knowledge might be expected to become college ready within one semester, compared to the traditional one to three semesters.

While emporium models can accelerate the time required to complete content in a remedial course, challenges exist and recommendations for effective models have been provided. Bickerstaff, Fay and Trimble (2016) found in Virginia and North Carolina that the pacing of an accelerated course can be too fast for some students, which makes it challenging to catch up once they fall behind. Saxon and Martirosyan (2017) surveyed faculty and found that, while accelerating courses in mathematics have benefits for some students, courses must have a clearly defined structure, accurate placement, clear expectations, and proper advisement. In this study, emporium worked at their own pace, but had to meet some set timelines. Thus, the course was accelerated, but it had a clearly-defined structure that aided in preventing students from getting behind.

Improved Affective Measures

Even though I did not study affective measures, a hypothesis can be made that the emporium model possibly holds the promise of improving affective measures through increased mastery experiences and improved self-regulated learning strategies. Emporium models require that students exhibit mastery on a given topic before moving to the next topic. These models also help students demonstrate self-regulatory skills necessary to complete the course on time. Mastery experiences are important because they are a source of self-efficacy (Usher & Pajares, 2009; Zientek, Fong, & Phelps, 2019), and student success in mathematics has been predicted by self-efficacy (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajares & Miller, 1994; Zientek & Thompson, 2010). Furthermore, mastery experiences might possibly be linked to self-regulation through self-efficacy. Self-regulation has been identified as having a direct influence on self-efficacy, which then has a direct influence on mathematics anxiety. Therefore, increases in self-regulation can increase self-efficacy, which can reduce mathematics anxiety (Jain & Dowson, 2009).

Mastery experiences and mathematics anxiety. The emporium course structure encourages mastery of content. In an emporium model, students must demonstrate academic mastery as determined by reaching a benchmark grade on a proficiency exam. This is different than a traditional course, where students can take a test and continue the course without demonstrating mastery of each topic. A student in a traditional course could, for example, fail questions on adding fractions and still receive a passing grade in the course without demonstrating mastery on that content. Mastery learning requires students to be tested more frequently on smaller amounts of information and then reach a grade threshold before moving onto new materials. These frequent assessments afforded students with an opportunity to improve their performance and knowledge in smaller increments (Boylan, 2002). Boylan, Bonham, Claxton, and Bliss (1992) found that mastery-learning techniques resulted in more students passing developmental courses with higher grades and increased retention rates at the college, compared to their traditional counterparts.

Mastery experiences, as one of four sources of self-efficacy, have been touted as the most powerful source (Usher & Pajares, 2009; Zientek et al., 2019). Based on the structure of the emporium course, a hypothesis can be made that emporium models might have an impact on self-efficacy and reduce mathematics anxiety. Students in developmental mathematics exhibit high mathematics anxiety levels (see Zientek, Yetkiner, & Thompson, 2010), which can have a negative impact on mathematics achievement (Ma, 1999). Bandura (1997) noted that decreases in mathematics anxiety can occur by increasing self-efficacy, which follows from the fact that physiological states are also a source of self-efficacy. In mathematics, the physiological state that has been explored most often is mathematics anxiety (Hembree, 1990; Ma, 1999; Zientek et al., 2010). Those assumptions and hypothesis are supported by results from Taylor's (2008) study that found students in an emporium class exhibited lower mathematics anxiety levels and better attitudes towards mathematics, in general, compared to students in a traditional face-to-face setting.

Self-regulated learning. In emporium courses, making sure that specific course benchmarks are met is more the responsibility of the student than in a traditional course. Zimmerman (2005) defined self-regulated learning as the planning and adoption of an achievement goal, where a person's thoughts and feelings play an integral part. Emporium students must (a) monitor their progress without an instructor standing in class laying out the calendar and lesson benchmarks that should be met for the day, (b) have more responsibility for modifying their learning methods and planning their goals, and (c) be their own driving motivator to complete assignments early to progress to the next course faster. As students can be at various stages in the course throughout, they are motivated to continue, based on their own mastery criteria rather than that of other students in the course (Zimmerman, 1990).

Classroom Practices in Emporium Courses

Emporium courses provide opportunities for students to have frequent individualized contact with instructors, receive immediate feedback, and set high expectations. Those opportunities correspond to three of Chickering and Gamson's (1987) seven principles for classroom practices for faculty members to follow to increase a students' engagement and, thereby, their persistence. In different delivery modalities, the use of these principles will vary, but in the emporium method for this study, those three Chickering & Gamson (1987) principles of good practices apply.

Engagement through interaction with faculty. Astin (1999) believed a positive relationship existed between students' active engagement on campus and their intellectual and social growth. Bloom, Engelhart, Furst, Hill, and Krathwohl, (1956) defined engagement in students in three dimensions: behavioral, emotional, and cognitive, with each dimension having either a positive or a negative correlation on potential success in a course or college program. In this study, the reference to engagement is about interaction with the faculty. This study assumed that students' interaction with faculty members would impact their engagement, particularly their behavioral and emotional dimensions.

Astin (1999) defined involvement by the student as "… the amount of physical and psychological energy that the student devotes to the academic experience" (p. 518). Chickering and Gamson (1987) reported that student-faculty contact was "the most important factor in student motivation and involvement" (p. 3). Students in emporium courses, in this study, had on-demand individual assistance from faculty and professional tutors in the classroom during open lab periods; they could not proceed in the course without speaking with them at various stages of the course. For example, students who were on the cusp of a mastery grade or needed to retake an assessment had to meet with the faculty member to get approval. The frequent student-faculty interaction was a valued component of the emporium course as students interacted with faculty in an informal manner, while faculty members walked around to help students as they worked on the computer. Twigg's (2011) study found that in emporium courses, the most vulnerable students received more individualized support and assistance, as the faculty members had the time to respond to their immediate questions and needs. In reference to cognitive engagement, no assumption can be made that students in an emporium model were more cognitively engaged than students in a face-to-face or online classroom or just engaged in completing the modules to move to the next class. Research on cognitive engagement has been much like that of emotional engagement with a focus on motivation, but it has been difficult to measure (Fredricks, Blumenfeld, & Paris, 2004).

Prompt feedback. Prompt feedback is a positive practice in higher education that Chickering and Gamson (1987) advocated for to increase student learning. Feedback offers students the opportunity to organize their studies more effectively by learning from their errors and shows that instructors have reviewed the work completed by students (Boylan, 2002). In the emporium model, students received immediate feedback from the online assessment and faculty and tutors in the classroom, thus, their feedback was prompt. Emporium students also received immediate feedback from tutors that were embedded in the labs. This format keeps students actively engaged to acquire their own knowledge (Cousins-Cooper, Staley, Kim, & Luke, 2017). For the emporium courses in this study, faculty members worked during class time with individuals or small groups on areas that they struggled with.

High expectations through mastering learning. A variety of factors can influence student success, including expectations and influences of families, peer groups, and faculty members. High expectations can benefit students who are unmotivated or underprepared, as well as, high achieving students (Chickering & Gamson, 1987). In the emporium model, high expectations are set by students accelerating through course material and for the need of demonstrated mastery on topics they must learn. For students in emporium courses, high expectations were manifested through the achievement benchmarks that were required before moving to the next section, though, this does not mean that high expectations were not set in other course modalities, as well.

Course Delivery Modalities

Traditionally, developmental mathematics education has consisted of multiple courses that serve as pre-requisites for gateway courses such as statistics and college algebra. The traditional sequence of developmental mathematics courses seems to impede students' ability to continue to the college-level courses (Bailey, Jeong, & Cho, 2010; Edgecombe, 2011). Criticisms of students' educational experiences in mathematics across the K16 spectrum has been the lack of development skills focused on problem-solving, critical thinking, and reasoning, as students tend to follow the procedural steps demonstrated in class using memory strategies (Patterson & Sallee, 1986; Teeguarden, 2013). A push for a change has occurred within the mathematics education community. These challenges exist across course modalities because delivery methods often do not focus on curriculum changes. This study focuses on face-to-face, emporium, and online course formats.

Traditional face-to-face modalities. Traditionally, students enrolled in introductory-level mathematics classrooms at community colleges have been taught in face-to-face settings. Many students will choose face-to-face courses because it is what they are most comfortable with, having learned in that manner for much of their academic lives. In a study by Ashby, Sadera, and McNary (2011), younger college students still seem to select traditional face-to-face courses; 48 of the 58 students (82.7%) who self-selected face-to-face instead of blended or online courses were under the age of 24. In this traditional face-to-face setting, research suggests that developmental course students have been primarily taught via lecture. (Mesa, Celis, & Lande, 2014). In the traditional lecture-style course, the instructor decides when, what, and how students will learn the materials, with all students learning the same content at the same time. Students sit passively in the classroom taking notes, while the instructor presents the information on a board, perhaps with a slide presentation and with various levels of interaction in the classroom (Armington, 2003). Little time for in-class homework is normally provided. Hodara (2013) concluded students in a lecture classroom performed at lower rates than those in a cooperative-learning lab.

Today, teachers have been encouraged to incorporate active learning strategies. Face-to-face courses have benefits when students have opportunities to learn from each other (i.e., peer learning) and Chickering and Gamson's (1987) best practices are applied. Student-interaction on group projects can encourage peer learning. Questions asked by peers help students learn and can help them realize holes in their own learning. The promotion of active learning strategies such as think-pair-share, clickers, inquiry-based learning, flipped classes, and projects, have added benefits of engagement and uncovering misconceptions and misunderstanding about concepts (Braun, Bemser, Duval, Lockwood, & White, 2017). These student-centered instructional tools help students expand their own learning by providing multiple opportunities for partnerships in the classroom with their peers and faculty to engage in learning (Bishop, Martirosyan, Saxon, & Lane, 2017).

Online settings. The increase in technology in the 1990s changed how education systems could reach and teach students and led to the evolution of online courses. Weisbrod, Ballou, and Asch (2008) found that the number of students taking online courses increased from 744,000 in 1999 to over three million by 2005. The growth of online courses at community colleges has been higher than other institutions and accounts for half of all online enrollments (Allen & Seaman, 2013). Computer-aided software made collecting and grading homework easier for faculty and students (Cafarella, 2014). In order to combat fraud, colleges were faced with purchasing and installing costly software.

Online courses have often been presented using learning management software such as Moodle, Desire to Learn (D2L), or Blackboard. Students rarely, if ever, meet with their instructor or other students face-to-face. Learning materials tend to be presented in a virtual folder that may include readings, notes, videos, slide presentations, homework, and other assessment tools like discussion boards (Ashby et al., 2011). Interactive tools, like chat rooms or discussion boards, may help students with difficult concepts and foster interactivity.

Typically, students are not tied to a specific classroom time or setting (i.e., asynchronous) and can work ahead if necessary, although the instructor still mandates a schedule. This format allows them to work around family and work obligations with decreased costs of transportation and childcare. Feedback can often be more detailed and focused on each student (Ni, 2013). Some students learn better time management skills and become better independent thinkers in online formats (Cafarella, 2014).

Research findings on online courses have been conflicting. Some studies of online courses have found that students receive higher scores on exams and are more successful than students in brick-and-mortar lecture classes (Nguyen, 2015). Other studies have found that students in online courses withdrawal at higher rates mid-semester than their counterparts in a lecture course (Xu & Jaggars, 2013). A study completed in Texas, Keller, Bower, and Chen (2015) found that student success decreased by 30.9% compared to students taking a lecture course. The well-prepared student performs better in an online setting than those with less preparation and skills (Edgecombe, 2011). Regardless if a class is taught online or face-to-face, consistency between and within classes can be an issue for some institutions.

Emporium courses. Typically, emporium courses require that students exhibit mastery learning of the subject. Students work at their own pace, albeit with deadlines, and with an instructor nearby who serves more as a tutor or coach than as a professor. Students learn with the assistance of a computer software program that is personalized and on-demand (Twigg, 2011). The software package allows students to work independently on specific skills deficits identified by the program through content and frequent assessments of their abilities (Rutschow & Schnieder, 2011). Students will by-pass content that they have demonstrated mastery on via a pre-test and concentrate on material they struggle with by using individualized study plans (Twigg, 2011). Mastery must be demonstrated on a topic before moving on to the next topic, as measured by benchmark scores on short assessments (see Method section for mastery details). The emporium method allows students to pick up where they finished in the event they do not complete the course on time, whereas in face-to-face and online courses, students are required to start from the beginning of the course each semester, if they fail a course (Fain, 2011). Successful emporium models utilized workstations, tables, and commercial software programs to lower the costs of development. The tables and workstations allow students to work collaboratively and receive just-in-time remediation on specific topics. The software allows for active learning as students are actively engaged with the content through a variety of tasks (Braun et al., 2017).

Similarities between emporium and online courses. More so than traditional face-to-face courses, similarities exist between the emporium and online courses. In both emporium and online courses, students must choose which resources would best help them to master the content. They spend time filling in notes, watching videos, reading PowerPoints, reading the textbook, and completing online homework, quizzes, and exam assessments. Students work independently, but emporium students see their classmates in a classroom setting, whereas online students communicate primarily in an on-line setting. Emporium students also have an immediate connection to their professor or tutors, whereas online students might need to wait for their communication for a variable amount of time.

Research Questions

This study compared final exam grades, course grades and persistence of students enrolled in developmental mathematics emporium style-courses with those in corresponding face-to-face and online courses at a mid-sized, suburban community college in Northeastern Pennsylvania. I hypothesized that students who successfully passed an emporium developmental mathematics course would perform equally well or better, as measured by their final exam and grade-point average, as students who completed the same course in a face-to-face or online modality. It was additionally hypothesized that emporium students would persist at the college in equal or higher percentages that those in face-to-face or online courses. This study examined differences in success measures and persistence using the following questions:

1. For students enrolled in developmental mathematics courses, to what extent did differences exist between final exam grade by course modality?

2. For students enrolled in developmental mathematics courses, to what extent did differences exist between student success rates by course modality?
3. For students enrolled in Math 020 and Math 026, to what extent did differences exist between persistence rates in mathematics by course modality?

Method

This study examined the course modality of the developmental mathematics courses at Northampton Community College (N.C.C.) in Northeastern Pennsylvania to determine if differences existed in the final exam grades, final course grades, and persistence to the next mathematics course. This was a retrospective, nonexperimental study that used quantitative methods. Students could choose to register for their developmental mathematics course based on emporium (math lab with mastery experience), traditional face-to-face, or online formats. In this study, the self-section of courses and course completion have already occurred. All developmental course grades counted toward GPAs at N.C.C. Although none were enough for degree completion, LPN students who did not complete high school algebra had to pass Math 022 before they could attain their degree.

Selection of Participants

The sampling method was a purposeful convenience sample conducted in a retrospective manner. N.C.C. was selected because (1) the researcher was employed at the college, which made this a convenience sample, and (2) the college had diversity in terms of course structure and student population, which made the sample purposefully chosen. The sample was also purposeful in the sense that it was selected from students who had either been enrolled or were currently enrolled in a mathematics course, starting fall 2015 through spring 2019. To determine persistence, enrollment data for summer and fall 2019 were also collected. Data collected from the institutional research office included student enrollment in all mathematics courses along with course modality (i.e., emporium, face-to-face, online, and hybrid). Fall 2015 semester included Math 028, which was a face-to-face-only course that combined Math 022 and Math 026. Once emporium courses were offered full-scale, this course was removed from the course offerings. Because not all students enrolled in Math 022 were required to complete additional coursework, persistence was limited to Math 026 and Math 020.

Table 17 shows the number of developmental mathematics course offerings by modality from fall 2015 through spring 2019. Of the total number of developmental mathematics students, 4,606 (47.7%) enrolled in face-to-face sections, 2,891 (29.9%) enrolled in emporium sections, and 2,161 (22.4%) enrolled in online sections. Table 18 shows the breakdown of developmental mathematics students based on ethnicity and gender from fall 2015 through spring 2019. The ethnicity and gender of the students in developmental mathematics courses followed the same pattern as the overall college demographics with the largest representative group being White students (46.0%) followed by Hispanic (26.90%) and Black students (19.90%). Overall, more female students were placed into these courses than male students (61.90% vs. 38.10%) with an average age of 24.77 years. Almost half of the students in the sample ranged in age from

18 to 20 (48.3%), which put many students into college right after high school or soon thereafter.

Procedures and Research Design

Prior to this study, an Institutional Review Board (IRB) application was approved at Sam Houston State University and the participating research institution, N.C.C. (see Appendix A). For this study, archival student data were retrieved from the Office of Institutional Research at this community college. Data collected included the following student information: (a) student's ID (generated by N.C.C. Institutional Research to protect privacy), (b) gender, (c) race, (d) mathematics course name, (e) course section number, (f) mathematics course grade, (g) course semester, and (h) course year. It was assumed that the data collected from this institution were accurate and valid. Data for final exams was generated by the math lab manager from the online homework platform and included: (a) course year, (b) course name, (c) course section, and (d) final exam grade.

Data were sorted by student identification and semester. Students who completed a developmental mathematics course could receive either an "F, D, D+, or C-" as a failing grade, "A, A-, B+, B, B-, C+, or C" for a passing grade, "W" for a withdrawal, "I" for incomplete, and a "AZ, BZ, or CZ" for passing via testing out. Because instructors were not required to report plus and minus grades, I categorized final course grade as passing (C or higher), failing (C-, D or F), or W (withdrawal). All incompletes and grades with a "Z" were removed because of the small sample size. In order to determine persistence, I created a persistence variable; students who repeated a course were marked specifically for tracking persistence and completion. Student demographic information was also associated with each unique student ID to compare race and ethnicity success rates for the students in developmental mathematics.

This study used a causal-comparative research design to compare multiple groups in terms of the course they had chosen to complete (Creswell, 2014; FaTima, 2015). Manipulation of the independent variable in this nonexperimental design could not occur, as students self-selected into their respective developmental mathematics courses (Johnson & Christensen, 2014). For this study, modality was the variable with three categories of course structure: emporium, face-to-face, or online. Separate analyses by developmental mathematics course level (i.e., Math 020, Math 022, and Math 026) was conducted for final exam grades and modality and final course grades and modality. A separate analysis was conducted for the persistence of students based on course modality for just Math 020 and Math 026.

Instrumentation

In each developmental mathematics course, student achievement was assessed by scores from a 40 multiple-choice item comprehensive common final exam and final course grade. For each course, a final exam was created by a faculty subcommittee that focused on developmental mathematics redesign. The content of the exams followed the course objectives set forth by the mathematics department in Pre-Algebra, Elementary Algebra, and Intermediate Algebra. Across all semesters in this study and, regardless of learning modality, the final exam was the same and was mandated as the post-test for each course. Faculty created and administered the final exam using an online commercial software program, but the numbers were algorithmically generated, which meant that question type differed only by numerical values. Homework and quiz assessments were the same for all course modalities, but the course structure differed for the emporium courses.

Course Modality

Students chose the course section that they wanted to enroll in at N.C.C. based on course description and time schedule. Thus, they chose course modality. The number of emporium, face-to-face, and traditional courses varied from semester to semester. There was an attempt by the college to keep the same number of each type of course from semester to semester for continuity, as seen in Table 17. The quantity of each course offering was dictated by enrollment numbers each semester.

Emporium course. In the emporium courses, face-to-face courses were replaced with computers and course content was organized in modules or chapters with specific due dates. Students worked mathematics problems in the MyLabsPlus system and were encouraged to complete guided note packets. Each emporium section met in a computer lab two or three days a week for 50-75 minutes per class. In this study, a faculty member and two tutors were in the classrooms to facilitate learning and solve software issues.

The course structure was designed to keep students on track. Students began each module with a Skills Check. This assessment allowed them to either by-pass content if they scored an 85% or higher, or remove content from the corresponding homework, still allowing for acceleration. For each module, students completed homework, took a quiz, and then took an exam. When stumped on a problem in the classroom or an open lab, an emporium student had access to immediate help from tutors and faculty members. Students needed to attain an 85% on their homework before a corresponding quiz would open. Infinite opportunities were provided for students to improve their scores on their homework, and no points were taken off for missing a deadline. Students worked independently with one-on-one assistance that was given when requested. When a faculty member or tutor saw that multiple students were challenged by a concept, they conducted small breakout sessions in the classroom to bring those students together to foster collaborative work and clear up the discrepancies. Faculty members reviewed every incorrect exam question with students in order to help them work on areas of weakness. Unsuccessful students in this setting received additional resources to improve their knowledge base, which included additional worksheets, time in the learning center, or time in the math lab.

Students had two initial attempts on a quiz and could not continue to an exam until they had obtained a 73% on that specific module quiz. Quizzes were non-proctored assessments of content knowledge in that module. If students did not attain mastery (73% or higher), they worked with a faculty member and/or tutors before another attempt on the quiz was given. Work on both the homework and quizzes could be completed outside of the classroom time, but all exams were proctored on campus in the math lab. Exams also needed mastery of 73% before the next homework module would open. If students failed to achieve 73% on their exam, they could repeat the exam until a threshold of success was achieved. After two failed attempts, students were given additional time in the tutoring center or lab, one-on-one work with a tutor, or additional worksheets or homework to learn concepts that were missed on the exam. Retesting was designed to reduce anxiety for students and increase success and persistence. All students were required to take a comprehensive final exam, although no mastery was required on the final and only one attempt was provided. Study guides for the final exam, along with answer keys, were distributed to students for practice.

Attendance was required and was part of the students' final participation grade. All software was available to the students outside of the classroom. Open lab times in the classroom were specific for developmental students only and available during non-class times. Students who missed class could make up the class time in this open lab setting. Attendance was tracked and sent to faculty but not collected for this study. At the community college in this study, students enrolled in the emporium model could pay for one course, finish the course, and complete the next course free in the same semester (C. Wetzel, personal communication, July 17, 2016).

Traditional face-to-face and online courses. Online and traditional face-to-face courses had a similar structure, regarding content, assessments, and timelines, but mastery of content was not a requirement before learning new content. That meant that students could attempt quizzes without doing homework or skip homework or quizzes altogether and still continue on. At the instructors' discretion, students could be penalized for turning in work past the mandated due dates, but that data could not be tracked. Both online and face-to-face courses had mandated common comprehensive final exams that were proctored and similar to that in the emporium sections. Starting in fall 2018, all online and traditional face-to-face courses received common periodic exams that also required proctored testing facilities to improve course consistency. These exams were made up of the same questions from the emporium courses, though combined into larger and less comprehensive exams. For example, in the emporium course, a proctored exam was given after every module. In the face-to-face and online sections, proctored exams were given after every two to three modules with the same number of questions (i.e., 20 to 25 questions).

To combat fraud in online courses, initially Northampton Community College (N.C.C.) in Pennsylvania purchased Biosig-ID from Biometric (D. Fisher, personal communication, July 7, 2016). Biosig-ID uses handwriting analysis software to authenticate users and live proctors for exams. This software was costly, which means that it might be out of reach for many institutions. By fall 2018, this service was no longer available to online courses, and all students were required to come to campus or other approved location to take proctored exams.

Traditional face-to-face courses were provided in one, two, or three-day a week sessions with students working mostly at home on their homework and online quizzes. Some faculty in these courses, who were in computer labs, allowed students to spend a limited amount of time in class working on assessments. In online courses, the use of online classroom support and instruction varied by instructor. Some professors held synchronous meeting times, some allowed for makeups for each exam, while still others used discussion boards to facilitate interaction with students. A few online instructors included practice exams as part of their courses as well.

Data Analysis

For the variable modality, persistence in mathematics within the data timeframe was first coded as a dichotomous variable and then as a categorical variable. Persistence, as a dichotomous variable, was coded as a “0” = persisting in mathematics and a “1” = not persisting for a student that did not continue in mathematics during the data time period. The categorical persistence variable was coded as a “1” = passed the course and persisted to the next math course, “2” = failed or withdrew but retook the mathematics course, “3” = passed their course but did not take another mathematics course, and “4” failed or withdrew from their course and did not retake the course. For this analysis, the grades were coded as “Passing” if a student earned an A, B, or C, “Failing” if a student earned a D or F/C-, and “Withdrawn” if a student withdrew before the drop date during the 14th week of the semester. The coded data were exported into the Statistical Package for the Social Sciences v. 25 (SPSS). All analyses were conducted using SPSS. Table 19 contains variables, data type, and analysis conducted by research question.

The grouping variable for all three questions was course modality, which was categorical. Descriptive statistics were calculated to assess the overall achievement by modalities. To determine if statistically significant differences existed between mean final exam scores by course modality, an ANOVA was planned. However, the assumption of homogeneity of variance was violated, and a Kruskal-Wallis test was conducted. The Kruskal-Wallis test is a non-parametric test conducted when there is no assumption that the data came from a normal distribution (McDonald, 2014). Final exam grade was measured at an interval level. Course modality was coded into three categories: emporium, face-to-face, and online courses. Statistical significance was chosen a priori as using an alpha of 0.05 and eta-squared effect sizes were interpreted.

Chi-square tests were conducted to answer questions two and three, which had a categorical dependent variable and categorical independent variable. The chi-square statistic measures how the expected values compared to the actual observed data. Cramer's V effect sizes were considered small at the .05 level, somewhat noteworthy at the .15 level, and noteworthy at the .25 level (Zaiontz, 2019, p. 1). Groups were mutually exclusive, were drawn from independent variables, and had a sufficient sample size.

Results

Descriptive statistics, 95% confidence intervals for the mean, and minimum and maximum scores are presented in Table 20. Average final exam grades per course modality and course type by academic year are presented in Table 21. Approximately 50% of all developmental mathematics students from fall 2015 through spring 2019 completed their course to the final exam.

Research Question 1: Final Exam Grade by Course Modality. The first research question looked at the extent to which that there were differences in the common final exam grade by course modality in the developmental mathematics programs. Homogeneity of variance assumptions was conducted with Levene's test and was not met ($p < .05$). Therefore, a non-parametric Kruskal-Wallis test was conducted. The assumption that there was no relationship between the groups themselves was met, which means that there were different categories for each group and no group overlapped. For example, someone could not be in an emporium class and online class at the same time. For the emporium modality, 95% confidence intervals of the means for the final exam did not overlap the confidence intervals for face-to-face and online courses. As shown in Table 20, the lower limit of confidence for emporium courses was seven points higher than the upper limit for both face-to-face and online courses. Table 21 contains the average exam grades disaggregated by course level and modality. There was a statistically significant difference between groups on final exam scores for Math 020, $\chi^2(2, n = 1130) = 109.986, \rho < .001$, for Math 022, $\chi^2(2, n = 1613) = 125.998, \rho < .001$, and for Math 026, $\chi^2(2, n = 1177) = 85.547, \rho < .001$. The mean rank final exam score was 1699.48 for face-to-face courses, 2272.50 for emporium courses and 1660.95 for online courses and eta squared effect size of .0666 (see Zientek, Dorsey, Stano, & Lane, 1999 and Tomczak & Tomczak, 2014 for explanation on effect size). The median final exam course grades were 80.00 for emporium courses, 70.63 for online courses, and 72.5 for face-to-face courses. The percentage of students taking the final exam, shown in Table 22, was generally highest in Math 022 across modalities although the final exams, seen in Table 21, were highest on average for emporium students across all courses.

Research Question 2: Final Course Grade by Course Modality. Chi-square tests of independence were conducted for the second research question to examine the extent to which differences existed in final course grade (pass, fail, or withdraw) by course modality (face-to-face, emporium, or online) in the developmental mathematics program. A chi-square test is used to determine how much an observed distribution is due to chance (Light, 2008). Results from chi-square analyses indicated that statistically significant differences existed between course modality and final course grade for Math 020, $\chi^2(4, n = 2728) = 90.383, \rho < .001$, with a noteworthy Cramer's V effect size of .129, for Math 022, $\chi^2(4, n = 3809) = 274.117, \rho < .001$, with a noteworthy Cramer's V effect size of .190, and for Math 026, $\chi^2(4, n = 3059) = 91.880, \rho < .001$, with a noteworthy Cramer's V effect size of .123. In Math 020, pass rates were 61.3% for face-to-face courses, 48.2% for emporium courses, and 41.0% for online courses. In Math 022, pass rates were 57.3% for face-to-face courses, 57.6% for emporium courses, and 29.6% for online courses. In Math 026, pass rates were 57.8% for face-to-face courses, 53.4% for emporium courses, and 36.0% for online courses. Students in Math 022 and Math 026 had similar success rates for those students in emporium and face-to-face courses, which may be the result of experience as a student and in those learning modalities. As seen in Table 23, students in online courses withdrew and failed at higher percentages in all classes.

Research Question 3: Persistence by Course Modality. A chi-square test of independence was conducted for the third research question to examine the extent to which differences existed in the dichotomous persistence variable to the next mathematics course by course modality in the Math 020 (Pre-Algebra) and Math 026 (Intermediate Algebra) courses. A second chi-square test was conducted to compare course modality to the categorical persistence variable that considered whether students passed, failed, or withdrew from their respective course. Persistence rates by course and modality are provided in Table 24.

3A: Dichotomous persistence by modality. Chi-square results for Math 020 indicated that statistically significant differences existed on persistence in mathematics by course modality at the $p < .05$ level when persistence was measured as a dichotomous variable, $\chi(2) = 6.893, p = .032$, with a small Cramer's V effect size of .050. No cells had an expected count less than five.

Math 020 students in face-to face courses persisted 66.8% of the time compared to 65% in emporium and 60.2% in online courses. Thus, the differences were related to lower persistence rates in Math 020 online courses. Chi-square results for Math 026 indicated that no statistically significant differences existed on persistence in mathematics by course modality at the p < .05 level when persistence was measured as a dichotomous variable, $\chi(2) = .183, p = .913$, with a Cramer's V effect size of .008. No cells had an expected count less than five. Overall, students in Math 026 persisted at high rates and those rates were approximately the same percentage across course modality.

3B: Categorical persistence by modality. Statistically significant differences also existed by persistence category that considered success measures (i.e., pass, fail, or withdrew) by course modality for students who enrolled in Math 020, $\chi(6) = 67.346, p < .001$, with no cells having an expected count less than five, and a Cramer's V effect size of .111. As seen in Table 24, persistence rates for students who also passed the course were highest for the face-to-face Math 020 students. Statistically significant differences also existed by persistence category that considered success measures (i.e., pass, fail, or withdrew) by course modality for students who enrolled in Math 026, $\chi(6) = 97.878, p < .001$, with no cells having an expected count less than five, and a Cramer's V effect size of .126. The differences were related to online courses. While students in different modalities appeared to persist at around the rate of students in Math 026, when disaggregated further, persistence rates of students who passed were 50.2% in face-to-face courses, 48.8% in emporium courses, and 32.1% in online courses. However, students who failed or withdrew in an online course for Math 026 were more likely to persist in mathematics (51.1%) than students who failed in a face-to-face course (32.8%) or emporium course (33.7%).

Discussion

Conversations, within and among institutions of higher education, have focused on how to increase graduation rates while decreasing time to degree completion. These graduation rates become a measure of accountability and evaluation of institutional performance (Gold & Albert, 2019). Community colleges have been faced with the challenge of reducing time to degree completion for a large population of students who need academic remediation. Emporium models were introduced as one method for accelerating students' remediation, instead of taking semester-long remedial courses offered in developmental education programs (National Center for Academic Transformation, 2014). The purpose of this study was to investigate the extent to which there were differences in final exam grades, final course grades, and persistence to the next mathematics course by course modality (i.e., face-to-face, online, and emporium). The main message from these findings was that, except for students who are placed in pre-algebra content, emporium courses are viable options for accelerating students through a developmental course sequence. It should be noted that emporium courses in this study were designed to provide the needed support and access to tutors and instructors. Results indicated that (a) final course grades and persistence was similar for students in emporium and face-to-face courses, except in the lower-level course and (b) students who chose to enroll in online courses were not as successful in the course. The viability of final exam scores in research on student success should be questioned, given that success rates in face-to-face courses were higher than emporium models in Math 020 and slightly higher in Math 026, with even lower final exam scores.

Student Success Rates by Course Modality

In response to a national and regional call to increase students' access to and increase success in college-level mathematics, N.C.C. began offering developmental mathematics as face-to-face, online, and emporium modalities in fall 2015. Offering a variety of course modalities has been heralded as a best practice for developmental mathematics (Boylan, 2002). Emporium, as a course modality, was promoted at educational conferences and by textbook publishers as an option for helping students accelerate through remedial content and, thus, more quickly enter college-level courses. The strength of the emporium courses is they allow students to skip previously mastered materials and accelerate through the course and possibly finish the next course in one semester rather than multiple semesters. The mathematics faculty at N.C.C. agreed that incorporating a more cohesive and consistent course structure that allowed students to accelerate through the course material they had already mastered could increase student success and persistence.

Final Exam Scores

Final exam grades were examined because they serve as a measure of knowledge learned throughout the course. However, there are limitations using this one-time score in a study. Students' decision to invest time in studying for the final might be dependent on their current grade. For example, the student who has a low C average, but can maintain a passing grade with a low final exam score, might decide to invest less energy into studying for the math final exam. Contrarily, students who have a high C and can earn a B if they do well on the final, might invest a lot of studying time for the final exam. Perhaps that explains why a Kruskal-Wallis test indicated statistically significant differences existed by course modality, with emporium students scoring higher on the common final exam but having lower pass rate in the course, while face-to-face students had higher pass rates and lower final exam scores. Students in Math 020 emporium sections scored an average final exam grade of 83.2% but passed their respective course only 48.2% of the time compared with the average final exam scores of face-to-face (74.3%) and online (77.9%) who passed at 61.3% and 41.9% respectively. Regardless, as seen in Table 21, students benefited in the emporium course on a culminating test, which corroborated findings by Cousins-Cooper et al. (2017), and differences might also be explained by withdrawal rates. The emporium structure promoted mastery learning through frequent assessments and required grade benchmarks that had to be met throughout the course (Bandura, 1997); thus, emporium students had been working under the mentality that mastery was required. Students in emporium courses knew that in order to succeed, they had to work to mastery benchmarks throughout the semester. This mentality might have influenced higher scores on the final exam. For several academic years, students enrolled in emporium sections scored approximately five to ten percentage points higher than those enrolled in a face-to-face or online courses.

Final Course Grades

Statistically significant differences also existed by course modality in the final course grade, but these differences appeared to be primarily because of lower pass rates and higher withdrawal rates in the online courses as seen in Table 23. Efforts are underway to further improve student success in online courses. Starting in fall 2019, N.C.C. began utilizing a new computer-aided learning platform for all developmental mathematics modalities, employing measures of demonstrated mastery of content at multiple levels, and limiting the number of students who took online developmental mathematics courses. Starting with fall 2019 registrations, students who wished to enroll in an online mathematics course had to go through an application process before being accepted. Only students with experience in online education or with documented work or family obligations qualified for an online course.

Differences in withdrawal rates might also stem from the institutional policy. Emporium students at N.C.C. were encouraged to withdraw closer to the end of the course so that they could pick up where they left off in the following semester. This policy was not available for the other modalities and helped emporium students with their GPAs by allowing them to continue to accelerate if they chose the same modality the following semester. This could explain higher values in withdraw rates seen in Table 23.

Lowest-level courses. For the lower course, students seem to benefit from face-to-face courses. This seems logical because they might not have the discipline or confidence to work independently on mathematics topics. A hypothesis for why those students were less successful with the emporium and online courses could be higher levels of mathematics anxiety and lower self-regulated learning strategies. Another hypothesis is that students with minimal understanding of basic pre-algebra concepts need more supports to learn that material. Given that Bickerstaff et al. (2016) found accelerated courses may be too fast for some students, it might be that these students in the lowest-level course could not keep up with a pace in an emporium model.

Emporium courses. Reasons for success rates in emporium courses in Math 022 and Math 026 that mirrored success rates in face-to-face courses might be because of the well-defined emporium program that followed the guidelines suggested by Saxon and Martirosyan (2017) along with quality face-to-face classrooms. One reason students in emporium courses succeeded at rates similar to face-to-face courses might be because they were given the opportunity to choose the modality for their course. In other words, this was a format that students chose over online and face-to-face options. Another practice that was unique in this study was that, in the emporium courses, students initially took a second placement test, which might have helped in placement accuracy. In addition, best practices recommended by Chickering and Gamson (1987) were applied that dealt with prompt feedback, interaction with faculty, and high expectations. Emporium students had to demonstrate mastery on topics and, thus, received success at frequent intervals during the semester. Successful students also had to demonstrate that they could monitor their progress and timelines, albeit some timelines were established within the course structure. When unsuccessful, emporium students were provided resources to improve their ability to succeed and students were required to meet with faculty or a tutor before proceeding. Thus, emporium appeared to be a viable option for acceleration for many students.

Persistence in Mathematics by Course Modality

Persistence in mathematics was limited to upper and lower-level courses because not all students in the middle level were required to complete a subsequent mathematics course. As seen in Table 24, persistence was similar for the emporium and face-to-face courses in Math 020 and similar across all three course structures in Math 026. A better picture is gathered when considering persistence along with success measures. When focusing within each modality, 020 students who passed their face-to-face persisted at higher rates than other modalities and persistence was similar for face-to-face and emporium 026 students.

The similarity in success and persistence in mathematics rates for emporium and face-to-face courses, particularly for the upper-level courses, seems to contradict findings by Hodara (2013) and English (2016), but support results by Cousins-Cooper et al., (2017). Cousins-Cooper et al., (2017) found pass rates (grades A through C) between emporium and lecture courses were not statistically significantly different; thus, their results corroborated findings from this study. Ashby et al. (2011) noted in their study that success may be related to the learning environment and whether attrition was considered. Success rates in face-to-face settings might be attributed to faculty members who are more comfortable teaching in face-to-face settings, which was true at N.C.C. based on anecdotal conversations with faculty. A challenge in this study was that the sample was not restricted to first-time enrolled freshman, thereby giving them a slight advantage, in regards to academic and emotional maturity. Regardless, more attention should be given to the early entry-level skills of students who are placed into the lowest-level course.

Limitations

An inherent property of studies is limitations. For this study, one limitation was that it was conducted at only one institution in Northeastern Pennsylvania. Thus, results are not generalizable as Pennsylvania colleges do not share identical learning outcomes or structures for any of their developmental mathematics courses. This study was also limited in that the teachers for each course varied each year; no determination could be made if a faculty member influenced the learning or success of a course. A further limitation was that small refinements were made to the course structure each year and these refinements were not tracked or evaluated for their influence on student success and persistence. Another limitation is that the results are biased towards those that persisted. Thus, for the students who persisted in these courses, on average grades were similar. A final limitation worth noting is that in Pennsylvania persistence data are not collected by the state. Persistence from one college in Pennsylvania to another cannot be tracked to determine if students did indeed continue with their education, even if not at N.C.C. Another limitation of the study was the inability to consider teacher effect. Future studies with larger sample sizes should take into account the teachers' role. A final limitation is that utilizing existing data limited the ability to examine a number of factors that can impact student success such as their mathematical background and understanding of mathematical concepts.

Implications and Further Research

Evaluating program changes with data can help educators make evidence-based decisions. This research study informs the administration and faculty members at N.C.C. about the success and persistence rates of students in developmental mathematics courses at the college after the adoption of an emporium modality and can aid in making evidence-based decisions about future changes. Findings from this study suggest that an emporium model that requires mastery benchmarks, proctored exams, in class tutors, an in-class instructor, additional placement confirmation, and retesting is a viable option for accelerating students through the developmental mathematics course sequence when students' remediation is not extensive (i.e., placed above pre-algebra). An added benefit of the emporium model is the just-in-time learning and teaching, based on the needs of individual or groups of students. A concern with emporium by some faculty is that, while students in the upper two levels of developmental math passed at approximately the same rate, students who accelerate too quickly may not have retained enough concepts when moving into the college-level courses (see Jaggars & Hodara, 2011). Thus, future research could explore that concern. Students who place into the lowest-level pre-algebra course and are not near the cut-off placement score for the next course probably should start in a traditional face-to-face pre-algebra course with an option to accelerate in the emporium model after gaining those pre-algebra skills.

An implication from this research is that pass rates are still lower than desired. Even though emporium options appear to accelerate more students enrolled in upper- and middle-level courses through the developmental sequence, at least 40% of students were not successful across course level and course modality. Those findings suggest that increasing success in developmental mathematics courses will require more than changes in delivery models or additions of mastery benchmarks. The mathematical education community has embraced the need to change the curricula and teaching methods in mathematics courses to a model that focuses both on conceptual understanding and procedural fluency (National Council of Teachers of Mathematics, 2000; Smith, Bill, & Raith, 2018; Star, 2005; U. S. Department of Education, 2008). The need for encouraging reasoning and understanding was supported by Stigler, Givven, and Thompson's (2010) study that found developmental mathematics students tended to rely on a faulty recollection of when and how to apply procedures (Stigler, Givven, & Thompson, 2010). While Stigler et al. (2010) described developmental mathematics students' understanding of concepts as both weak and fragile, they found reason for hope in the fact that (a) students could be coaxed into reasoning by asking appropriate questions followed by allowing students license to reason instead of approaching problems duplicating the method they were taught and (b) "when students are able to provide conceptual explanations, they also produce correct answers" (p. 13). Thus, students who are failing across modalities need an intervention that addresses their comprehension of mathematical concepts, procedural fluency, in addition to the socio-cognitive and motivation constructs that has been documented as an inhibitor to student success.

Continued research and tracking of student success and progression through to a degree program is also recommended, along with tracking reasons why students withdrew. Although Pennsylvania does not have a centralized tracking system in place to determine where students attend colleges and for how long, it behooves the administration at N.C.C. to focus on the retention of the students they have for continued growth and sustainability. The implementation of Success Navigators, who are advisors hired for specific majors and students, and a new learning management software system has begun the work of holding onto the students N.C.C. currently has. Knowing where students are failing or dropping out, especially in mathematics, can lead to identifying the factors that are controllable by the college to create interventions that improve the outcomes of success and persistence.

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Table 17

Breakdown of Course Sections and Totals

	Math 020			Math 022			Math 026		
	E	FtF	O	E	FtF	O	E	FtF	O
FA15	11	4	3	10	4	4	5	4	2
SP16	7	4	3	10	5	4	7	4	2
SU16	0	1	1	1	1	2	2	1	2
FA16	10	4	3	10	3	4	6	4	3
SP17	6	4	3	10	5	4	7	4	3
SU17	0	1	2	1	1	2	2	2	2
FA17	8	5	3	10	5	4	6	5	3
SP18	6	4	3	10	5	5	7	4	3
SU18	1	1	1	1	1	2	2	2	2
FA18	9	4	3	10	4	4	6	4	3
SP19	8	4	1	10	5	2	7	2	2

Note: E = Emporium, FtF = Face-to-Face, and O = Online.

Table 18

Ethnicity and Gender of Developmental Mathematics Students, Fall 2015 – Spring 2019

	Frequency	Percent
Ethnicity		
American Indian	34	0.40
Asian	141	1.50
Black	1918	19.90
Hispanic	2597	26.90
Multi-Racial	314	3.30
Non-Resident Alien	56	0.60
Pacific Islander	27	0.30
Undeclared	124	1.30
White	4447	46.00
Gender		
Male	3684	38.10
Female	5974	61.90

Table 19

Research Questions for Study Three

Research Question: To what extent:	DV	Data Type	IV	Defined	Data Type	Analysis
1) were there differences in final exam grade by the course modality of the developmental mathematics course?	Final exam grade	Interval	Course Modality	“0” = E, “1” = FtF, “2” = O	Cat	ANOVA /Kruskal-Wallis
2) were there differences in final course grade by the course modality of the developmental mathematics course for Math 020, Math 022, and Math 026 students?	Developmental Math Course Grade A to C (pass), C- to F (fail), W (withdrew)	Cat	Course Modality	“0” = E, “1” = FtF, “2” = O	Cat	Chi-Square
3A) were there differences in persistence to the next mathematics course by course modality of Math 020 or Math 026	Persistence (“0” persisted and “1” not persisted)	Cat	Course Modality	“0” = E, “1” = FtF, “2” = O	Cat	Chi-Square
3B) were there differences in persistence to the next mathematics course by course modality of Math 020 or Math 026	Persistence (“0” persisted & passed, “1” failed/withdrew but persisted “2” passed but not persisted, “3” failed/withdrew but not persisted)	Cat	Course Modality	“0” = E, “1” = FtF, “2” = O	Cat	Chi-Square

Note. Cat = Categorical; E = Emporium; O = Online; FtF = Face-to-Face; DV = dependent variable; IV = independent variable.

Table 20

Results for Final Exam Scores Based on Course Modality

					95% CI			
	n	*M*	*SD*	*Md*	*LL*	*UL*	Min	Max
Emporium	1830	77.88	13.46	80.00	77.26	78.50	.00	100.00
Face-to-Face	1430	69.71	17.49	72.50	68.80	70.62	.00	101.00
Online	660	68.63	19.12	70.63	67.16	70.09	.00	100.00
Total	3920	73.34	16.61	75.50	72.82	73.86	.00	101.00

Note. *M* = Mean; *SD* = Standard deviation; *Md* = Median; *LL* = Lower limit; *UL* = Upper limit.

Table 21

Average Final Exam Scores by Modality by Academic Year (AY) and Course

	Final Exam Grades		
Emporium	Math 020	Math 022	Math 026
AY 2015 – 2016	86.42%	75.99%	81.08%
AY 2016 – 2017	81.64%	74.13%	78.75%
AY 2017 – 2018	82.79%	75.93%	76.54%
AY 2018 – 2019	81.95%	74.85%	73.80%
Face-to-Face			
AY 2015 – 2016	76.04%	68.91%	68.55%
AY 2016 – 2017	73.75%	64.74%	69.35%
AY 2017 – 2018	72.91%	68.34%	70.93%
AY 2018 – 2019	74.47%	69.62%	71.55%
Online			
AY 2015 – 2016	83.07%	64.30%	67.07%
AY 2016 – 2017	79.98%	64.95%	66.23%
AY 2017 – 2018	73.73%	63.15%	67.07%
AY 2018 – 2019	74.74%	72.87%	69.28%

Table 22

Total and Percentage of Students Taking Final Exam by Modality by Academic Year (AY) and Course

	Math 020		Math 022		Math 026	
Emporium	*n*	%	*n*	%	*n*	%
AY 2015 – 2016	157	32.0	218	44.0	115	23.0
AY 2016 – 2017	152	26.0	265	45.0	165	28.0
AY 2017 – 2018	106	19.0	250	46.0	181	33.0
AY 2018 – 2019	101	21.0	240	50.0	135	28.0
Face-to-Face						
AY 2015 – 2016	126	31.3	126	31.3	150	37.3
AY 2016 – 2017	133	34.9	111	29.1	137	36.0
AY 2017 – 2018	148	32.5	143	31.3	165	36.2
AY 2018 – 2019	116	32.9	137	38.8	100	28.3
Online						
AY 2015 – 2016	41	23.7	90	52.0	42	24.3
AY 2016 – 2017	56	24.7	105	46.3	66	29.1
AY 2017 – 2018	70	30.3	102	44.2	59	25.5
AY 2018 – 2019	39	27.1	57	39.6	48	33.3

Table 23

Descriptive Statistics for Developmental Mathematics Course Grade

	Math 020			Math 022			Math 026		
	FtF	E	O	FtF	E	O	FtF	E	O
Success	*n* = 895	*n* = 1255	*n* = 578	*n* = 909	*n* = 1962	*n* = 938	*n* = 1000	*n* = 1417	*n* = 642
Passed	549	605	237	521	1131	278	578	756	231
	61.3%	48.2%	41.0%	57.3%	57.6%	29.6%	57.8%	53.4%	36.0%
Failed	188	240	137	237	342	374	228	292	177
	21.0%	19.1%	23.7%	26.1%	17.4%	39.9%	22.8%	20.6%	27.6%
Withdrew	158	410	204	151	489	286	194	369	234
	17.7%	32.7%	35.3%	16.6%	24.9%	30.5%	19.4%	26.0%	36.4%

Note. FtF = Face-to-Face; E = Emporium; O = Online.

Table 24

Persistence by Congruence of Modality for Math 020 and Math 026

	Math 020			Math 026		
	FtF *n* = 895	E *n* = 1255	O *n = 578*	FtF *n =1000*	E *n = 1417*	O = *n = 642*
Persisted	598 66.8%	816 65.0%	348 60.2%	830 83.0%	1169 82.5%	534 83.2%
Not Persisted	297 33.2%	439 35.0%	230 39.8%	170 17.0%	248 17.5%	108 16.8%
Pa & P	430 48.0%	480 38.2%	180 31.1%	502 50.2%	692 48.8%	206 32.1%
F/W & P	168 18.8%	336 26.8%	168 29.1%	328 32.8%	477 33.7%	328 51.1%
Pa & NP	119 13.3%	125 10.0%	57 9.9%	76 7.6%	64 4.5%	25 3.9%
F/W & NP	178 19.9%	314 25.0%	173 29.9%	94 9.4%	184 13.0%	83 12.9%

Note: FtF = Face-to-Face; E = Emporium; O = Online; Pa & P = Passed & Persisted; F/W & P = Failed/Withdrew but Persisted; Pa & NP= Passed but Not Persisted; F/W & NP = Failed/Withdrew but Not Persisted.

CHAPTER V: Discussion

For many college students, completing developmental education coursework has been an obstacle to obtaining a college degree (Bonham & Boylan, 2012). There are many studies that have focused on developmental education coursework (Bailey, Jaggars, & Jenkins, 2015; Barnett, Bergman, Kopko, Reddy, Belfield, & Roy, 2018; Belfield & Crosta, 2012). The purpose of this journal-ready dissertation was to contribute to the current body of research by investigating, in developmental mathematics courses at one community college in Northeastern Pennsylvania, the extent that differences exist in (a) placement policies by success and persistence measures across course levels, (b) students' perceptions about motivation and anxiety measures by course modality and success measures, and (c) student success and persistence rates by course modality. The data set for this study included students who took developmental mathematics from fall 2015 through spring 2019 for a total of 9,658 students. The students could select their developmental course from emporium, face-to-face, or online formats. At this institution, little data collection or analyses of these courses concerning success, persistence, motivation and anxiety, or placement by course modality had been conducted prior to this study.

This chapter synthesizes the results for the three studies conducted. In the first study, differences between the placement policies at the college and student success and persistence rates based on course modality were determined. In the second study, differences between the student's perception of intrinsic and extrinsic motivation, worry, and NAR by their course grade and modality were analyzed. Finally, in the third study, differences in final exam grade, final course grade, and student persistence in mathematics at this college based on course modality were investigated. A limitation of persistence in this study is that we can never ascertain if students who withdrew persisted at other institutions. This journal-style, retrospective quantitative research study has made connections with literature and theoretical frameworks, while providing recommendations for practitioners, policymakers, and future research studies.

Summary of Study One Results

For those in higher education tasked with helping underprepared students in mathematics, more attention needs to be paid to the effectiveness of placement practices. The intention of the first quantitative study was to examine differences in success and persistence in mathematics courses by placement policy, particularly, placement by high school transcripts and ACCUPLACER scores. While the college also used SAT scores for placement, the only course students could qualify for with these scores was College Algebra. Therefore, those data points were not used for this study. The sample was limited to students who took the course that their highest level of placement put them into. Students who took a course lower than what their placement score recommended were excluded from this study.

The diverse academic preparation of students in open-access institutions such as community colleges creates a need for varied and accurate placement. An assumption is that the more accurately students are placed into courses, the more likely the course will meet the developmental needs of the student. Research suggests that one way colleges can increase the effectiveness of their placement policy is to give students responsibility for their level of preparation for the placement (Goeller, 2013; Koch, Slate, & Moore, 2012). Saxon and Morante (2015) suggested that a comprehensive model of assessment and placement creates a more accurate and refined process. The involvement of both the college and student implies an action must occur.

As part of the enrollment process, institutions of higher education's placement of students into mathematics, writing, and English courses has often been based on highly-valued placement options, such as placement exams or other standardized tests (Gerlaugh et al., 2007; Hughes & Scott-Clayton, 2011; Bailey, Jeong, & Cho, 2010). High school transcripts have been used less often for placement (Gerlaugh et al., 2007). Research has been emerging about the effectiveness of multiple measures of prior mathematics, along with placement test scores, for accurate placement (Ngo & Kwon, 2014). The analyses for high school transcript and ACCUPLACER were conducted separately and success and persistence were examined by course level. Students who have been out of high school for more than five years could not use their high school transcripts and were regulated to using ACCUPLACER scores.

Student Success by Course-Level Placement

Table 25 shows the summary chi-square test results for this study. Statistically significant differences were revealed between the high school transcript placement and the success of students in all levels of developmental mathematics. Across the three course levels, placement by high school transcript appeared the least successful for students in the highest-level course (46.6% passing) and the most effective for placement in the middle-level course (58.0% passing). Even though there were no statistically significant differences for success across course level when placement was made via an ACCUPLACER score, placement by ACCUPLACER appeared more successful for the highest-level course (38.3% passing in MATH 026) compared to the other course-levels.

However, the sample size for the highest-level developmental mathematics course was small (*n* = 47), so the inference to that course level should be met with caution. Students placed via their ACCUPLACER score withdrew about 40% of the time compared to those with high school transcript placement (approximately 15%) and passed at lower rates than placement by high school transcript (see Table 7) These results were consistent with several studies that found that student success was strong when students were placed with their high school transcripts (Belfield & Crosta, 2012; Ngo & Kwon, 2014; Scott-Clayton, 2012). My recommendation would be to use high school transcript evaluations of mathematics courses from the past five years, when available.

Persistence by Course-Level Placement

There were also statistically significant differences in the persistence of students based on the final course grade and placement by the high school transcript. Only students in the lowest and highest level of developmental mathematics were considered for this question. Students who took Math 022 had the option to be finished, continue with developmental mathematics, or go onto a college-level mathematics course based on majors. As that information was not tracked, those data points were not considered for this analysis. When persistence was dichotomized and analyzed by high school transcript, the somewhat noteworthy Cramer's V suggests that small differences in persistence by course level might occur, even though the test results were not statistically significantly different ($p = .054$). When placement was made by ACCUPLACER score, statistically significant differences existed in persistence by course level. The picture that the data gives is that persistence rates were low by ACCUPLACER placement and high by high school transcript. Comparisons of the percentages show that students in developmental courses placed by their high school transcript tended to persist in mathematics (76% in Math 020 and 83% in Math 026) compared to those placed by ACCUPLACER (7% in Math 020 and 15% in Math 026).

When persistence was categorized, students who were placed by their high school transcript were more persistent, regardless if they passed, failed, or withdrew from their respective developmental course. Students who placed into the lowest-level course (Math 020) based on their ACCUPLACER score passed the course almost 29% of the time, but approximately only 10% of those students persisted in mathematics (i.e., 21/215; see Table 8). This was still much lower than the students placed by their high school transcripts. For example, approximately 54% of those Math 020 students passed, and 43% of those students persisted in mathematics (269/335; see Table 8).

Table 25

Summary of Chi-Square Results for Course Placement Level by Success and Persistence

	Success (PFW)		Persistence (Dichotomous)		Persistence (Categorical)	
Placement Policy	Statistically Significant	Cramer's V	Statistically Significant	Cramer's V	Statistically Significant	Cramer's V
HST	Yes	Somewhat noteworthy .077	No	Somewhat noteworthy .060	Yes	Somewhat noteworthy .085
ACCU	No	Nominal .031	Yes	Very noteworthy .670	Yes	Very noteworthy .389

Note: HST = high school transcript; ACCU = ACCUPLACER

Comments

Research indicates that placement tests might not serve as a good portent of developmental course grades (Belfield & Crosta, 2012). Commercial placement tests are often adaptive exams but do not give a full picture of students' mathematical knowledge, motivation, socio-cognitive factors, and academic behaviors. High school transcripts provide a more cohesive pictures of students' past achievements and self-regulatory thoughts and behaviors; therefore, the transcript evaluations, possibly, have more merit for placement purposes than a single test score. Research should focus on potential changes in placement criteria from a single-test score to multiple measures. A challenge with understanding placement by high school transcripts is missing data, particularly, when students received their GED or credit for work or military experience. Regardless of that challenge, placement by multiple measures continues to be a worthwhile endeavor. Future research for those with job or military experience should be explored to accommodate those students out of college for more than five years.

One of the challenges of this study was obtaining placement scores for all students because data were not always included in the same student data files. Data collected from the institution was difficult because of changes to the federal guidelines about privacy; consequently, obtaining the information in one file that allowed for tracking of data became a challenge. Grade distributions at the community college included grades with pluses and minuses, which were not standardized across the board. A final challenge was determining persistence for Math 022 students because not all majors required additional mathematics courses beyond Math 022. Therefore, because major was unknown, persistence in mathematics of Math 022 students was not examined.

Summary of Study Two Results

In the second empirical investigation, the extent to which there were differences in students' perceptions about intrinsic motivation, extrinsic motivation, worry, and NAR levels by students' final course grade and modality were examined. The sample of students surveyed consisted only of those who were registered and taking a developmental course in the spring of 2019. Students were not mandated to take the pre- and post-surveys. As the data collection revealed, because only a small number of participants that responded to both surveys, only post-survey responses were analyzed. Students rated their responses to questions using a Likert scale of 1 (not at all) to a 7 (very much) for fear and dread (NAR) and worry from the Math Anxiety Questionnaire (MAQ; Wigfield & Meece, 1988) and questions pertaining to intrinsic and extrinsic motivation from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, & McKeachie, 1991).

Mathematics anxiety was considered because Zientek, Yetkiner, and Thompson (2010) found anxiety levels of developmental mathematics students to be high. Mathematics anxiety is a derivation of self-efficacy, the latter of which has been shown to be one of the greatest predictors of achievement in mathematics (Pajares, 1996; Pajares & Graham, 1999; Pajares & Kranzler, 1995; Pajraes & Miller, 1994; Zientek & Thompson, 2010). Understanding anxiety levels is important because students with higher anxiety levels tend to avoid situations or activities that require mathematics (Ashcraft, 2002; Dowker, Sarkar, & Looi, 2016). Social background may explain differences in the level of anxiety in the classroom (Jackson & Leffingwell, 1999), therefore, conducting this research with different course modalities and a diverse student population will further add to current research. Table 26 summarizes the MANOVA and *t*-test summary results.

Post-Tests and Course Modality. For research question one, a MANOVA was conducted to test the differences of post-survey beliefs by course modality. Before running the MANOVA, multivariate normality was tested. There was only one person designated as an outlier because he or she categorized himself or herself as low intrinsically and high extrinsically motivated. Plots of the Mahalanobis D^2 vs. chi-square suggested the data was close to multivariate normal on measures of motivation, NAR, and worry; therefore, regardless of the modality, students' responses were similar. On average, students were more worried about their potential success in the course and were extrinsically motivated than had NAR or were intrinsically motivated. Some of the grade policies for acceptance into high demand fields like the nursing program at N.C.C. may contribute to the worry and external motivation for the students. Figure 3 showed overlapping confidence intervals for all variables across course types, supporting that no noteworthy differences existed.

Table 26

Summary of MANOVA and t-test Results for Placement by Success and Persistence

	MANOVA			Statistical
	Statistically Significant	Effect Size	*t*	Significance *p*
MNARW	No	.05249		
PostNAR			-2.295	.024
PostWorry			-1.887	.062
PostINT			- .992	.324
PostEXT			- .121	.904

Note: MNarW = Motivation, NAR, and Worry; NAR = Negative Affective Reaction or Anxiety; INT = Intrinsic Motivation; EXT = extrinsic motivation

Post-Tests and Course Grade. The second research question looked at students' perception of their NAR, Worry, Intrinsic and Extrinsic Motivational levels, and their final course grade. This study was limited in location and sample size. After applying Bonferroni corrections, *t*-test results found no statistically significant differences existed on these constructs by course success. However, correlations provided in Table

16 show that Worry was correlated with Intrinsic and Extrinsic Motivation at noteworthy levels. Regardless of modality, this sample of students were more extrinsically motivated and worried about their overall success in doing mathematics. For some students who passed the course, their mathematics anxiety (i.e. NAR and Worry) appears to be at lower levels than those who failed the course (see Table 14), which follows other research findings (see Hembree, 1990; Zientek et al., 2010). Boxplots in Figure 4 indicated that all students rated their Worry at a 4.5 or higher regardless of the modality. It is recommended that due to the low power the study be conducted again with a larger sample size.

Comments

Several studies have focused on mathematics anxiety and mathematics performance (Andres & Brown, 2015; Ashcraft, 2002; Chang & Beilock, 2016). The role of motivation and performance is based entirely on students' perceptions and values (Hendijani, Bischak, Arvai, & Dugar, 2016). Maloney and Beilock (2012) theorized that helping students regulate or reframe their anxiety may help them see an increase in their mathematical performance. Results from this study showed the students were more worried about their performance than fearing or dreading the mathematics (i.e., NAR), which may be the result of the college's implied pressures for specific degree programs. Finding ways to lessen that worry may help students change their frame of mind in the future.

This research was limited by a small, biased response rate. Most of the students who responded to the post-survey completed the course. The students who completed the post-survey passed their remedial courses at 78.9% for the Emporium, 86% for the

Lecture, and 66.7% for the Online students. Future research should consider a larger sample size and incentives to encourage participation. Examining differences by program majors may give further insight into high demand fields like the nursing program at N.C.C. that may contribute to the worry and extrinsic motivation. In addition, future research should be conducted to determine if the implementation of a new computer program in the developmental mathematics course will alter students' perceptions of intrinsic and extrinsic motivation and anxiety at this college.

Summary of Study Three Results

In the third study of this journal-ready dissertation, the extent to which differences existed in final exam grade, final course grade, and persistence in mathematics by course modality were investigated. Emporium was particularly of interest, given the ability to accelerate students through the developmental course sequence. Research suggests that emporium courses with clearly-defined structure and expectations, as was the case at this college, could benefit some students (Saxon & Martirosyan, 2017). The mastery component of the emporium course structure has been found to result in more students passing with higher grades and increased retention rates in some studies (Boylan, Bonham, Claxton, & Bliss, 1992). This course structure can set an expectation to demonstrate mastery, throughout the course, keeping students actively engaged in the acquisition of their own knowledge (Cousins-Cooper, Staley, Kim, & Luke, 2017).

Final Exam Grade and Course Success by Course Modality

Students' success was analyzed for all three courses (Math 020, Math 022, and Math 026). As seen in Table 27, statistically significant differences existed by course modality for final exam grade and course success, across all three course levels.

Emporium students scored higher on the final exam, whereas face-to-face and emporium students passed the course at similar success rates. Online students passed at lower rates. Those results suggest that final exam grade might not be the best assessment to measure impacts of an intervention. Regardless, mastery throughout the emporium course might have led to higher final exam scores, overall, for emporium students. Students in the Math 022 course were more likely to take their final exam, which might be indicative of the policy that students could go immediately into several college-level courses when they complete that course.

Persistence by Course Modality

Students who enrolled in either emporium or face-to-face courses were more likely to persist in mathematics at the college than students who took the same course in an online format. Persistence in mathematics at the college was limited to students in Math 020 and Math 026. Chi-square analysis found that students in Math 026 persisted in mathematics at the college about 83% of the time, compared to approximately 60-66% of the time for Math 020 students. When persistence was disaggregated further, based on the pass, fail, or withdraw of the students, those in face-to-face and emporium courses persisted after passing at higher percentages than for those in online sections. Students who took Math 026 online were more likely to fail or withdraw but come back to the college for mathematics at the highest percentage (51.1%). Students who enrolled in emporium Math 026 passed and persisted at a rate within 2% of traditional lectures, perhaps indicating that, once students were exposed to the emporium style of learning, they adapted as well as to lectures. Statistically significant differences in persistence, both dichotomous and categorical, were evident for students in Math 020. Students in Math 026 had statistically significant differences in their categorical persistence variable.

Table 27

Summary of Results for Success and Persistence in Mathematics by Course Modality

	Final Exam (interval)	Final Course Grade (PFW)		Persistence (Dichotomous)		Persistence (Categorical)	
	Statistically Significant	Statistically Significant	Cramer's V	Statistically Significant	Cramer's V	Statistically Significant	Cramer's V
Math 020	Yes	Yes	Noteworthy .129	Yes	.050	Yes	Noteworthy .111
Math 022	Yes	Yes	Noteworthy .190	Not included	Not included	Not included	Not included
Math 026	Yes	Yes	Noteworthy .123	No	.008	Yes	Noteworthy .126

Note: PFW = Pass, Fail, or Withdraw

Comments

What works best for some students is not the same for all students; based on this data, emporium classes were just as effective in terms of pass rates as face-to-face courses when students had the option to choose the course modality that they took. After analyzing the data for this study, emporium courses seemed to benefit students who might need a simple brush up of skills or who have the skills and study habits to complete an accelerated model. Future considerations should be made to include mastery learning in all course modalities for greater success in the courses, and less or no online sections of developmental mathematics. The data suggest students at the lowest levels of placement should not be placed in online or emporium courses, as this research shows they benefit more from the face-to-face instruction. Administrators should examine the efficacy of offering such courses to students with little built-in academic or student-support services. Future research could investigate what changes in online format are needed to be successful with these students. One limitation of this study was that, while students had a choice about which course format they wanted, more sections of emporium courses were offered than face-to-face or online sections.

Conclusion

This study adds to the body of research comparing the reengineering of developmental mathematics courses, particularly, delivery methods (see Zauner, Salaman, Miller, & Matovich 2013). The purpose of this journal-style dissertation was to look at affective measures, placement policies, and course modalities by success measures. While the data size for the second study was small, students tended to be more worried than exhibiting NAR and were extrinsically motivated, regardless of the course modality. Placement by high school transcript was more successful in regard to success and persistence in mathematics rates. Finally, the success of students by their final exam and final course grade and their persistence in mathematics at the college had statistically significant differences based on their course modality. This study has shown that students in emporium and face-to-face developmental mathematics courses have similar success and persistence in mathematics rates when students have the option to choose course formats.

While the rise of computer software in developmental mathematics has aided in providing immediate feedback, individualized focus in topics, and the ability to accelerate in courses, the role of the instructor should not be marginalized. Continuing the practice of offering developmental mathematics in both emporium and face-to-face modalities should offer similar stories of success for the students at N.C.C. Further studies on success and persistence of students in mathematics based on course modality need to continue to be added to the increasing research for best practices for an ever-changing population.

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APPENDIX A

IRB Approval for research from N.C.C.

11/6/2018
Date Submitted

EXEMPT REVIEW FORM

Northampton Community College Institutional Review Board

Instructional Methods for Teaching Developmental Mathematics and Their Success, Persistence, and Retention Rates at a Community College in Northeastern Pennsylvania.

Title of Research Project

Principal Investigator/Project Director	Department	Phone Extension	Email address
Celisa Counterman	Business and Technology	1837	ccounterman@northampton.edu

Co-investigator/Student Investigator	Department	Phone Extension	Email address
Click here to enter name..	Click here to enter department.	Click here to enter phone..	Click here to enter email address.

Co-investigator/Student Investigator	Department	Phone Extension	Email address
Click here to enter name.	Click here to enter department.	Click here to enter phone.	Click here to enter email address.

Anticipated Funding Source:	n/a
Projected Duration of Research:	12 months
Projected Starting Date:	2/1/2019
Other organizations and/or agencies, if any, involved in the study:	n/a

Exempt under code (see definitions – check one): 1 ☐ 2 ☐ 3 ☐ 4 ☒ 5 ☐ 6 ☐

SUMMARY ABSTRACT: Please supply the following information below:

- BRIEF description of the participants, the location(s) of the project, the procedures to be used for data collection, whether data will be confidential or anonymous, disposition of the data, who will have access to the data.

Archival data on student common final exam grades, final course grades, gender, ethnicity, Pell Grant status, and persistence to the next math course will be collected from a person working for Institutional Research at Northampton Commujninty College and the math lab manager for all students who attended Northampton Community College from fall 2014 through spring 2019. All data will be collected in an excel sheet which will be kept in a file on the intranet at NCC accessible only by the researcher and password protected. After data is merged, all identifying markers (student ids) will be deleted from the data file by the researcher. There is no need for informed consent as all the data is archived data and no current data will be accessed. Once the research is complete, the data will be deleted from the server. Students will be asked in spring 2019 to consent to an anonymous survey on SurveyMonkey to address questions of intrinsic and extrinsic motivation and perceived anxiety about mathematics. This data will not have any identifying student markers in any format.

- ***Attach copy*** of the Informed Consent Form and/or the measures (questionnaires) to be used in the project.

RESPONSIBILITIES OF THE PRINCIPAL INVESTIGATOR:

- Any additions or changes in procedures in the protocol will be submitted to the IRB for written approval prior to these changes being implemented.
- Any problems connected with the use of human subjects once the project has begun must be communicated to the IRB Chair.
- The principal investigator is responsible for retaining informed consent documents for a period of three years after the project.

Celisa Counterman	1/7/2019
Principal Investigator Signature	*Date*
Click here to enter text.	Click here to enter a date.
Co-Investigator/Student Signatures (if appropriate)	*Date*
Click here to enter text.	Click here to enter a date.
Co-Investigator/Student Signatures (if appropriate)	*Date*

	1/7/2019
Signature of IRB Committee Chair	*Date*

APPENDIX B

Consent for Participation in Research

Instructional Methods in Developmental Mathematics at a Public Two-Year College in the Northeast

Why am I being asked?

You are being asked to be a participant in a research study about student motivation and anxiety in mathematics courses. My name is Celisa Counterman, and I am conducting this research under the direction of Dr. Linda Zientek. I am a full-time graduate student of the Educational Leadership at Sam Houston State University (SHSU) and a full-time mathematics professor at Northampton Community College. You are being asked to participate in this research because you currently are enrolled in a developmental mathematics course at Northampton Community College. We ask that you read this form and ask any questions you may have before agreeing to be in the research.

Your participation in this research is voluntary. Your decision on whether or not to participate will not impact your course grade or current or future relationships with Northampton Community College or Sam Houston State University.

Why is this research being done?

This research is being conducted as part of my dissertation study and will look at the relationship between motivation, anxiety, course structures and student success in developmental mathematics. I hope that data from this research will provide faculty members with an understanding of students' mathematics anxiety and motivation.

What is the purpose of this research?

The purpose of this research is to examine relationships between mathematics anxiety, motivation, mathematics course structure, and student success in mathematics.

What procedures are involved?

If you consent to participate in this research, you will be asked to *complete a 19-question survey about your gender, ethnicity, mathematics course, and motivational and anxiety factors* at the beginning and end of the semester. Any data obtained from you will only be used for this study. Course grades will be collected. In addition, your data will remain confidential. This research will require about *10 minutes* of your time. Participants will not be paid or otherwise compensated for their participation in this project.

Participation is voluntary. If you decide not to participate in this research, your decision will not affect your current or future relations with SHSU or Northampton Community College. Also, if at any point during the research you decide to withdraw, you are free to withdraw your consent and to discontinue participation without affecting those relationships or your course grade. Approximately 1,000 students may be involved in this research at Sam Houston State University.

What are the potential risks and discomforts?

The research is relatively straightforward, and we do not expect the research to pose any risk to any of the volunteer participants.

Are there benefits to taking part in the research?

The research will inform educators about students' mathematics anxiety and motivation. There are no benefits to the students who are participating in the study.

What about privacy and confidentiality?

The only people who will know that you are a research participant are members of the research team. No information about you or provided by you during the research will be disclosed to others. When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. All survey information that contains students' college IDs will be kept on an external server, which will be accessible by myself only via a password. Once pre- and post-semester survey responses and course grades are matched, students' IDs will be deleted from the file.

Will I be reimbursed for any of my expenses or paid for my participation in this research?

There is no reimbursement for your participation in this survey. Students' grades will also not be affected by their decision to participate or not to participate.

Can I withdraw or be removed from the study?

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer and remain in the study. The investigator may withdraw you from this research if circumstances arise that warrant doing so.

Who should I contact if I have questions?

The researcher conducting this study is Celisa Counterman. You may ask any questions you have now. If you have questions later, you may contact the researcher at the information listed below or her faculty coordinator.

Celisa Counterman Northampton Community College 2411 Route 715 Tannersville, PA 18372 Phone: (570)369-1837 E-mail: cyc009@shsu.edu	*Dr. Linda Zientek* SHSU *Department of Mathematics and Statistics* Sam Houston State University Huntsville, TX 77341 Phone: (936) 294-4874 E-mail: lrzientek@shsu.edu

What are my rights as a research subject?

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

You may choose not to participate or to stop your participation in this research at any time. Your decision whether or not to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled, and the subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

The investigator may also end your participation in the research. If this happens, your class standing or grades will not be affected. You will not be offered or receive any special consideration if you participate in this research.

Agreement to Participate

Consent: I have read and understood the above information, and I willingly consent to participate in this study. I understand that if I should have any questions about my rights as a research subject, I can contact Celisa Counterman at 570-369-1837 or by email at cyc009@shsu.edu

Please mark either agree or disagree.

	I agree to participate.	
	I do not agree to participate.	

APPENDIX C

Student Survey Questions

Variable	Description
Student Information	
Student ID	Numeric
Gender	nominal; (0 = male, 1 = female, 2 = prefer not to answer)
Ethnicity	Categorical; (0 = White, 1 = Black, 2 = Hispanic, 3 = Asian, 4 = American Indian, 5 = Other, 6 = Mixed Race, 7 = prefer not to answer)
Course Modality	Categorical (course name); (0 = lab, 1 = lecture, 2 = online)
Math Anxiety Questions (MAQ; Wigfield & Meece, 1988)	
(1) When the teacher says they are going to ask you some questions to find out how much you know about math, how much do you worry that you will do poorly?	Interval; (1 = not at all, 7 = very much)
(2) When the teacher is showing the class how to do a problem, how much do you worry that other students might understand the problem better than you?	Interval; (1 = not at all, 7 = very much)
(3) When taking tests I usually feel…	Interval; (1 = very relaxed, 7 = not relaxed)
(4) When I am in math, I usually feel ...	Interval; (1 = not nervous, 7 = very nervous)
(5) Taking math tests scares me.	Interval; (1 = not at all, 7 = very much)
(6) I dread having to do math.	Interval; (1 = not at all, 7 = very much)
(7) It scares me to think that I will be taking advanced high school math.	Interval; (1 = not at all, 7 = very much)
(8) In general, how much do you worry about how well you are doing in school?	Interval; (1 = not at all, 7 = very much)
(9) If you are absent from school and you miss a math assignment, how much do you worry that you will be behind the other students when you come back to school?	Interval; (1 = not at all, 7 = very much)
(10) In general, how much do you worry about how well you are doing in math?	Interval; (1 = not at all, 7 = very much)
(11) Compared to other subjects, how much do you worry about how well you are doing in math?	Interval; (1 = not at all, 7 = very much)

Student Survey Questions continued

Variable	Description
Motivation Questions (MOT; Pintrich, et al., 1991)	
(1) In a class like this, I prefer course material that really challenges me so I can learn new things.	Interval; (1 = not at all, 7 = very much)
(2) In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	Interval; (1 = not at all, 7 = very much)
(3) The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.	Interval; (1 = not at all, 7 = very much)
(4) When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.	Interval; (1 = not at all, 7 = very much)
(5) Getting a good grade in this class is the most satisfying thing for me right now.	Interval; (1 = not at all, 7 = very much)
(6) The most important thing for me right now is improving my overall grade point average, so my main concern in this glass is getting a good grade.	Interval; (1 = not at all, 7 = very much)
(7) If I can, I want to get better grades in this class than most of the other students.	Interval; (1 = not at all, 7 = very much)
(8) I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.	Interval; (1 = not at all, 7 = very much)

Note: *n* (students)

APPENDIX D

Re: MAQ permission

Allan L. Wigfield <awigfiel@umd.edu>

Sun 1/13/2019 2:46 PM

To: Counterman, Celisa <cyc009@SHSU.EDU>;

Hi Celisa,

You have my permission; that scale is now in the public domain so feel free to use it whenever you would like. I do appreciate that you will cite the original study where it was published.

Good luck with your study.

Allan Wigfield

On Sun, Jan 13, 2019 at 2:43 PM Counterman, Celisa <cyc009@shsu.edu> wrote:

> Dear Professor Wigfield,
>
> I am a graduate student in the Developmental Education Administration Doctoral program at Sam Houston State University. I am writing to seek permission to (a) administer the 11-item Mathematics Anxiety Questionnaire published in your 1998 *Educational Psychology* journal and (b) publish the anxiety items in both my dissertation and a future journal article.
>
> The instrument will be administered online in the spring 2019 semester. Of course, I will reference your 1998 article on the online instrument and in a note under the table in all publications.
>
> Thanks in advance for your consideration.
>
> Sincerely,
>
> Celisa Counterman
>
> 1690 Old Tioga Tpke.
>
> Stillwater, PA 17878
>
> cyc009@shsu.edu

VITA

Celisa Counterman

Education

Sam Houston State University
EdD Leadership: Developmental Education Administration 2020
Dissertation Topic: *Course Placement, Course Modality, and Student Success: Developmental Mathematics at a Public Two-Year College in the Northeast*.

Montclair State University
MS Mathematics 2007
Thesis *Topic: The changing face of developmental education in post-secondary education: A study for integrating project-based learning and how to develop projects to align with NCTM standards*

University of Phoenix 2004
MaEd Adult Education

East Stroudsburg University 2002
BS Computer Science
Minor: photography (media communications)

Academic Employment

Tenured, Professor of Mathematics 2004 – present
Northampton Community College, PA

Adjunct, Mathematics Instructor 2002 – 2005
Montclair State University

Adjunct, Mathematics & Computer Science Instructor 2002 – 2004
Lehigh Carbon Community College, PA

Adjunct, Mathematics Instructor 2002 – 2004
Warren County Community College, NJ

Publications

Ebersole, D., & Counterman, C. (2015). A community of learners: Including part-time instructors in Mathematics faculty department. *MathAMATYC Educator, 7*(1), 31-34.

Leadership Roles

Family Promise of Monroe County: *board member & Secretary*	2012 – 2014
Northampton Community College: *Writing Intensive Co-coordinator*	2012 - 2014
United Way of *Monroe* County: *board member*	2014 – 2016
Pennsylvania State Mathematics Association of Two-Year Colleges: *President, Past-President, Scholarship Committee*	2014 – present
Pennsylvania Association of Developmental Education: *board member*	2018 – present
Northampton Community College: *Developmental Mathematics Coordinator*	2013 – present

Grant Work

Northampton Community College: *ACeS co-coordinator*	2006 – 2007
Northampton Community College: *STEM Scholarship*	2008 – 2011
Northampton Community College: *NSF Wider Grant co-coordinator*	2013 – 2015
Northampton Community College: *NSF IUSE Grant co-coordinator*	2015 - 2016

Conference Presentations

Celisa Counterman, *Reading, Writing, and 'Rithmetic in the Classroom,* PADE, Gettysburg, PA, 2014

Celisa Counterman & Dennis Ebersole, *Evidence-Based Practices – Why Not?*, AMATYC, New Orleans, LA, 2015

Celisa Counterman, *M.A.T.H. Making Algebraic Thinking Holistic*, PADE, York, PA, 2017

Celisa Counterman, *Perceptions of Success and Failures from Developmental Mathematics Students,* NADE, Baltimore, MD, 2018

On-Campus Training and Presentations

Northampton Community College, SMART Scholars for girls presentations	2008 – 2010
Northampton Community College, Faculty speaker at groundbreaking	2009
Northampton Community College, MyMathLab and MyLabsPlus training	2014 – present
Northampton Community College, Math Night for the Community	2014
Northampton Community College, Faculty welcome Spring graduation	2014
Northampton Community College, Super Saturday & Opening Day Presentations:	
Writing – Intensive	2011 – 2014
NSF Presentations	2013 -2015

Research Experience

Determining success and persistence of freshman math students at East Stroudsburg University, Spring 2018

Courses Taught

Basic mathematics	Pre-algebra	Calculus I
Intermediate algebra	College algebra	Trigonometry
Calculus I	Discrete math	Pre-calculus
Intro to programming	Intro to computers	C++
Elementary Algebra	Math for Elementary Teachers I & II	Natures of Math
Applications in Math	Statistics	

Service to the College

Northampton Community College: Instructional group for collaborative learning	2007 – 2009
Northampton Community College: Adult student learners think tank	2006
Northampton Community College: Member of:	
External strategic planning committee	2005
College life committee	2011
Hiring committee: Associate Dean, FT & PT counselors, Dean of Student Services, Dean of online learning, VP of Institutional Advancement, Math Lab Manager, Math faculty positions	2004 – present
PTK Scholarship Committee	2012 -2015, 2017
Presidential inauguration committee	2011
Academic advisement committee	2017 – present
Northampton Community College: Middle States co-coordinator	2013 – 2015
Northampton Community College: Advisor to the following	
Band of Brothers	2015 – 2016
Multicultural Club	2012 -2 015
Phi Theta Kappa	2007 – 2016
United Way Faculty & Staff campaign	2011 – 2014
Northampton Community College: Math summit with high school teachers	2015 – present

Technology

Blackboard & Blackboard collaborate	Mathematica
Screen-Cast-o-Matic	Google Hangouts
Geometer's Sketchpad	WebAssign
All Microsoft Office Products	MyMathLab
MyLabsPlus	HTML

Hawkes learning system	Remind
SPSS V22 & V24	BlueJeans
GoTo Meeting	Zoom

Professional Affiliations

AMATYC (state representative)	NADE
PADE (2-year representative)	NFRW
PSMATYC (past president)	AWM
NCTM (PSMATYC representative)	