

EFFECTS OF PEER TUTORING ON PASSING DEVELOPMENTAL
MATHEMATICS

by

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Abstract

The cost of remediation is high, for both postsecondary institutions (Pain, 2016) and the students who are enrolled in developmental math courses (Attewell et al., 2006). Academic support services such as tutoring, have been associated with positive student outcomes in developmental math (Bonham & Boylan, 2012). The Learning Center is a fee for service program at a four-year postsecondary institution that provides comprehensive academic support services for students with learning and attention challenges. Little is known, however, if these types of support services are effective for students with learning and attention challenges. Thus, a program evaluation study was conducted on the effectiveness of tutoring services at the Learning Center. Specific research questions are (a) What is the effect of peer tutoring on the incidence of passing developmental math? (b) How do students with learning and attention challenges engage with on-campus academic support services?

Four cohorts of developmental math students from fall semesters 2012 through 2015 were examined in this cross-sectional study, which consisted of 182 complete cases. Variables to conduct this program study included a binary outcome of passing the developmental math course, and the primary independent variable of math tutoring usage at the Learning Center. Controls variables included student demographic information, prior academic achievement in mathematics, and student usage of additional available academic support services on campus and at the Learning Center.

A logistic regression analysis revealed that usage of math tutoring at the Learning Center was not an effective intervention. Nearly half of the students did not engage in math tutoring services at the Learning Center. Engagement with tutoring for other

subjects at the Learning Center was significantly related to the outcome with an eight percent increase in the likelihood of passing the developmental math course for each additional hour of usage $\chi^2 (1, n = 182) = 10.43, p = .001$. Prior academic achievement in math also was significantly related with the likelihood of passing developmental math $\chi^2 (1, n = 182) = 10.1, p = .001$ with an increased odds of 78 percent for every one standard deviation increase in math performance on a standardized math exam. Thus, student characteristics such as prior academic achievement in math and engagement with other academic support services were indicators of passing developmental mathematics. Recommendations for adjusting future academic support intervention efforts at the Learning Center for developmental math based upon the unique characteristics of these students are provided as a result of these findings.

Chapter 1 **Challenges of Remediation**

Approximately one-third of students who enter postsecondary education require remedial coursework (Calcagno et al., 2008; Martorell & McFarlin, 2011; McCormick & Lucas, 2011). As students have gained increased access to higher education through remedial coursework, risks exist such as increased opportunity costs regarding time to graduation and limitations in the majors students choose. (Attewell et al., 2006; Martorell & McFarlin, 2011; Parsad & Lewis, 2003). Parsad and Lewis (2003) identified philosophical arguments for and against the implementation of remedial coursework in institutions of higher education. On one hand, the inclusion of developmental coursework in postsecondary institutions can potentially increase access for students who have deficiencies in core subject areas. On the other hand, opponents of developmental courses question the role of postsecondary institutions in providing remediation (Parsad & Lewis, 2003). Outcomes such as time to graduation and degree completion for students who take developmental courses are inconclusive (Bettinger, Boatman, & Long, 2013). Attewell et al. (2006) found that the majority of students enrolled in developmental writing and reading courses were able to complete the courses, however, only 30% of students enrolled in developmental mathematics successfully completed a course sequence on the first attempt.

Because there is risk that students who enroll in remedial coursework might drop out of college at higher rates than students who do not take these courses, on-campus interventions have been implemented such as tutoring (Bonham & Boylan, 2012; Bremer et al., 2013) and individualized online instructional delivery for remedial coursework (Bell & Federman, 2013; Bettinger & Boatman, 2013; Bonham & Boylan, 2012;

Davidson & Wilson, 2015). Transitional pre-college programs such as Gear Up, Upward Bound, TRIO, (Davidson & Wilson, 2015), and Summer Bridge (Diel-Amen, 2011) have also been created to help students who have been identified at-risk for retention in their first year of postsecondary education. On-campus programmatic approaches that incorporate adaptive online instructional platforms with tutoring, counseling, and supplemental instruction within learning center settings were found to increase student retention in developmental math courses (Bonham & Boylan, 2012). Online coursework can offer a cost-effective means of delivering instruction to many at an individualized level (Castillo, 2013), however, challenges regarding tracking of student engagement in the program might exist (Bonham & Boylan, 2012).

Some students who possess learning and attention challenges are enrolled in online developmental mathematics courses at the postsecondary level. In addition to visual demands of online coursework, the demands of executive functioning (i.e., self-regulation to sustain and complete tasks, time management, and planning) can be challenging for some students in this population (Keeler & Horney, 2007). Additional academic support services exist beyond programmatic interventions in developmental mathematics for students with learning and attention challenges. These support services can include tutoring (Green & Rabiner, 2012; Rath & Royer, 2002) and disability accommodations (e.g., note-taking, extended test time). The transition between secondary and postsecondary education, however, carries expectations that students will learn to develop self-advocacy skills (Hadley, 2011; White et al., 2014). Thus, implications for college students with learning and attention challenges are that they must self-advocate for additional accommodations and academic support services.

Few empirical studies have been conducted on students with learning and attention challenges at the postsecondary level (Gray et al., 2016; Kimball et al., 2016; Sparks & Lovett, 2009; Wilson et al., 2015). Although a large amount of research has been conducted on primary school students, learning and attention challenges can persist throughout adulthood (Weyandt & DuPaul, 2006). Students at the postsecondary level with learning and attention challenges are likely to experience disability-related difficulties while navigating their online coursework in developmental math. These students are also likely to spend great amounts of effort keeping up with their coursework compared to their peers who do not have learning challenges (Gray et al., 2016; Lefler, Sacchetti, & Carlo, 2016).

Learning and Attention Challenges Associated With Difficulty in Mathematics

Upon reviewing the literature, several prominent challenges surface that might affect performance in online developmental mathematics at the postsecondary level for students with learning challenges. Within the context of this study, the term ‘learning and attention challenges’ includes specific learning disabilities and disorders that can affect information processing. Learning and attention challenges that affect students’ performance in developmental math at the postsecondary level are described in reference to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, 2013). The learning and attention challenges were identified as anxiety, attention deficit hyperactivity disorder (ADHD), and specific learning disorders regarding reading disability (RD) and mathematics disability (MD). These challenges rarely occur independently of each other (Lewandowski et al., 2013; O’Keefe, 2013). Thus, the

magnitude of impact that one can experience regarding the prominence of these challenges can have considerable variation.

The visual-spatial component of working memory has been associated with achievement in mathematics (Swanson, 2012), and can specifically impact one's ability to estimate (Dehaene et al., 1999). Difficulty in mathematics has also been associated with language processing (Wilson et al., 2015), and has been associated with the ability to perform exact calculation (Dehaene et al., 1999). ADHD, RD, and MD are highly associated, and have a negative impact on working memory (Wilson et al., 2015). Anxiety also negatively impacts working memory, specifically affecting one's long-term retrieval of previously learned material (Ashcraft & Kirk, 2001) and mathematical problem solving strategies (Prevatt et al., 2010).

Anxiety. High levels of anxiety can have detrimental effects on math performance (Ashcraft & Kirk, 2001; Woodward, 2004). Students with learning disabilities were found to have significantly higher levels of anxiety than students who do not have learning challenges (Nelson & Hardwood, 2011). Individuals with anxiety disorders experience excessive amounts of worry that can be related to evaluation. Anxiety disorders can also lead to avoidant behavior, as one will likely avoid situations or tasks that are anxiety-inducing (DSM-5, 2013). Individualized instructional features in online developmental mathematics courses can consist of frequent assessment, therefore students with anxiety disorders might be at risk for non-completion of course material.

ADHD. The demands of attending college require self-regulation and organization, which can be problematic for some students who have ADHD (Nugent & Smart, 2014). Researchers found that students who have ADHD can struggle with time

management (Green & Rabiner, 2012), executive functioning (Gray et al., 2015), and excessive procrastination (Gray et al., 2016). Postsecondary students with ADHD are also at greater risk for experiencing issues associated with the transition of becoming an independent adult, such as managing free time, money, and planning (Nugent & Smart, 2014). Through interviews and survey data, Gray et al. (2015) found high levels of distress were associated with lower levels of persistence in college students with ADHD. Issues that students experience with time management can negatively impact their ability to maintain consistency in a self-paced online math course.

Reading Disability. Dyslexia, or a disorder associated with reading is a challenge that might negatively impact one's performance in online coursework (Habib et al., 2012). This challenge has been identified as difficulty that one can experience in language processing (Björklund, 2011). In addition to difficulty with reading, dyslexia was found to negatively affect individuals' performances in processing speed for addition and subtraction (Gobel & Snowling, 2010). Within the context of online coursework, struggles have been identified regarding typed chat features, multiple online platforms, and fear of having to post typed public responses (Habib et al., 2012). Virtual classroom features and protocol might present barriers for students with dyslexia.

Mathematics Disability. Dyscalculia, or a math disorder can impair one's ability to perform arithmetic through difficulties in storage and retrieval of mathematical facts, spatial deficits, and lack of procedural skills (Geary, 2004). This challenge has been generally described in the literature as an impairment of one's ability to perform arithmetic (Geary, 2004; Kucian et al., 2011). A strategy for working with students who have dyscalculia has been identified as the use of manipulatives (Butterworth et al.,

2011). As students with mathematics learning disabilities might lack conceptual knowledge of underlying principles (Geary, 2004), working with manipulatives might provide some benefit for a student who struggles with math.

Academic Support at the Postsecondary Level

Mandated systems of support for students with learning and attention challenges are different between secondary and postsecondary levels of education (Hadley, 2011; Nugent & Smart, 2014). Accommodations in secondary education that are mandated by IDEA can include curricular modifications and additional support services to help students with learning and attention challenges. At the postsecondary level, academic accommodations deemed ‘reasonable’ are granted to students with learning challenges (Janiga & Costenbader, 2002) after eligibility is determined by campus disability service personnel (DaDeppo, 2009). Some examples of accommodations at the postsecondary level according to ADA include extended test taking time, alternate testing locations, support for vision and hearing impairments, and course notes. These accommodations do not require instructors to make curricular modifications for students with disabilities.

Self-advocacy at the postsecondary level might be difficult for students who have not developed an understanding of how their particular challenges affect their ability to learn (Trammell, 2009). The expectation to self-advocate for support at the postsecondary level might present barriers for students who have learning and attention challenges. The majority of these students experienced high levels of parental and teacher involvement regarding advocacy on their behalf throughout primary and secondary education (Milsom & Hartley, 2005). Therefore, some of these students might

lack experience with self-advocacy for academic support services at the postsecondary level.

Some students with learning and attention challenges might also be reluctant to engage or seek academic support services due to complex reasons regarding self-empowerment and the cost of social interaction (Wilson et al., 2000). The act of seeking academic support can be anxiety inducing for students with learning challenges at the postsecondary level (Connor, 2012). Social skill deficits exist for students with learning disabilities compared to their peers who do not have learning disabilities (Kavale & Forness, 1996). As navigation of postsecondary bureaucratic systems requires social interaction, this might be daunting for students with learning and attention challenges.

Students with learning and attention challenges might have difficulty with social interactions such as seeking academic support due to negative prior experiences. Lisle and Wade (2014) found that including the term 'learning disability' when describing an individual can elicit negative perceptions including less potential for success, issues with emotional stability, and less physical attractiveness. Thus, previous experience with negative bias might present barriers for self-advocacy. Additionally, students with learning and attention challenges might be more hesitant to engage in social activities in their postsecondary experience.

Effects of social skills interventions have been inconclusive (Kavale & Mostert, 2004). Although some students gained skills and increased knowledge from intervention efforts (i.e., workshops and role-playing activities), little is known about actual transfer to social situations. Researchers have identified, however, that engagement in social activities and academic support is associated with greater semester-to-semester

persistence at the postsecondary level for students with learning and attention challenges (DaDeppo, 2009; Mamiseishvili & Koch, 2010).

On one hand, engaging with others for academic support at the postsecondary level can help students with learning and attention challenges. On the other hand, social interactions and self-advocacy for academic support might be costly for these students. From a surface perspective, learning and attention challenges alone can inhibit academic performance in an online developmental math course. Beyond personal struggles, these students can experience institutional and social barriers that might impede success at the postsecondary level regardless of the availability of academic support.

Postsecondary students with learning and attention challenges can struggle even within the context of an online developmental math program that incorporates learning center academic support services. Although intervention support services such as tutoring and academic counseling might be available as part of a larger support program, these students might be reluctant to seek help. Students with learning and attention challenges might also have difficulty engaging with instructors for office hours and classmates for group study sessions. Therefore, students with learning and attention challenges who do not engage in academic support services might be at risk for a lower likelihood of success in online developmental mathematics.

Summary

Some students with learning and attention challenges might be enrolled in developmental math programs in postsecondary institutions. These students can experience unique difficulty in mathematics regarding their specific learning challenge, in addition to difficulty regarding the social demands of obtaining academic support.

Although programmatic systems of support are available for students with learning and attention challenges, some of the students might not engage with the services for reasons regarding stigma, self-empowerment, and convoluted bureaucratic processes (Gray et al., 2016). Therefore, developmental math students who have learning and attention challenges might be at-risk for successful completion of the course. Non-completion of college-level math can increase the time that students spend in college, limit major choice, pose a possible retention risk, and can come with increased costs of attending a postsecondary institution. The purpose of this study is to determine the effect of academic support services on students' likelihood of passing developmental math. Specific research questions for this study regarding students who have learning and attention challenges in a postsecondary institution are: 1. What is the effect of peer tutoring on the incidence of passing developmental math? 2. How do these students engage with on-campus academic support services?

Chapter 2

Background on Developmental Math the Learning Center

Information throughout the following chapter was obtained through meetings and conversations with the developmental mathematics coordinators at the university and staff at the Learning Center. Additional information regarding the content of the developmental math course was obtained through in-person observations of the online course, access to the course syllabus through the university's learning management system, and through access granted to the course content in Assessment and Learning Knowledge Spaces (ALEKS).

Online Developmental Mathematics

Students were placed into developmental mathematics if they scored below 30% on the math entrance exam. The university offered a full support program for students who were enrolled in developmental math through the Main Campus Academic Support Center. As part of this intervention effort, students were enrolled in a math success course for approximately six to seven weeks, had access to math tutoring services, and were assigned to a learning specialist for monthly meetings. These support services were offered to any student who was enrolled in developmental math at the university. The purpose of this program was to help ease transition from developmental math to university level algebra. An intermediate preparatory course followed developmental math, and consisted of a similar course format. Upon successful completion of the intermediate course, students could place into a variety of college-level math courses.

The developmental math course lasted approximately seven weeks, and began halfway through the fall semester. The instructional component of the developmental math course was accessed through the students' learning management system course

page, and was delivered through Blackboard or Adobe Connect software. Students logged in for two virtual class meetings per week during pre-designated times. One weekly meeting would feature student presentations of course material and the other meeting was a lab session. Both meetings were preceded by a lecture on course topics delivered by an Undergraduate Teaching Assistant (UTA). The UTAs would interact with students throughout the virtual class meetings and check their progress on the course materials.

Progress in developmental math was tracked through ALEKS. Outside of the online class meetings, students worked through topics at their individual pace through ALEKS. Progress in ALEKS was monitored through the completion of topics. In order to complete a topic, two problems needed to be correctly solved in a row. ALEKS featured a pie that contained segments related to radicals, exponents, functions, linear equations, real numbers, geometry, proportions, fractions, and whole numbers. Each section of the pie contained an array of topics related to the segment. After successful completion of approximately 30 topics, ALEKS would deliver an assessment. Students were required to complete the assessment before returning to the pie. If problems were answered incorrectly during an assessment, ALEKS would add additional topics to the pie.

Developmental math students took proctored summative midterm and final exams in live classroom settings. These exams took place at a testing center during designated times, and were weighted more heavily than the standard assessments in ALEKS. If problems were missed on the exams, topics would be added to a student's pie. In order to complete the course successfully, approximately 450 of 550 topics needed to be

completed. Incorrect answers on the final exam would remove progress taken towards completion of topics. For example, a student could enter the final exam with 455 topics completed. If that student gave several incorrect responses on the final exam, ALEKS would remove progress and the student might be left with less than 450 topics upon completion. That same student would not be eligible to pursue the next level of college preparatory mathematics.

Upon successful completion of developmental mathematics, a student would be eligible to take the next stage of preparatory math for college level algebra. If a student successfully completed the first two levels of developmental math, they would be eligible for a college-level algebra course in the following summer or fall semester of their sophomore year.

Background: The Learning Center

Students with learning and attention challenges could enroll in a voluntary fee for service program upon their acceptance to the university. For the purposes of this study, this program is referred to as ‘The Learning Center’. This program admitted enrolled students who provided documentation of a learning challenge or a reason regarding their need for additional support at the postsecondary level. The services offered at the Learning Center extended beyond two other campus entities that provided academic support services for all other enrolled students. The other two entities were the Main Campus Learning Center and campus Disability Services.

The Learning Center was established as a student support program in the early 1980s, and provided additional academic support beyond the access accommodations implemented by the campus Disability Services and the academic support services

offered by the Main Campus Learning Center. Approximately 600 students were enrolled annually in the Learning Center throughout the course of the study. Three aspects of support are provided for students who enroll in the Learning Center: 1. Student Programs and Services (SPS), 2. Educational Technology, and 3. Learning Support Services (LSS).

Student Programs and Services at the Learning Center primarily featured weekly learning specialist meetings. The learning specialists worked individually with students on general academic strategies, time management, advance planning, organization, and help with transitional issues. Learning specialists also conducted various voluntary group workshop sessions for students. Workshop topics usually focused on academic success strategies such as test taking, memory, and note taking. Small student support groups and social activities are also coordinated primarily through the SPS team.

Assistive technology programs were available for students enrolled in the Learning Center. These programs were available for student use on dedicated computers within the Learning Center. The programs featured speech-to-text, text-to-speech, and a variety of organizational and visual mapping tools. Student workers known as ‘Tech Consultants’ were recently added in order to enhance the educational technology services. Tech Consultants helped students use assistive technology provided by the Learning Center. The Tech Consultants also helped students with downloading, installing, and using assistive technology on their own electronic devices.

In the following section, I provide a detailed description of the tutoring services offered at the Learning Center. Because the current study examines the effect of tutor

usage as the primary independent variable of interest, detailed descriptions of the tutoring program and training curriculum design principles are given.

Tutoring Program

Approximately 80 peer tutors were employed part-time each semester by the Learning Center in this study. The majority of peer tutors were undergraduate students who were upperclassmen at the university. The Learning Center also employs a small amount of tutors who are from the local community (i.e., community college instructors and professionals in their respective fields of study) and graduate students.

The tutor-training program at the Learning Center was certified by the College Reading and Learning Association (CRLA) International Tutor Training Program Certification (ITTPC). CRLA is a professional service organization that provides guidelines for tutor program certification at the postsecondary level. Guidelines for the application process, standards, and outcomes are listed on the CRLA website (CRLA, 2016). The CRLA currently certifies over 1,000 tutoring programs internationally. Oversight for tutor certification is the responsibility of programs that have been certified by CRLA. Tutors who have been awarded CRLA certification may transfer their certification to other participating learning centers.

Minimum qualification guidelines were provided by the CRLA for tutor employment. Tutors could only help students in courses that they received either an 'A' or 'B' letter grade. The Learning Center also implemented additional guidelines for tutor hiring. Applicants were required to submit a cover letter, complete unofficial transcripts, a letter of recommendation, a completed application form, and a writing sample if they were interested in working in the Writer's Lab. Tutor applicants also needed to be at

least a college sophomore, and had a cumulative grade point average (GPA) above 3.0. Potential tutor applicants were interviewed by the tutoring staff members at the Learning Center and were considered for hire.

Upon being hired, new tutors were required to complete a policy and procedure training. The tutoring policies at the Learning Center are aligned with the CRLA guidelines for tutoring ethics. The CRLA ethical guidelines were adopted from the Association for the Tutoring Profession (ATP). Following ethical and university guidelines, tutors at the Learning Center were required to complete training on sexual harassment, confidentiality, and academic integrity. All tutors needed to complete these trainings prior to their first tutoring session.

Three levels of ITTPC are offered to peer tutors at the Learning Center. All tutors at the Learning Center were required to complete Level I (Regular) certification by the end of their first year of employment. Tutors voluntarily pursued Level II (Advanced) and Level III (Master) certification. Tutors were recruited to cover most courses offered at the university. Therefore, a conceptual approach to student learning was implemented in the curriculum design. The CRLA approved tutor-training curriculum was designed to target general principles of learning rather than specific subject matter.

Tutoring staff members at the learning center monitored tutor progress through the certification levels and deliver the training modules. The main components of each CRLA certification level were attendance of specific training sessions, completion of a predetermined amount of tutoring time with students (measured in hours through student visit records), and formal evaluation by the tutoring staff members. Tutors who pursued Level I and Level III were also required to participate in mentorship activities.

Occasionally, Level II tutors were asked to mentor new tutors in cases where there were few tutors who pursued Level III.

Tutors at the Learning Center completed certification levels as they worked with students throughout the school year. They were responsible for attending training sessions to complete their certification. The Learning Center paid tutors to participate in the training sessions, and offered raises upon completion of each certification level.

Tutoring staff monitored training through the use of various databases and TutorTrac software. Student visit records extracted through TutorTrac allowed the tutoring staff to determine the amount of hours that tutors met with students. A tutor could have been available for drop-in for several hours a week, however, was only credited towards certification requirements when meeting with a student during that time. Students logged in to record visits at kiosks stationed in the tutoring areas in the Learning Center. Data pertaining to student log in records were cleaned and verified by a tutoring staff member weekly for the purpose of rectifying tutor payroll records.

The curriculum described in the following sections reflects an instructional program that was approved and implemented throughout the timeframe of this study. Throughout the 2012-2015 cohorts, minor adjustments to the training curriculum were implemented following staff and tutor feedback. These minor adjustments did not change the initial intent of the training sessions or deviate from the pre-approved CRLA certification.

Appointment-based tutoring was the primary model at the Learning Center. Tutoring sessions were scheduled for hour-long periods. Students could view tutor availability for each of their enrolled courses, and booked appointments with tutors

through TutorTrac software. The Learning Center also had a Writer's Lab and a Math and Science Lab where students could work with tutors in both appointment based and drop-in settings. Tutors were selected for the Math and Science Lab if they were comfortable working with students on college-algebra level courses. Students can also find tutors for various science, engineering, business, and computer programming courses. Tutors who worked in the Writer's Lab were selected if they provided a satisfactory writing sample. The Writer's Lab staffed tutors from a wide variety of majors. The Math and Science Lab and Writer's Lab also had tutor leader positions. Tutor Leaders were peer tutors who were more experienced, and were usually certified at Level II or III. The tutor leaders worked during peak hours to manage the flow of drop-in tutoring in addition to providing extra tutoring support for drop-in.

Monthly meetings for lab tutors were held for the tutors at the Learning Center. These meetings provided the tutoring staff with an opportunity to deliver content-specific training. The lab meetings also allowed tutors to collaborate with their lab on specific issues that arose throughout the semester. Lab meetings allowed for impromptu training for cases such as upcoming exams and changes to courses. Experienced tutors were also provided with the opportunity of leading some of the impromptu trainings. In these cases, methodology for engaging students on specific types of problems was shared and discussed with the rest of the lab tutors. The lab meetings occurred monthly, lab tutors were required to attend at least two meetings per semester.

The topic of working with students who were enrolled in the online developmental course was addressed regularly in the Math and Science Lab meetings following the concerns of learning center staff regarding student success. Informal

training was developed by tutoring staff in order to help students navigate the online course (i.e., helping students identify their progress, syllabus navigation, and course website navigation). A recent effort evolved in training the Math and Science Lab tutors. The monthly meetings focused on the use of manipulatives for helping students with specific types of problems. Sustaining these informal training interventions was difficult, as attendance at the Math and Science Lab meetings was inconsistent, and the pool of MSL tutors tended to cycle from semester to semester.

Chapter 3

Theory and Practice of Peer Tutor Training

The use of trained peer tutors might be an effective intervention for students who are in developmental math, because they likely have lower levels of prior academic achievement (Xu et al., 2001). Students with learning and attention challenges might have an increased risk of lower prior academic achievement in mathematics than their peers who do not have learning and attention challenges (Stevens et al., 2015). Peer tutors at the postsecondary level can be trained to help students with learning and attention challenges navigate online developmental math courses in addition to assisting them with direct academic support.

Students can also experience affective benefits from working with tutors such as increased self-confidence for self-planning, time management, and organization (Arco-Triado et al., 2011). These affective benefits, including feelings of support, can help to increase student retention at the postsecondary level (O’Keefe, 2013). Working with peer tutors on developmental mathematics might help to promote self-confidence and reduce feelings of anxiety for students who have learning and attention challenges. Therefore, peer tutors can be a potential resource for academic support and student retention at the postsecondary level.

Few extant studies have been conducted on the effects of peer-tutoring programs at the postsecondary level on academic achievement (Cooper, 2010; Rath & Royer, 2002; Xu et al., 2001). As some students with learning and attention challenges at the postsecondary level might be at risk for retention (O’Keefe, 2013), trained peer tutors might be a helpful resource for student support in developmental mathematics at the postsecondary level. Peer tutors can assist students with implementing process-oriented

academic strategies (Roscoe & Chi, 2007), within supportive environments that promote learning (Drane, Micari, & Light, 2014).

The purpose of this program evaluation study is to examine the effects of tutoring on students' likelihood of passing a developmental math course at the postsecondary level. Another objective of this study is to examine how developmental math students who were enrolled in the Learning Center engaged with academic support services. The tutoring program in this study is part of a comprehensive academic support center for students at a large western postsecondary institution located in the United States who have learning and attention challenges. As part of employment requirements, all peer tutors in the tutoring program either possessed or were working towards completion of College Reading and Learning Association (CRLA) certification.

Conceptual Context of Tutor Training Curriculum: Role Development

Inconsistencies have been identified in the literature regarding the role of peer tutors in postsecondary settings (Colvin, 2007). Upon reviewing the literature, a clear definition regarding the role of a peer tutor in a postsecondary institution was not evident. Within the context of this study the role of peer tutors at the Learning Center was to assist students with their coursework based upon an individualized approach in order to foster independent learning, following a set of ethical guidelines. This approach could be determined by peer tutors through interactions with the student and course material, and was implemented with learning strategies.

Occasional barriers for tutors can occur through difficult tutoring sessions marked by situations of role strain. These situations can involve the expectation that tutors are experts in their subject area, yet they cannot provide direct answers to questions due

ethical considerations on academic integrity. The role of a peer tutor can potentially stretch in multiple directions such as a mentor, a guide, an instructor, or a coach. Due to this ambiguity, tutors can experience strain within their role (Galbraith & Winterbottom, 2011). Tutors might also experience situations of student crisis, or students who are looking for direction in personal matters that might not apply directly to the course material. Therefore, the goal of tutor training at the Learning Center is to help tutors develop a general sense of efficacy about tutoring within the implications of their role, and to provide support in helping students with learning and attention challenges become independent learners.

Tutoring domains found in extant literature were used to provide a conceptual framework for the development of the role of a peer tutor. These domains were identified as differentiation of knowledge building and knowledge telling behaviors (Roscoe & Chi, 2007; Velasco & Stains, 2015; Wood, Bruner, & Ross, 1976).

Knowledge Building and Knowledge Telling. Tutoring is a complex process that involves continuous assessment, explanations, feedback, and questioning (Roscoe & Chi, 2007). Peer tutors face the demands of being an expert in their subject area, yet might possess certain gaps in knowledge as they are not the formal instructors of a particular course (Galbraith & Winterbottom, 2011; Topping, 1996). In cases where tutors do not know the answer to a question, they would likely refer to a student's course materials or general reference resources (i.e., textbooks or online searches). In these cases, tutors risk engaging in knowledge-telling behaviors that promote surface learning such as simple reiteration of the material (Roscoe & Chi, 2007; Velasco & Stains, 2015).

A general concern among tutors at the Learning Center is the possibility of not knowing how to answer various student questions. This concern can be serious, as the primary format of tutoring at the Learning Center is hour-long appointment-based tutoring. Due to the specialized demands of course-specific tutoring, tutors at the Learning Center might not be able to call for help among other tutors or the tutoring staff in situations where they do not know the answer to a question. Researchers identified that students can perceive peer tutors as authority figures (Colvin, 2007; Galbraith & Winterbottom, 2011). This authority might be challenged in situations where the tutor does not know the direct answer to a question, and can result in potential role strain (i.e., embarrassment, not being taken seriously, or over preparation for future scenarios) for the tutor (Galbraith & Winterbottom, 2011). An outcome of this concern is the potential threat of client loss and client no-shows.

The Work of A Tutor

Tutor self-explaining while engaging in course content is a method that can facilitate higher-order learning (Roscoe & Chi, 2007). This process might help to facilitate discussion about a given topic (Galbraith & Winterbottom, 2011), and could give a tutor the opportunity to model a given set of learning strategies acquired through their training such as the role reversal of tutor and tutee (Topping, 1996). This approach, however, requires that the tutor would be comfortable with the application of a given set of strategies for approaching a problem with a student. Additionally, the student must believe in the tutor's ability to help them navigate the process of a problem without an immediately apparent answer.

Domains established in the literature that involve the work of a tutor include building positive rapport with students (Drane, Micari, & Light, 2014; Topping, 1996; Velasco & Stains, 2015) and learning strategy implementation (Drane, Micari, & Light, 2014; Galbraith & Winterbottom, 2011; Roscoe & Chi, 2007; Wood, Bruner, & Ross, 1976).

Building Rapport. The social demands of postsecondary education can be just as challenging as the academic demands for students who have learning and attention challenges (Connor, 2012). Researchers found that students with learning and attention challenges are likely to have difficulty with social interactions (Beauchemin, Hutchins, & Patterson, 2008; Isle & Wade, 2014; Kavale & Forness, 1996). Social interactions can be difficult due to the specific nature of the learning challenge (Beauchemin, Hutchins, & Patterson, 2008), and the perceived associated social stigma (Isle & Wade, 2014). Difficulty with social skills can persist throughout one's life, and can lead to withdrawal from social settings (Kavale & Forness, 1996).

Social integration (i.e., attending office hours, study groups, and social experiences) at the postsecondary level is important for students with learning and attention challenge, as it can be associated with retention (Connor, 2012; DaDeppo, 2009; Mamiseishvili & Koch, 2010). Working with tutors can be a social integration experience, and is also related to student retention from semester to semester (Bremer et al., 2013; Topping, 1996). Positive relationships among students and peer-tutors can allow for a safe and supportive environment while keeping students on track with the curriculum in their courses (Drane, Micari, & Light, 2014). Peer tutors who have

established positive rapport with students might be effective in engaging students in an active learning experience (Colvin, 2007; Roscoe & Chi, 2007).

Strategy Implementation. Tutoring provides advantages for students over large lecture instructional formats, with opportunity for direct interaction and active learning (Drane, Micari, & Light, 2014). In the context of this study, the term ‘strategy’ describes an approach or technique. Tutors can be trained to engage students with learning strategies. Learning strategies can help postsecondary students with learning and attention challenges to develop self-awareness regarding their own learning process (Burchard & Swerdzewski, 2009). The perceived usefulness of various strategies by students with learning and attention challenges at the postsecondary level, however, is inconsistent (Ruban et al., 2003). Examples of learning strategies found in the literature are breaking down complex material into understandable pieces (Galbraith & Winterbottom, 2011; Roscoe & Chi, 2007; Wood, Bruner, & Ross, 1976), deliberate role exchange of the tutor and tutee (Topping, 1996), and engaging students who have learning and attention challenges with multi-modal (i.e., video, auditory, and kinesthetic) approaches (Vaughn & Linan-Thompson, 2003).

Inconsistent utilitarian perceptions of learning strategy implementation for postsecondary students with learning and attention challenges might create a barrier for academic independence. Strategy implementation in learning situations is a key factor for performance in self-regulated learning (Zimmerman, 2002). Researchers found that self-regulation can foster independent learning, and has a positive association with academic achievement (Burchard & Swerdzewski, 2009; Mega, Ronconi, & DeBeni, 2014; Ruban et al, 2003). Self-regulated learning can occur in social situations

(Zimmerman, 2002), such as peer tutoring. Peer tutors can teach students who have learning and attention challenges how to integrate compensatory strategies within the context of their own coursework (Buchard & Swerdzewski, 2009). Eventually, the students will learn to implement a given set of strategies on their own, thus becoming more self-regulated in their own learning process.

Tutor Training and Role Development at the Learning Center. The philosophy of tutoring at the Learning Center involved helping students become independent learners. This message was thematic, and was the driving purpose of the tutor training sessions. The tutoring philosophy was aligned in part with the programmatic goals of the Learning center regarding the development of self-advocacy skills for students with learning and attention challenges. Self-advocacy is important for student development at the postsecondary level (Milsom & Hartley, 2005; White, 2014), and is a key component of becoming an independent adult (Hadley, 2011). Tutors were trained to help students identify their strengths as learners and in their communication of specific learning needs, thus helping to promote self-advocacy.

The format of tutoring at the Learning Center is consistent with Topping's definition of "Dyadic cross-year fixed-role peer tutoring" (Topping, 1996, p. 355). This implies that peer tutors who are employed by the Learning Center have either already taken a course that they tutor, or have a background in that subject area. As peer tutor classification at the Learning Center is clear, areas of ambiguity surrounded the actual role of a tutor in training.

Tutoring staff members presented a training on the role of a tutor during new tutor orientation. New tutors identified basic job functions of teachers and compared them to

tutors. This might have been problematic, as the new tutors likely did not know the intricacies of a teaching position. The tutoring staff did not provide a succinct definition regarding the role of a peer tutor. Implications surrounding the role of a tutor were derived by the new tutors following a group discussion. New tutors identified personal qualities that they believed were important for tutors to possess (i.e., friendliness, a good listener, patient, someone who is on time). Tutoring staff also made implications regarding the role of the tutor related more to university policy on academic integrity, student privacy (Family Education Rights and Privacy Act, 1974), employment law, and the code of tutoring ethics (see ATP, 2016).

An opportunity exists to develop a focused training regarding the role of a tutor at the Learning Center. The role of the tutor at the Learning Center implies specific job functions such as providing help with course content in addition to supporting the philosophy of fostering independent learning. This opportunity might extend to other postsecondary tutoring programs as conceptualization of the role of a peer tutor could potentially provide guidance for the development of training opportunities. Postsecondary learning centers and tutoring programs can vary in scope, size, and purpose. The role of a peer tutor should be flexible in order to accommodate programmatic goals and needs. Further research is needed on exploring the specific role of peer tutors in a variety of postsecondary settings.

Summary. Tutor training curriculum at the Learning Center was aligned with the conceptual domains of knowledge building, strategy implementation, and building rapport at the time of the study. Through these domains, tutors could explore their role within academic support and learn about the specific work of a peer tutor. Independently,

these domains can positively influence various aspects of student success at the postsecondary level as described in the literature. The interrelated nature of these domains must also be considered regarding tutor training, however, as students with learning and attention challenges might require a specialized approach.

Although students with learning challenges can be taught learning strategies that promote self-regulation (Burchard & Swerdzewski, 2009), the strategies must be tailored to each student's unique learning experience (Ruban et al., 2003). Students with learning challenges might have inconsistent utilitarian perceptions of learning strategies (Ruban et al., 2003). Learning strategies can be taught as tutors guide students through the learning process. Demanding or aversive student behavior (i.e., demanding direct answers or non-engagement) can negatively impact knowledge building, and can promote knowledge telling (Roscoe & Chi, 2007). Therefore, tutors who have established positive rapport with students through demonstrated competence and interpersonal skills might be effective with engagement in course materials (Colvin, 2007) and knowledge building in order to promote independent learning (Drane, Micari, & Light, 2014; Galbraith & Winterbottom, 2011; Roscoe & Chi, 2007).

Conceptual Framework for Training Curriculum Design

Tutor training curriculum at the Learning Center was based on principles derived from social learning theory (Bandura, 1971; 1986). Primary features of social learning theory implemented for instructional delivery were modeling, providing opportunities for active learning through enactive attainment, and feedback. Training that is designed and delivered within these aspects of social learning theory can facilitate transfer of skills to actual work situations (Salas et al., 2012). Transfer of training has been widely studied,

and can be influenced by one's personal motivational factors, opportunities to implement skills (Van den Bossche, Segers, & Jansen, 2010) and organizational support characteristics (Blume et al., 2010). Actual rates of training transfer were found to be relatively low (i.e., up to 20%) in prior literature (Van den Bossche, Segers, & Jansen, 2010), thus highlighting the importance of curriculum design, delivery, and ongoing opportunities to provide feedback for tutors.

Consistent with the construct of self-efficacy in social learning theory (Bandura, 1977; 1986), persistence regarding the implementation of strategies learned in training might be related to the use of social models in training (Weissbein et al., 2011). Additionally, behavioral models in training can support the immediate acquisition of procedural and declarative knowledge regarding skills (Taylor et al., 2005). Models used in tutor training can be found through a variety of sources. Tutors can observe other tutors, view examples of techniques that have been previously video recorded, and participate in live demonstrations of skills that are led by other tutors or tutoring staff members. The use of these types of models in training sessions can lead to active learning experiences that incorporate hands-on practice with newly acquired techniques.

Active learning experiences in higher education settings might be effective in scenarios where efficiency for instructional impact is required. An active learning format could be beneficial over traditional lecture for long and short-term recall of concepts due to limitations on participants' attention (Prince, 2004). Some active learning formats have been identified in the literature as problem based learning, group work, peer instruction (Michael, 2006), simulation (Mazarnia & Subramaniam, 2016), role-play (Bromley, 2013), and discussion sessions (Pollack et al., 2011). Training workshops for

tutors at the Learning Center feature isolated topics, and do not have the advantage of consistent instructional delivery as in a standard college-level course. Therefore, active learning formats in tutor training sessions might promote greater understanding of concepts than information delivery sessions.

Active learning can promote increased student engagement (Michael, 2006), although impact on long-term training transfer is inconclusive. For example, May and Kahnweiler (2000) designed an interpersonal skills intervention for managers and supervisors that involved active listening through the use of video models, role-play materials, self-reflection, and feedback throughout the training scenario. The researchers found significantly higher retention of knowledge about skills ($d = .40$) and demonstration of skills ($d = .38$) in the treatment group. Long-term transfer of these complex skills was not evident after several weeks when compared to managers in the control group following the training.

Limitations for active learning have also been identified in the literature regarding student perceptions. Researchers found that some students possessed either strong positive or negative views on active learning experiences. General student complaints about active learning included perceptions of a heavier workload (Ferreri & O'Connor, 2013; Findlay-Thompson & Momboourquette, 2014). The risk of student non-engagement could also present a barrier for large-group discussion activities (Bromley, 2013). Pollock, Hamann, and Wilson (2011) found that students with overall higher grade point averages (GPA) did not engage in large group discussion as frequently as students with lower GPA. Since peer-tutors are typically recruited as high achieving

students, situations of non-participation could arise in training scenarios that involve large group discussion.

As tutor training involves the development of complex interpersonal and technical skills, ongoing feedback can assist with transfer of these skills to work situations (Salas et al., 2012; Van den Bossche, Segers, & Jansen, 2010). Opportunities for tutors to receive feedback from supervisors and mentors might be beneficial, as formative self-referenced feedback paired with ongoing practice can help to increase one's effort regarding skill acquisition (Shute, 2008). Mulder (2013) found that employees were receptive to constructive feedback and were more likely to engage in an informal learning experience (i.e., conversations with colleagues or reading about the topic) and self-reflection as a result. Providing tutors with opportunities for specific, self-directed feedback in their actual practice following training sessions might help to increase the transfer of concepts and skills.

As transfer of skills learned in one-time training sessions might be difficult, an increased risk is possible for tutors returning to default knowledge telling behaviors in difficult sessions (Velasco & Stains, 2015). Due to the complex interpersonal and technical demands that tutors face, a well-designed system of training and support is essential. Therefore, the importance of training curriculum design that includes a diverse palette of active instructional formats, opportunity for practice, and ongoing feedback about their individual practice might be beneficial for sustaining the development of tutoring skills.

Design Principles

I conducted an analysis of the existing Tutor Training curriculum at the Learning Center for this study. The central driving focus of tutor training was to help tutors foster independent learning with their students. Tutor training curriculum was primarily delivered through workshop settings that were designed for active learning experiences. These workshops featured hands-on activities with manipulatives, open discussion, simulation, and role-play situations. Tutors also engaged in observing other tutors, receiving ongoing feedback from tutoring staff, and a formal evaluation process.

Design principles were used to create a conceptual framework for the analysis of the existing tutor-training curriculum in this study. The design principles identified in the Learning Center's CRLA tutor training curriculum were: 1. Peer mentoring, 2. Observation, 3. Reflection, 4. Peer Instruction, and 5. Make thinking visible (Table 1). As a result of this retrospective curricular analysis, some of the design principles identified in various training workshops were partially constructed. For example, a training workshop constructed with the general aspects of peer instruction might not feature all of the components of that principle (i.e., student voting was not present).

Peer Mentoring. Peer mentoring has been described in prior literature as a dyadic relationship between a mentee and a more experienced peer who is within the same organizational level (Bryant, 2005; Ensher, Thomas, & Murphy, 2001). The primary goal of a mentor relationship is to help the mentee become independent, and this can occur through reciprocal mutual interactions of observation and communication (Schunk & Mullen, 2013). Functional aspects exist within peer-mentor relationships. These functions can be psychosocial (i.e., affective support) and career related (Crisp, 2009; Terrion & Leonard, 2007). Less relational challenges can also occur with a peer-

Table 1. Design Principles

<i>Design Principle</i>	<i>Description</i>	<i>Training component</i>
Peer Mentoring	New tutors engage with more experienced tutors to share concerns and experiences.	<ul style="list-style-type: none"> • Monthly in-person meetings • Weekly email correspondence
Observation	Tutors observe other tutors. Staff members observe tutors. Tutors video record sessions for self-observation.	<ul style="list-style-type: none"> • Observation scripts • Digital video records
Reflection	Tutors engage in self-reflection prior to formal evaluation meeting. Tutors produce written reflections following sessions for formative staff feedback.	<ul style="list-style-type: none"> • Session Summary Forms • Formal self-evaluation checklist
Peer Instruction	Experienced tutors create and lead training sessions for new tutors. Peer-to-peer discussion format for various training sessions.	<ul style="list-style-type: none"> • Strategic tutoring training sessions • Tutor Panel event • Monthly lab meetings • Subject area meeting • Tutoring Scenarios training session
Make Thinking Visible	Tutors are trained to engage students in a cognitive apprenticeship (Collins, Brown, & Holum, 1991) through learning strategies in order to help with self-identification of knowledge gaps.	<ul style="list-style-type: none"> • Visual mapping • Notetaking strategies • Mnemonics • Tactile/kinesthetic techniques • Guided questioning • Test taking strategies • Study strategies

mentoring model as opposed to a traditional mentor (i.e., supervisors mentoring protégés) arrangement (Ensher & Murphy, 2011)

Protégés and mentors can experience affective benefits from their relationships such as increased organizational commitment, and the development of social relationships (Beltman & Schaeben, 2012; Colvin & Ashman, 2010; Ghosh & Reio,

2013; Waters, 2004). Proteges can also experience utilitarian benefits such as efficient transfer of organizational knowledge (Bryant, 2005; Swap et al., 2001) values, and norms (Swap et al., 2001). Functional benefits for mentors have been identified as opportunities for promotion and increased compensation (Ghosh & Reio, 2013). Mentoring programs can also benefit their respective organizations regarding employee retention and assimilation (Ensher, Thomas & Murphy, 2011; Ensher & Murphy, 2011; Terrion & Leonard, 2007), as attrition is costly (Hancock et al., 20123).

Inhibiting factors can exist in peer mentor relationships. Challenges for mentors can include unresponsive mentees, perceived lack of mentee motivation (Holt & Lopez, 2014), and mentees who became overly dependent (Colvin & Ashman, 2010). Mentees reported challenging aspects of relationships such as unresponsive mentors and mentors who contacted them too frequently (Colvin & Ashman, 2010). Mentees can hold the expectation of a safe, caring relationship with their mentor (Crisp, 2009; Janssen et al., 2014; Vuuren, & de Jong, 2014), and delivery of negative feedback might create problems in mentor relationships (Janssen et al., 2014). The cost of time can also be a barrier for mentor and mentee relationships (Swap et al., 2001; Colvin & Ashman, 2010; Janssen, Vuuren, & de Jong, 2014), including organizational expenses such as mentor training.

Tutors at the Learning Center participated in peer mentorship as part of the certification process. New tutors were usually assigned as protégés to experienced tutors as they began employment at the Learning Center. Tutoring staff members assigned mentors and mentees according to subject area background, and instructed them to have monthly half-hour meetings. The mentors and mentees were also expected to engage in

weekly email correspondence. The meetings were mandatory for peer tutors throughout their first semester of employment. Although mentors and mentees were free to discuss any issues that arose, minimal structure was provided for the meetings and correspondence. The minimalistic structure for the mentor meetings and frequent email correspondence at the Learning Center might have decreased the potential effectiveness of the peer-mentor model (Colvin & Ashman, 2010; Crisp, 2009). The rationale for the minimalistic structure was to provide freedom of correspondence between mentors and mentees, and to instill confidence in mentees that they could confide with their mentors about minor concerns.

Observation. Observation of behavior can be highly effective as an instructional tool, following the tenets of vicarious experience according to social learning theory (Bandura, 1971; 1986). Social models can have a powerful influence on shaping observers' behavior (Nisbett & Ross, 1980). Observation is commonly used in training scenarios, and can facilitate the acquisition of new skills. With video recording technology, pre-recorded scenarios and self-observation are also possible tools for training.

In teacher training scenarios, peer observation can facilitate the acquisition of new strategies and instructional approaches for observers (Hendry, Bell, & Thompson, 2014; Hendry & Oliver, 2012, Tenenberg, 2016). Additionally, peer observation might help to reassure observers' own instructional approaches (Hendry, Bell, & Thompson, 2014). Guidance in training can direct observers' focus on desired behaviors and might lead to positive outcomes. For example, Stegman et al., (2012) found that medical students who used observation scripts in a simulation exercise on doctor-patient communication skills

retained significantly more knowledge about the communication skills than those who did not use training scripts ($\eta^2 = .16$).

Collaboration paired with observation is a powerful training tool. The use of video recording can allow for observers to discuss behaviors or dialogue from pre-recorded scenarios. Video playback can be manipulated (i.e., stopped or reversed for repeated playback) when observing instructional videos, and collaborative dialogue throughout this process can promote gains in observers' knowledge (Chi, Roy, & Hausmann, 2008; Muldner, Iam, & Chi, 2014). In a recent physical education study, Palao et al. (2015) found that hurdlers who self-recorded their technique and received feedback from their coach upon viewing the videos had greater skill execution than hurdlers who only received feedback from their coach.

Tutor training at the Learning Center incorporated live peer-to-peer observation, live observations conducted by supervisors, and video recordings of tutoring sessions. Observation scripts were provided for peer-to-peer observation and supervisor observations of tutors. Tutoring staff collected peer observation scripts, and this feedback was only used for staff review. The video recorded tutoring sessions were used as an evaluation tool for tutors who were pursuing either level II or III certification. Tutors had the opportunity to view segments of their recorded session and received feedback from their supervisors following various points of the tutoring sessions. Exemplary video segments of various techniques and strategies were used for examples to supplement other training scenarios at the Learning Center.

Reflection. Reflective practice is widely encouraged and implemented in education and training. Reflection can allow individuals to gain deeper understanding of

their actions and support the growth of personal identity (Beijaard, Meijer, & Verloop, 2004). Although wide implementation of reflection exists in training, researchers found vague theoretical grounding with this practice (Collin, Karsenti, & Kormis, 2013). In a review of the literature on reflective practice in teaching, Beauchamp (2015) uncovered several thematic aspects of criticism associated with this concept. Researchers made recent efforts, however, to provide context for reflection and explore the utilitarian value of this practice.

Reflection is triggered through experience, and can occur during an experience, following an experience, or as a result of anticipation (Bell & Mladenovic, 2015; Nguyen et al., 2014). Triggers for reflection can be informal, such as conversations with peers in the workplace (bell & Mladenovic, 2013). Triggers for reflection can also be formally induced through observation and feedback scenarios (Mulder, 2013). For example, Bell and Mladenovic (2015) found that casual teaching staff naturally engaged in reflection upon observing their peers. As a result of the observations and reflection, some teaching staff became more focused on individual student needs.

Salient types of reflection that have been identified in educational research were practical (i.e., management of students), technical (i.e., logistics regarding the use of tools), and critical reflection (Bell et al., 2010). Critical reflection was described as a form of deep reflection within the moral and political context of an environment that can shape beliefs regarding one's identity (Kelchtermans, 2009). As critical reflection can be beneficial for those who might have established direction in their given profession, Arrastia et al. (2014) found that new teachers experienced difficulty in producing critical reflection statements through journaling. Therefore, continued reflection throughout

one's career might be beneficial as the quality of reflection can be an indicator of development in practice (Peeters & Vaidya, 2016).

Reflection was an ongoing component of tutor training at the Learning Center throughout all certification levels. Peer tutors regularly completed Session Summary Forms following tutoring sessions. The forms prompted tutors to identify the various strategies used in the tutoring session, a brief description of the session, and to present their thoughts on how to help the student become an independent learner. The forms were returned to tutors with feedback from the tutoring staff. Tutors also engaged in less structured reflection by entering their notes about a tutoring session into TutorTrac. As part of the formal evaluation process, tutors were given self-evaluation forms to complete after a tutoring staff member observed them. The tutor reflection documents served a utilitarian function for the tutoring staff as tutor development could be informally and formally tracked.

Peer Instruction. Peer instruction (PI) is an active instructional method that involves the facilitation of peer-to-peer discussion on a given topic. Like most active instructional strategies, PI can be used as a tool to increase student engagement with the course material (Crouch & Mazur, 2001). The instructional sequence of peer instruction generally includes a question posed by the instructor followed by individual thinking and small group peer discussion. Highlights from the small group discussions are presented to the class followed by group discussion and confirmation or disconfirmation of the responses by the instructor (Vickrey et al., 2015).

In classroom studies, PI can facilitate deeper conceptual understanding of course material than traditional lecture format (Reisman, 2012; Smith et al., 2011; Smith et al.,

2009). Students who engaged in peer instruction reported benefits of receiving immediate feedback from peer discussion following instructor explanation of a concept (Nicol & Boyle, 2003). Peer-to-peer discussion was also beneficial for generating correct responses from groups that did not have a student member who knew the correct answer (Smith et al., 2009).

Limitations for PI have been identified such as peers who dominated discussions (Nicol & Boyle, 2003; Pollack, Hamann, & Wilson, 2011), disagreements among peers (Nicol & Boyle, 2003), large amounts of planning time required on behalf of the instructor (Bromley, 2013; Reisman, 2012), and students who might not participate in discussions (Pollack et al., 2011). Regular implementation of PI as an instructional method throughout a semester-long postsecondary course might be difficult due to the large informational demands of courses (Jenkins, 2015). Training workshops offered on a limited basis, however, might be an ideal format for this instructional method. Instructional planning could be focused for one-time training sessions, and the required active participation in these sessions would likely engage the trainees in the content.

Tutor training workshops at the Learning Center generally followed the format of PI. Tutors were not always prompted, however, to write down responses following questions by the session leader. This might have presented a limitation to the instructional design of some workshops, as responses and thinking might have been biased following immediate peer discussion (Nicol & Boyle, 2013). Tutors who pursued Level III certification were required to design and deliver a subject area meeting that incorporated active elements of PI. The Tutor Panel event and Tutoring Scenarios training sessions were also primarily led by Level III tutor candidates. Kalie, Levin-

Peled, and Dori (2009) found that peers who taught tended to gain more from the instructional materials than the peers who were being taught. Although this might present a potential limitation in the instructional design, the Level III candidates likely benefited from the opportunity of sharing their knowledge with the lower level tutors at the Learning Center.

Make Thinking Visible. Students can be guided towards becoming independent learners through a process of cognitive apprenticeship, which involves the implementation of learning strategies (Collins, Brown, & Holum, 1991). Peer tutors can be trained to guide students in making their thinking visible through various learning strategies, thus helping students to identify gaps in their understanding of the course curriculum (Olney, Graesser, & Pearson, 2012). With little guidance, students might struggle with self-implementation of learning strategies such as concept maps (Stull & Mayer, 2007). Tutors who help students with learning and attention challenges must be explicit about the process of strategy implementation (Vaughn & Thompson, 2003). Therefore, tutor self-explanation while engaging in a learning strategy can help to make this process visible for the student (Chi & Wylie, 2014).

Incorporating visual concept maps while engaging in course content can promote deeper conceptual understanding of the material (Ainsworth, 2006; Clayton, 2006; DiCecco & Gleason, 2002; Wheeler & Collins, 2003). Researchers also found that mnemonic strategies and acoustic elaboration of unfamiliar words helped students with recollection of key terms (Bakken & Simpson, 2011; Hall et al., 2013). The use of manipulatives combined with sketches and diagrams helped students with learning and

attention challenges develop greater understanding of abstract mathematical notation (Strickland & Maccini, 2012).

Helping students to use compensatory learning strategies is a primary function of the tutor training at the Learning Center, as this can promote self-regulated learning (Ruban et al., 2003). Making student thinking visible is a triple-layered training approach for the tutors. For example, the tutor must first become familiar with how to use a given set of learning strategies. Next, the tutor is expected to guide a student in the use of these strategies through self-explanation. The final step is for the student to engage in the strategy independently. The tutor must also be trained about developing awareness of individual student learning characteristics in order to select appropriate strategies (Ainsworth, 2006).

Summary of Tutor Training Certification Levels

Level I. The primary objective of Level 1 certification at the Learning Center was to introduce new tutors to their role in student learning. Training topics included to help new tutors explore their role were management of difficult tutoring scenarios, the use of available technological resources, and understanding the nature of learning and attention challenges. Topics included in order to assist tutors with their work were general tutoring strategies regarding multiple learning modalities, memory, note taking, and exam preparation. In order to complete Level I certification, new tutors needed to complete 25 hours of recorded student visits. New tutors were required to attend several hour-long training workshops related to these topics. Additionally, the Level I candidates either met with a Tech Consultant or completed an online training module on the use of assistive technology available at the Learning Center.

Level II. The purpose of Level II training at the learning center was to help tutors become attuned to individual student learning needs and adapt their tutoring approach accordingly. Level II candidates attended in-person workshops on probing questions, student learning styles, managing group tutoring sessions, and in the use of manipulatives. Although the Level II workshops were thematically linked to the topics covered in Level I, they were framed within the context of implementing strategies based upon the individual needs of the student. The Level II workshops were designed to help the tutors shift their focus from the assignment to the student. Tutors were also required to have at least 75 hours of recorded student visits.

Level III. The final level training engaged tutors in the development of leadership roles. The primary assumption for this certification level was that the tutors were highly skilled in their practice, and were ready to provide training and guidance for new tutors at the Learning Center. A minimum of 175 hours of recorded student visits were required to attain this certification level. Level III candidates led Level I training on dealing with difficult tutoring scenarios, and were also assigned to mentor new tutors. Level III candidates also were required to develop the training materials and lesson plan for the subject area meeting. As a capstone project, the tutors were given time to develop an artifact (e.g., board game for review purposes, subject-specific training manual, tactile model) that could be used by other tutors at the Learning Center in future tutoring sessions.

All Certification Levels. All tutors who are pursuing a level of certification at the Learning Center must conduct observations of other tutors, attend the Tutor Panel event, and participate in a formal evaluation process. In addition to these training

requirements, all tutors were encouraged regularly to complete session summary reflection forms following tutoring sessions so tutoring staff could provide them with ongoing formative feedback.

The Tutor Panel event format featured small group breakout sessions followed by a large panel discussion. Level III candidates lead both small group discussions and the large panel discussion. The Level III candidates were given a list of topics for discussion prior to the event. The tutors were not expected to adhere strictly to the list of topics in order to facilitate more spontaneity in discussion, if needed. The large forum discussion following the small group sessions allowed the Level III candidates to form a panel in order to respond to questions from the lower level tutors. A tutoring staff member moderated the panel discussion, and lower level tutors were given the opportunity to ask additional questions that might not have been addressed in their small groups.

Directions For Future Training Development

The tutor-training curriculum at the Learning Center featured a cohesive design, which was ideal for supporting the breadth of academic demands at the Learning Center. Strengths of the training curriculum included workshops designed around peer-instruction, opportunities for observation and reflection, ongoing formative feedback, and the formal evaluation process. As part of the formal evaluation, tutors were rated on their implementation of specific behaviors covered in training. Researchers found that frequent evaluation from supervisors in addition to evaluation criteria based upon implementation of behaviors covered in prior training were associated with greater rates of training transfer (Saks & Burke, 2012).

As a result of this curricular analysis, fine-tuning some of the aspects of tutor training at the Learning Center might be helpful for future development. The areas for consideration are peer mentoring among tutors, providing increased opportunities for written responses during peer instruction, development of training on building rapport with students, and increased involvement with experienced tutors training new tutors.

Although peer mentoring was typically an informal practice, tutors at the Learning Center could benefit from an increased amount of structure through mentor training (Colvin & Ashman, 2010). Increased structure for peer mentoring among tutors at the Learning Center could occur through themed email correspondence and guidance for discussion topics in monthly meetings. The weekly email correspondence might strain mentor and mentee relationships due to the high frequency of communication (Colvin & Ashman, 2010). Mentors and mentees at the Learning Center reported difficulty in finding discussion topics for the weekly correspondence. Less frequent correspondence that relates directly to knowledge building, strategy implementation, and building rapport with students within the context of prior tutoring sessions might provide an opportunity for more impactful correspondence.

Observations between mentors and mentees could provide guidance for monthly discussion, and increase the transfer of skills learned in training through continued conversation. As observations are currently a required part of certification at the Learning Center, mentees and mentors could be directed to observe each other. Observations that occur between mentors and mentees would create a safe situation for constructive feedback (Hammersly-Fletcher & Orsmond, 2005; Hendry & Oliver, 2012). Critical feedback, however, might be damaging for mentor and mentee relationships

(Hammersly-Fletcher & Orsmond, 2005). Therefore, accountability for training mentors in the delivery of constructive feedback is essential (Eby et al., 2010).

The peer instruction format of most training workshops involved immediate peer discussion following prompts or questions from the presenter. Consistent with problems that arose in the literature, there were occasions when certain tutors would dominate discussions and possibly influenced the opinions of other attendees. As a small adjustment, tutors could be asked to write individual responses immediately following questions posed by the presenter. This might not be practical or applicable in all cases, however, this adjustment could promote more autonomous thought and facilitate further discussion among peers.

The importance of establishing positive rapport with students was informally discussed in training at the Learning Center, however, no specific tutor training on building rapport and conveying positive expectations of students was offered. Tutors were also rated on their ability to establish positive working relationships with students as part of their formal evaluation. Tutoring staff members looked for verbal and nonverbal cues that conveyed positive expectations during observations (i.e., active engagement with the student, asking open-ended conceptual questions, and incorporating wait-time for student responses). These types of behaviors can convey positive expectations of students, and have been linked to higher mathematics achievement in classroom settings (Good & Grouws, 1979; Rubie-Davies et al., 2015). Therefore, the inclusion of a training session on establishing rapport and conveying positive expectations of students might be beneficial for the tutor-training program at the Learning Center.

Researchers found mutual benefits to both students and tutors who engage in meta-cognitive study strategies (Arco-Triado et al., 2011; Galbraith & Winterbottom, 2011; Topping, 1996). Kali, Levin-Peled, and Dori (2009) found that peers who engaged in instruction had greater knowledge gains than the peers who were instructed. Therefore, an opportunity to increase the transfer of training for peer tutors at the Learning Center would be to involve the Level II and III tutors in more workshop delivery. Although the Level I candidates would likely experience the same benefit of attending the training workshops, concepts could potentially be solidified for the higher level tutors as they engage others in instruction. Involving higher-level tutors in instructional delivery could also provide incentive for attaining higher certification levels, as these tutors might experience increased commitment and leadership opportunities within the Learning Center.

Few empirical studies have been conducted on the development of tutoring skills at the postsecondary level (Roscoe & Chi, 2007), including training programs for peer tutors. Directions for future research could include further investigation in the conceptual domains of knowledge building, strategy implementation, and building rapport with students in peer tutor training programs at the postsecondary level. Training transfer in relation to postsecondary tutoring programs also warrants further investigation. Considerable amounts of resources regarding time, staffing, and money can be consumed on tutor training. Examination of methodology to make tutor training more lasting and impactful might provide utilitarian value for learning centers both financially, and in quality of service.

Tutors and students could have faced specific difficulties while working on developmental math. The fundamental goal of tutor training at the Learning Center is to facilitate independent learning through a process-oriented approach. Due to the product-oriented outcome of the developmental math course design, this could have created situations of friction between students and tutors during sessions. In ALEKS, students were essentially rewarded for producing correct answers to math problems as they navigate the pie. No partial credit for responses was given, and no space to show work is provided on the online platform. Incorrect responses resulted in the student being required to solve additional problems.

As content-specific tutoring was provided for most course offerings at the University, a conceptual approach was required for tutor training. Tutor training did not formally address student support in developmental mathematics consistently. Tutors, however, were trained to implement a variety of general academic strategies that could be applied to specific course content. The general set of tutoring skills (i.e., time management, organization, and planning) covered in training might have some benefit for the tutors who worked with students in developmental mathematics. As the content of this course was self-paced, these general skills could have helped some students' executive functioning for maintaining consistent engagement with this class.

Chapter 4

Method

The purpose of this program evaluation study was to determine the effect of math tutor usage at the Learning Center on passing a developmental mathematics course. Permission to conduct this curricular study was obtained through an Institutional Research Board (IRB). The retrospective study was classified as exempt from board review. Additional permission was obtained from the Learning Center administration and the Main Campus Learning Center administration. The math department at the university was also notified about this study. Data were collected during September, October, November, and December of 2016 and January, 2017.

A counterfactual approach (Khandker, Koolwal, & Samad, 2009) provided conceptual context for the data analysis in this study. Since random assignment to treatment and control conditions under quasi-experimental conditions was not feasible, a counterfactual was used to address the hypothetical prospect of students who did not benefit from receiving Learning Center Services. The Learning Center is a fee for service program with a separate admission process from the university and students voluntarily participated in Learning Center services. Admission to the Learning Center required that student be enrolled in the university and was based upon unique criteria. Locating a comparison group of students was not possible due to these constraints, so a theoretical counterfactual addressed the primary research question. The theoretical counterfactual in the case of this study was consideration of the outcome if the same group of developmental math students at the Learning Center did not have access to services at the Learning Center.

Participants

All students who were targeted for analysis were enrolled in the Learning Center, possessed learning and attention challenges, and took developmental mathematics. An initial number of student cases ($n = 231$) was extracted among four fall-semester cohorts of 2012 ($n = 48$), 2013 ($n = 58$), 2014 ($n = 62$), and 2015 ($n = 63$). Student data were targeted for extraction based upon an enrollment indicator for developmental mathematics during the latter fall-semester cohorts. Criteria for inclusion in this analysis were that the student needed to be a) at least 18 years old by the time of first semester enrollment at the university; b) enrolled in the Learning Center; c) taking developmental math during their first semester of enrollment at the university during the fall cohorts of 2012, 2013, 2014, or 2015; and d) enrolled in the university throughout the entire first semester.

Following an initial screening of the student data to determine eligibility, 23 cases were removed from the analysis. 21 Students dropped the developmental math course within the university deadline to drop the course or withdrew from the university during the fall semester were removed from the analysis. One Student cases was also dropped due to missing data at the Learning Center. An additional case was dropped because the student took developmental math prior to enrollment in the Learning Center.

Approximately ten percent of student cases were removed from the initial sample. The final sample consisted of 208 student cases.

All students included in the analysis were first time, full-time freshmen that were enrolled in both the University and the Learning Center. Ages of the students ranged from 18 – 20 years old. The demographic composition of the sample included three Native American, eight Asian, four African American, two Native Hawaiian or Pacific

Islander, 26 Hispanic, and 165 White students. Four students did not specify ethnicity in the sample. Other demographic information included 106 students who identified their gender as female, and 102 students who identified their gender as male.

Data Collection Procedures

Identifiable student data were stored exclusively on encrypted files on a password-protected computer at the Learning Center. All data were collected, organized, and cleaned on the computer at the Learning Center. De-identified data for analysis and reporting purposes were transferred to a password-protected laptop computer that was in my possession. IBM SPSS statistical software v.24 (IBM, 2016) was used to conduct all analyses in this study. Microsoft Excel (Microsoft, 2016) software was used for storage and transfer of student records. Pivot tables in Excel were also used for data screening and visualization.

Learning Center staff cleaned and verified student visit records using AdvisorTrac software. AdvisorTrac and TutorTrac are separate systems contained within the same software platform. Learning Specialists were responsible for creating student visit records, and documenting the type of student contact that was made (i.e., in person, phone, or email). All in-person student visits were recorded as 30 minute segments, following the default visit settings in AdvisorTrac software.

TutorTrac software was used to extract student usage of Learning Center services such as math tutoring, tutoring for other subjects, learning specialist visits, identification of students who took developmental math, age verification for eligibility, and to determine concurrent first-semester student enrollment in the Learning Center with developmental mathematics. Students were responsible for logging in and out for

tutoring sessions at the Learning Center at kiosk stations located in the tutoring areas. Kiosks were a feature of TutorTrac software. Visit records were recorded in TutorTrac when students logged in at the Learning Center. As occasional login mistakes occurred (i.e., forgetting to log in, logging in too early, not logging in, logging in for the incorrect course, or not logging out for visits), student data on usage of appointment-based tutoring at the Learning Center were cleaned weekly by tutoring staff. Student visit records were reconciled with tutor payroll records as part of the cleaning process.

Appointment-based tutoring usage was recorded as billable hours for upper-division students. Therefore, maintaining accuracy of these records was essential. Lower-division students were not billed for appointment-based tutoring, however, their usage was still reconciled with tutor payroll records. Student usage of drop-in hours at the learning center was not cleaned or reconciled with tutor payroll hours because drop-in times were not considered billable.

University proprietary records software was used to determine if students passed the developmental math course and for the presence of enrollment in the next step of college-level preparatory mathematics. Each student case was examined individually in order to ensure accuracy of data collection and to determine their eligibility for extraction based upon birthdate. Additionally, ACT and SAT math scores were extracted with university proprietary software. The Learning Center administration provided data on gender and probationary status. The Main Campus Learning Center administration provided student usage records for LSPEC visits, math tutoring and tutoring received for other subjects. These data were collected through a separate TutorTrac system located at the Main Campus Learning Center.

Variables to Conduct Program Evaluation

Variables to conduct this program evaluation were selected in order to address the conditions of omitted variable bias. Variables that can potentially bias an analysis if omitted might correlate with the independent variable of interest and could directly influence the outcome of the dependent variable (Stock & Watson, 2007). In the case of the present study, variables associated with students' likelihood to seek math tutoring and that could potentially influence the outcome of passing developmental mathematics were included as controls. The following section provides descriptions of the variables, with rationales for inclusion in the final analysis.

Dependent Variable. The dichotomous outcome variable represented whether or not a student moved through the first phase of developmental mathematics. This variable was determined through individual student enrollment records on university proprietary records software. Course grades were assigned regarding performance on various assignments, exams, and attendance in virtual classes. The grades were not reliable indicators of successful completion, however, due to the course design. Completion of approximately 450 topics in ALEKS would allow a student to enroll in the next level of preparatory math. In some rare situations, a student could receive a passing grade (i.e., B or C) and not be eligible to enroll in the next preparatory math course due to the completion of less than 450 topics by the end of the course. Therefore, the final determinant of whether a student successfully completed the first phase of developmental mathematics was evidence of enrollment in the second phase of preparatory math. In the scope of this study, students enrolled in the second phase of preparatory math either in

the late fall semester or at the beginning of the spring semester were coded for successful completion of developmental math.

Independent Variable. The primary independent variable of interest in this study was identified as the amount of time that students visited with tutors for developmental math at the Learning Center. Student visits with math tutors were recorded in hours consisting of both integers and fractions. These hours were specifically reported for developmental mathematics. Tutoring hours for developmental math were collected during students' fall semester enrollment through TutorTrac software. The variable is continuous, and representative of time spent in both appointment-based and drop-in tutoring for math.

Control Variables. Control variables selected to reduce omitted variable bias were learning specialist visits at the Learning Center, learning specialist visits at the Main Campus Learning Center, academic probation status following the fall semester, visits for math tutoring at the Main Campus Learning Center, and tutoring visits for all other subjects at both the Learning Center and the Main Campus Learning Center. Student demographic information such as gender and ethnicity were also included as control variables. A final variable was created to control for prior academic achievement in mathematics.

Student usage of additional tutoring services available at the Learning Center and through the Main Campus Learning Center were extracted. Visit hours were recorded in integers and fractions, and included both appointment-based and drop-in tutoring throughout the student's first semester of enrollment at the university. As part of the programmatic intervention effort of developmental math, tutoring for this course was

offered through the Main Campus Learning Center. The number of hours spent in tutoring for other subjects at both learning centers and for math tutoring at the Main Campus Learning Center were included as continuous predictors for the analysis. A student's likelihood to engage in other tutoring services available on campus might be associated with the likelihood to seek tutoring for developmental mathematics.

Therefore, seeking additional academic support could potentially influence the outcome of successfully completing the first phase of developmental mathematics.

Learning specialists worked with students on general academic strategies, including organization and time management techniques. Learning specialists tailored their approach regarding academic strategies and support based upon the individual needs of the student. Students were assigned to learning specialists for weekly 30-minute meetings at the Learning Center upon admission. Learning specialists could meet with students for additional time in cases that required additional support. Students were also assigned to meet with learning specialists at the Main Campus Learning Center for monthly meetings as part of the developmental math program. All learning specialist meetings were voluntary. Accurate time for learning specialist visits could not be determined, so visit records were reported in integers. For example, the amount of times that a student visited a learning specialist was accurately recorded. The quantity of time that students spent with learning specialists was not accurately recorded. Thus, the integer of visit frequency as opposed to time spent with learning specialists was included in the analysis. Visit records with learning specialists during students' fall semester enrollment were collected. Because online developmental mathematics required executive function skills such as time management, students might have benefited from

meeting with learning specialists regarding the establishment of routines for working on the course.

Student demographic characteristics included for analysis were gender and ethnicity. Gender and ethnicity were included as discrete predictors in the analysis. Steele (1997) found that non-Asian minority students might be susceptible to stereotype threat, thus diminishing performance on standardized exams. Additionally, he found that stereotype threat might decrease women's performance in math. Due to these findings, student demographic characteristics might be associated with the tendency to seek academic support and could influence the outcome of successfully completing developmental mathematics.

As an exploratory measure, academic probationary status during fall semester was included in the analysis. Probation status was provided by the Learning Center administration on a data file. Students were assigned to academic probation when their cumulative GPA dropped below 2.0 at the university. Although probationary status would likely be highly correlated with the outcome of passing developmental mathematics, the course grade in developmental math did not influence GPA. A grade for the course was posted on students' transcripts. This grade was not weighted, however, with GPA. A possibility existed for some students to pass developmental mathematics, and still be classified for academic probation.

The final control variable included for analysis was prior academic achievement (IPAA) in math. This variable was determined through math performance on standardized SAT and ACT exams. For students who took either exam multiple times, the most recent scores were retained for analysis.

Strategy for Analysis

The dependent variable of passing developmental math is binary and the primary independent variable is continuous. The set of control variables contains a mix of continuous and discrete predictors. Therefore, logistic regression was used for an analytical model to determine students' likelihood of passing developmental math based upon engagement in academic support services and background characteristics. The following equation contains the primary dependent variable as the outcome (Y), the primary independent variable (X_1), and the set of control variables ($X_2...X_j$):

$$\hat{Y} = \frac{e^{A + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_j X_j}}{1 + e^{A + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_j X_j}}$$

Logistic regression holds no assumptions for skew, homogeneity of variance, equal variances among predictors, or equal 'n' for binary predictors (Tabachnik & Fidel, 2013). Issues of multicollinearity among predictors can violate assumptions for logistic regression and bias the analysis. Excessive levels within predictors and variables-to-cases ratio can also bias the logistic regression model, following the assumption of parsimony. Therefore, data were screened to ensure that the assumptions for logistic regression were addressed.

Data Screening

Data were screened for missingness, the presence of multicollinearity, potential outliers, and accuracy of student records prior to the formal analysis. As a result, some data were re-coded in order to preserve sample size and to satisfy the assumptions of logistic regression. The ethnicity variable was re-coded into two categories: 1) White, 2) All other ethnicity. The majority of students ($n = 145$) in the complete cases sample (79.23%) in addition to 165 of the students (79.33%) in the whole dataset were identified

as 'white'. The data were recoded following the assumption of parsimony in logistic regression. The variables-to-cases ratio was considered in order to avoid overfitting the data with multiple levels within one predictor variable (Tabachnick & Fidel, 2013). Additionally, logistic regression holds no assumptions for equal proportions within dichotomous predictors.

One student case was determined to be an extreme outlier ($z = -3.68$) in the logistic regression model through an analysis of the standardized residuals (Tabachnick & Fidel, 2013). In this case, the student met with tutors for subjects other than math for approximately 49 hours, and did not pass the developmental math class. This case was removed to reduce bias in the logistic regression model. The final sample consisted of 207 students, with 182 complete cases that contained IPAA scores.

Multiple regression analysis with collinearity diagnostics was conducted on continuous predictors. Tolerances ranged from .80 - .95, and variance inflation factors (VIF) ranged from 1.07 - 1.26. Relatively high tolerance and low VIF indicated that no issues of multicollinearity existed among continuous predictors (Howell, 2013).

Multiway frequency analysis was conducted on dichotomous predictors in order to detect cases of high association among discrete predictor variables (Tabachnick & Fidel, 2013). Academic probation status was found to be problematic due to significant partial association ($\chi^2_{partial} = 19.66$, $p < .001$) with the likelihood of passing developmental math. Academic probation status was also associated with and low expected cell counts (i.e., less than 5) regarding gender, ethnicity, and the status of passing developmental mathematics. Although probationary status was not dependent on passing developmental mathematics, the variable was determined to be problematic and

could have presented a potential bias. Therefore, the academic probation status variable was removed prior to the final analysis. A second analysis was conducted after removal of the academic probation variable. No issues of significant partial associations and low expected cell counts existed among dichotomous predictors as a result of removing probationary status.

Missing Data. Approximately 12.1% of student cases ($n = 25$) did not possess an IPAA score. The only category that contained missing scores was IPAA. As a result, there were 182 complete student cases for the cohorts of 2012 ($n = 42$), 2013 ($n = 47$), 2014 ($n = 46$), and 2015 ($n = 47$). Missing value analysis was conducted in SPSS because prior academic achievement needed to be retained as a control variable. According to Little's Missing Completely at Random test, data were not missing completely at random $\chi^2(9) = 19.27, p = .02$.

The university did not require students to submit SAT or ACT scores in order to be considered for admission. University admission was determined through a wide variety of factors, and students could choose not to submit standardized academic achievement test scores. However, students would forego certain scholarship opportunities by not submitting standardized test scores. There might have been students in the sample who possessed low SAT or ACT scores and chose not to submit the scores in favor of being admitted to the university on other factors. Therefore, these data are likely not missing at random and could potentially bias the analysis. As an exploratory measure, multiple imputation (MI) will be conducted and the pooled results will be reported in addition to the results of the complete student dataset.

Normality. 92 students in the dataset possessed an SAT math score, and 100 students possessed an ACT math score. There were 10 students who possessed both SAT and ACT scores. ACT scores were retained for those who took both tests. SAT and ACT math scores were converted to a single composite Z-score (IPAA) in order to retain the sample size. Thresholds for normality were obtained from Curran, West, and Finch's (1996) guidelines. Low skew and kurtosis were associated with the SAT scores, and a severe positive skew (3.04) was associated with the ACT scores. Interestingly, the distribution of math SAT had multiple modes. When combined, the IPAA scores were moderately positively skewed (2.62) and retained peaked characteristics with multiple modes (Figure 1). Although logistic regression holds no assumptions for normal distributions of predictors, normality in continuous variables can increase statistical power of the model (Tabachnic & Fidel, 2013).

Skewness was low regarding learning specialist visits at both the Learning Center (-.52) and Main Campus Learning Center (1.75). However, the distribution of visits to learning specialists, were not normally distributed (Figure 2). The amount of time that students spent with tutors had a severe positive skew, as evident by the 'L-shaped' distributions. (Figure 3).

Figure 1. Standardized Distribution of Prior Academic Achievement in Mathematics

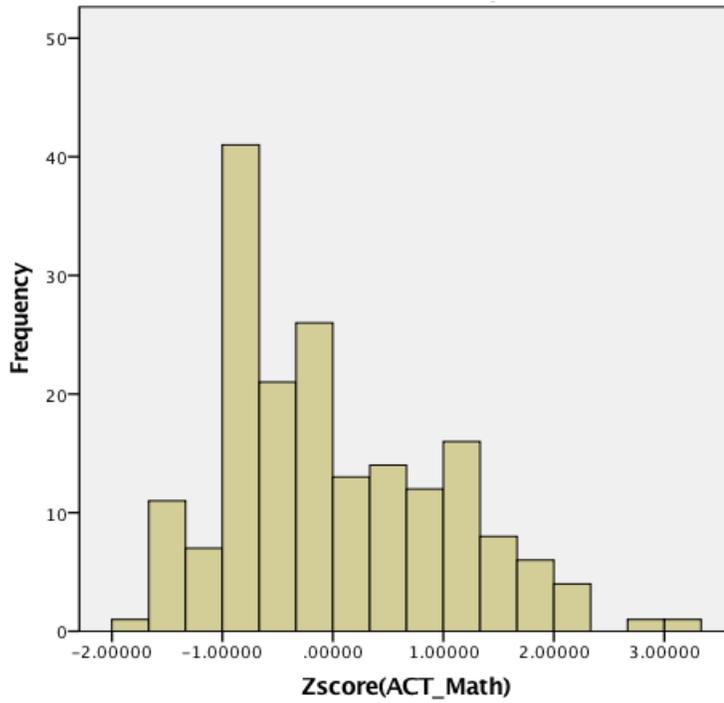


Figure 1. Distribution of combined SAT and ACT math scores for (n = 182) students in the sample.

Figure 2. Frequencies of Learning Specialist Visits

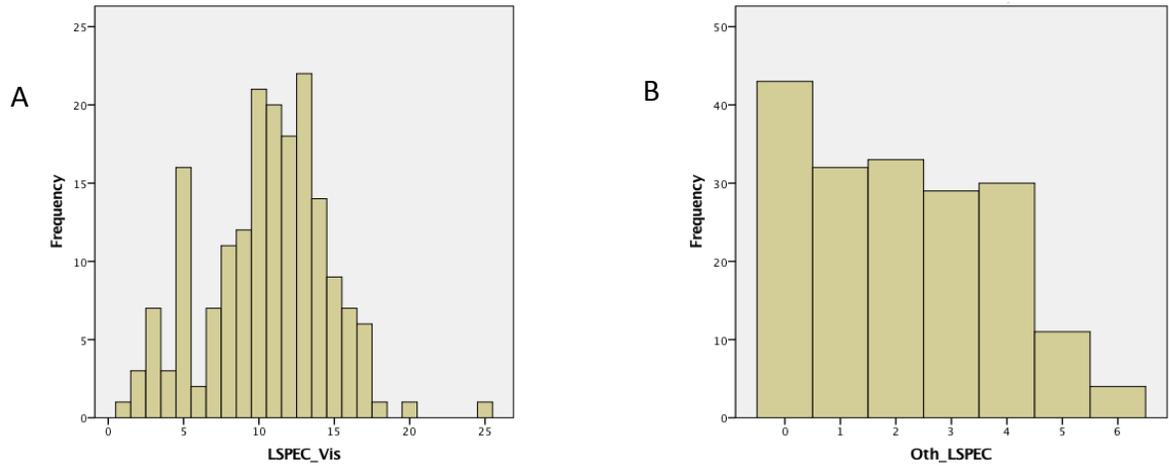


Figure 2. Number of student visits with learning specialists. These distributions are representative of ($n = 182$) students with complete data. (A) Visits with learning specialists at the Learning Center. (B) Visits with learning specialists at the Main Campus Learning Center.

Figure 3. Distributions of Tutoring Usage

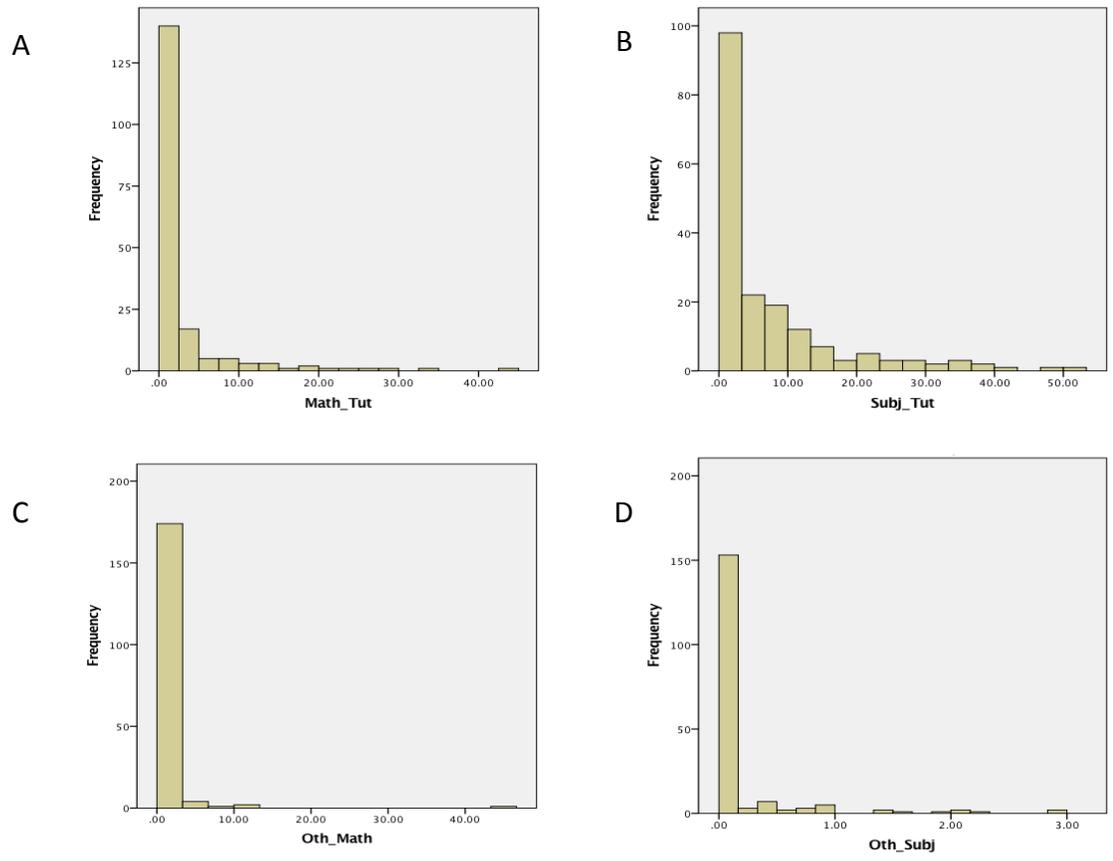


Figure 3. Student usage of tutoring services displayed in hours. These distributions are representative of 182 students with complete data. (A) Math tutoring usage at the Learning Center. (B) Tutoring usage for subjects other than math at the Learning Center. (C) Math tutoring usage at the Main Campus Learning Center. (D) Tutoring usage for subjects other than math at the Learning Center.

Chapter 5 Results

Direct-entry logistic regression was performed to determine the effects of student demographic characteristics and university support program services on the likelihood of successfully moving through the first phase of developmental mathematics. In the primary analysis of 182 students, 45.6% successfully completed developmental math and placed into the next level of college preparatory math. Descriptive statistics for the primary student sample with complete data ($n = 182$) can be found on Table 2.

Approximately half of the students ($n = 89$) in the sample engaged with math tutoring at the Learning Center at least once during their fall semester of enrollment at the university. Table 3 contains information on student engagement with campus tutoring services. Large numbers of developmental math students who did not engage in any math tutoring services at the university contributed to the 'L-shaped' distributions of tutoring usage with high negative skew.

As part of the analysis, sensitivity and specificity of the model were examined. The Hosmer and Lemeshow analysis yielded 75.8% correct classification of students who did not pass the course and 55.4% correct classification of students who successfully passed the developmental math course. Correct classification of the combined categories was 66.5%. The Hosmer and Lemeshow test yielded no significant difference in classification between the dataset when compared to an ideal model. Additionally, the Nagelkerke pseudo R Square yielded a small amount of variation accounted for by the model $R^2 = .28$.

Data for the full regression model can be found on Table 4. By testing predictors, no significant classification was found for math tutoring and the likelihood that a student

would pass their developmental math course. Interestingly, tutoring for other subjects at the Learning Center had significant classification with the likelihood of passing developmental math $\chi^2(1, n = 182) = 10.43, p = .001$. The odds ratio for passing the developmental math course increases by .08 per additional hour of working with a math tutor. Thus, meeting with tutors for support in other classes might increase a given student's chances of passing the developmental math course. Prior academic achievement in mathematics also had significant classification with the likelihood of passing developmental math $\chi^2(1, n = 182) = 10.1, p = .001$. The odds ratio of passing developmental math increases by .78 for every standard deviation unit increase on IPAA.

A secondary analysis was performed to address missing data regarding student IPAA scores. Descriptive statistics for the students who were included in the secondary analysis can be found on Table 5. Data for the entire sample can be found on Table 6. An overall completion rate of 45.67% was found in the entire sample ($n = 207$) of students. Following an expectation maximization (EM) multiple imputation procedure, results did not differ greatly. Five datasets were generated in this procedure. The pooled odds ratio for tutoring usage in other subjects on passing developmental math was 1.07:1. The pooled odds ratio for prior academic achievement on passing developmental math was 1.83:1. All other predictors did not have significant classification with passing the developmental math course.

Table 2. Descriptive Statistics for Primary Analysis

<i>Data Included For Primary Analysis</i>				
	Passed <i>n</i> = 83		Did Not Pass <i>n</i> = 99	
Continuous Predictor	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Math Tutoring (hours)	3.22	5.86	2.36	6.50
Tutoring, Other Subjects (hours)	10.82	12.84	3.91	5.43
LSPEC Visits	11.27	3.62	9.92	4.21
IPAA Score	.23	.93	-.14	1.04
Main Campus Math Tutoring (hours)	1.23	5.30	.25	1.19
Main Campus Tutoring, Other Subjects (hours)	.27	.66	.07	.30
Main Campus LSPEC Visits	2.43	1.75	1.84	1.60
Dichotomous Predictor	<i>Count</i>		<i>Count</i>	
Ethnicity				
• White	64		77	
• All Other Ethnicity	18		20	
Gender				
• Female	46		49	
• Male	36		48	

Table 3. Student Usage of Tutoring

<i>Student Characteristics of Tutoring Usage</i>					
Type of Tutoring	Location	*Student Usage	Student Count		
Math Tutoring	Learning Center		Passed <i>n</i>	Did Not Pass <i>n</i>	Total <i>n</i>
		Yes	47	42	89
	Main Campus Learning Center	No	36	57	93
		Yes	17	8	25
		No	66	91	157
Subject Tutoring	Learning Center		Passed <i>n</i>	Did Not Pass <i>n</i>	Total <i>n</i>
		Yes	66	69	135
	Main Campus Learning Center	No	30	17	47
		Yes	18	11	29
		No	65	88	153

Note. *Student Usage refers to the occurrence of at least one visit to the Learning Center or Main Campus Learning Center for tutoring. A visit could have occurred throughout the first fall semester of enrollment at the university.

Table 4. Logistic Regression Results

<i>Tests of Predictors Included In Binary Logistic Regression</i>					
Predictor	β	Wald χ^2 (<i>df</i>)	<i>p</i>	e^β	95% CI for e^β
Math Tutoring *(LC)	-.03 (.03)	1.04 (1)	.31	.97	[0.91, 1.03]
Subject Tutoring (LC)	.08 (.03)	10.43 (1)	*.01	1.08	[1.03, 1.14]
LSPEC Visits (LC)	.03 (.05)	.52 (1)	.47	1.03	[0.94, 1.13]
Math Tutoring *(MCLC)	.15 (.13)	1.22 (1)	.27	1.16	[0.89, 1.51]
Subject Tutoring (MCLC)	.72 (.47)	2.39 (1)	.12	2.05	[0.83, 5.11]
LSPEC Visits (MCLC)	.14 (.11)	1.60 (1)	.21	1.15	[0.93, 1.43]
Gender	.11 (.36)	.10 (1)	.75	1.12	[0.56, 2.26]
Ethnicity	-.47 (.42)	1.26 (1)	.26	.63	[0.28, 1.42]
IPAA	.58 (.18)	10.10 (1)	*.01	1.78	[1.25, 2.54]
Constant	-1.17 (.62)	3.57 (1)	.06	.311	

Note. LC: Learning Center. MCLC: Main Campus Learning Center.

Table 5. Descriptive Statistics Included for Secondary Analysis

<i>Additional Data Included For Secondary Analysis</i>				
	Passed <i>n</i> = 13		Did Not Pass <i>n</i> = 12	
Continuous Predictor	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Math Tutoring (hours)	11.47	13.97	1.38	2.59
Tutoring, Other Subjects (hours)	19.84	20.73	6.64	9.24
LSPEC visits (number of visits)	11.36	3.25	12	5.28
Main Campus Math Tutoring (hours)	.26	.75	0	0
Main Campus Tutoring, Other Subjects (hours)	.14	.29	.13	.24
Main Campus LSPEC Visits	2.21	1.76	1.29	1.65
Dichotomous Predictor	<i>Count</i>		<i>Count</i>	
Ethnicity				
• White	11		12	
• All Other Ethnicity	2		3	
Gender				
• Female	5		5	
• Male	8		10	

Table 6. Descriptive Statistics for Entire Sample

<i>Data Included for Multiple Imputation</i>				
	Passed <i>n</i> = 95		Did Not Pass <i>n</i> = 112	
Continuous Predictor	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Math Tutoring (hours)	4.46	8.10	2.28	6.19
Tutoring, Other Subjects (hours)	11.91	14.39	4.29	6.14
LSPEC visits (number of visits)	11.37	3.51	10.09	4.26
Main Campus Math Tutoring (hours)	1.11	4.97	.22	1.12
Main Campus Tutoring, Other Subjects (hours)	.25	.29	.09	.29
Main Campus LSPEC Visits	2.41	1.74	1.77	1.61
Dichotomous Predictor	<i>Count</i>		<i>Count</i>	
Ethnicity				
• White	75		89	
• All Other Ethnicity	20		23	
Gender				
• Female	51		54	
• Male	44		58	

Chapter 6 Discussion

Effectiveness of Math Tutoring

Time spent with tutors at the Learning Center for mathematics did not have an effect on students' incidence of passing a developmental math course. Speculation for reasons why math tutoring might have not been helpful includes factors regarding tutor training and student characteristics. This speculation derived from the finding of the secondary research question "How do these students engage with on-campus academic support services?" The majority of students in this sample engaged with little or none of the academic support services available for developmental mathematics.

Tutoring has been an effective intervention for students with lower prior academic achievement in math in prior literature (Xu et al., 2001). Differences in student population and type of math course might account for the contrary finding in the present study. Xu et al. (2001) examined a general population of college students who were taking a college-level algebra course. The student population in the present study likely had different characteristics than students who were enrolled in college-level algebra. Students who are enrolled in developmental mathematics at the postsecondary level might be at risk for high levels of math anxiety (Gula, Hoessler, & Maciejewski, 2015). Since students with learning and attention challenges are at risk for high anxiety (Nelson & Hardwood, 2011), they are at risk for lower achievement in math due to the negative impacts of anxiety on working memory (Dehaene et al., 1999; Wilson et al., 2015). Therefore, anxiety could have been a confounding factor on achievement in mathematics regardless of the available systems of academic support.

Accounting for math anxiety, researchers recently made adjustments to the instructional design format of a developmental math course in order to help student achievement. Gula, Hoessler, and Maciejewski (2015) found that the use of highly structured, graduated, step-by-step direct instructional delivery for developmental math was more effective than traditional lecture on student test scores. Effects of math anxiety reduction as a result of the treatment, however, were inconclusive. The current model of developmental math tutoring at the Learning Center might not have been effective due to complications regarding the role and work of the tutor established through training. As tutors were expected to facilitate student independence through knowledge building (Roscoe & Chi, 2007), strategies such as guided questioning and role-reversal of the tutor and tutee (Topping, 1996) might tax the working memory of students who have high levels of anxiety. Therefore, this type of Socratic questioning approach might have placed high demands on students' working memory while they engaged in support for developmental math.

The notion of designing tutor training for developmental math that involves direct instruction might be problematic considering the established role of a tutor. The role of the tutor at the Learning Center involves guidance of independent student learning. A direct instructional approach might create situations of role strain for tutors (Galbraith & Winterbottom, 2011), as they are not actual instructors of the developmental math course. A possible intervention effort at the Learning Center could include the addition of Supplemental Instruction (SI) for developmental math. Researchers found that developmental math SI was effective at reducing testing anxiety (Phelps & Evans, 2006). Experienced tutors at the Learning Center could be trained as peer instructional leaders,

allowing them to develop a new role that involves instructional delivery. Crucial topics such as rational numbers (Good et al., 2013) could be also explored in-depth with graduated step-by-step instruction. Rational numbers happened to be a large segment of students' developmental math curriculum at the university.

Even with additional intervention efforts for developmental math, engaging students who are enrolled at the Learning Center in developmental mathematics might be difficult. For students with learning and attention challenges, non-engagement in campus resources can be a risk indicator for retention (DaDeppo, 2009). Further intervention efforts at the Learning Center are needed in order to increase student engagement in academic support services. Researchers found that anxiety about math can lead to avoidant behavior (Carey et al., 2016; Zettle, 2003). Anxiety about engaging in math can be a result of a particular learning challenge or from one's prior negative experience in math (Carey et al., 2016). From Bandura's (1989) theoretical perspective, one's lack of belief in their ability to perform a task can be anxiety-inducing when one is required to perform that particular task. For those who have high levels of math anxiety, researchers found that pain centers in the brain were activated in response to the anticipation of performing mathematical operations (Lyons & Beilock, 2012).

Techniques from Cognitive Behavioral Therapy (CBT) can be implemented to reduce one's anxiety through prediction of anxiety-inducing situations and through the development of perceived control in these situations (Arch & Craske, 2008). This type of intervention was found to be successful in anxiety reduction for adults with ADHD. Safren and colleagues (2005) found that following a 15-week intervention, symptoms of anxiety and ADHD were significantly reduced for individuals who were stabilized on

ADHD medication compared to individuals who only took ADHD medication. Coping skills regarding anxiety and perceived sense of control for college students with ADHD were also improved following an eight-week CBT intervention (Eddy, Broman-Fulks, & Michael, 2015). A mindfulness intervention such as Acceptance and Commitment Therapy (ACT) can also be used to reduce one's anxiety and is similar to CBT (Arch & Craske, 2008). Zettle (2003) found that college students' symptoms of math anxiety were reduced after six therapy sessions. Outcomes on math achievement, however, were inconclusive.

Since most of the students in this study regularly attended meetings with their learning specialists, future intervention efforts could be directed towards staff development on anxiety reduction techniques. Researchers found that staff who operated in clinical settings could be trained in CBT methodology through a series of workshops (Sholomskas et al., 2005; Rose et al., 2011). An ongoing series of staff development in CBT would be feasible at the Learning Center. Although learning specialists aren't considered to be therapists, techniques regarding de-escalation of anxiety from CBT and ACT might be beneficial when working with students. This might also help to reduce students' anxiety about meeting with tutors for support in developmental math, thus increasing engagement with available support services.

Indicators of Student Success

Students who did engage with tutoring services at the Learning Center for other subjects than math were more likely to pass the developmental math course. The notion of student engagement with tutoring being associated with persistence is consistent with prior literature on tutoring programs (Bremer et al., 2013; Cooper, 2010). Reis, McGuire,

& Neu (2000) found that college students with learning and attention challenges who sought academic support services were successful in completing their degrees. These students also indicated that they had developed self-advocacy, time-management, and test-taking skills. Conversely, delay and avoidance of study habits were found to have small, significant negative effects on GPA for postsecondary students with disabilities (Murray & Wren, 2003). Procrastination was a thematic characteristic found in college students who have ADHD (Gray et al., 2016; Lefler, Sacchetti, & Carlo, 2016). Students are expected to initiate booking of their tutoring appointments at the Learning Center. Booking and attending tutoring appointments requires time management and organization skills. Occasionally, situations occur when a tutor is not available for a particular course. In these situations, students must initiate tutoring requests with the tutoring staff. Therefore, students who regularly engage with general tutoring services at the Learning Center likely possessed greater time management, organizational, and self-advocacy skills than those who did not engage.

Performance on the ACT or SAT mathematics exam was a significant predictor of student success in developmental math for the students in this study. Surprisingly, prior studies that were conducted on students with learning and attention challenges reported inconsistent results regarding prior academic achievement and college GPA (DaDeppo, 2009; Murray & Wren, 2003). Rationale for the inconsistencies included limitations of the predictive model (Murray & Wren, 2003), and academic accommodations that were likely provided in secondary school (DaDeppo, 2009). The findings of the current study were consistent with the established notion that prior academic achievement predicts persistence and GPA in college (Robbins et al., 2004).

Costs Associated With Developmental Education

Since prior academic achievement in mathematics was a significant predictor of passing a developmental math course, accurate placement of the students into developmental math must be considered. Scott-Clayton, Crosta, and Belfield (2014) found that approximately 25% of students were inaccurately placed into developmental mathematics courses. Costs of inaccurate placement for students that were identified by Scott-Clayton, Crosta, and Belfield (2014) can include larger amounts of coursework resulting in higher tuition expenses and opportunity costs of time. Some of the students at the Learning Center with higher levels of prior academic achievement in math might have been inaccurately placed into the developmental course following their performance on the summative entrance exam. The accuracy of math placement for students enrolled in the Learning Center, however, could not be determined. Psychometrics such as reliability and predictive validity of the math placement exam at the university were not available upon request at the time of the study.

Upon viewing student records for an indication of successful completion of developmental math and enrollment in the next level of college-level preparatory math, a trend of non-completion regarding the developmental course sequence was evident. Very few of the developmental math students had enrollment records that indicated progress in math beyond the second level of college-level preparatory math. This trend is evident in the literature, as researchers have identified opportunities for students to exit developmental course sequences between classes (Bahr, 2013; Bailey, 2009; Bailey, Jong, & Cho, 2010; Kosiewicz, Ngo, & Fong, 2016; Venzia & Hughes, 2013). Estimates

on the cost of developmental education in the United States approach seven billion dollars a year (Pain, 2016; Scott-Clayton, Crosta, & Belfield, 2014).

In order to improve developmental education, programmatic design features such as acceleration and modularization have been implemented. Modest gains on student re-enrollment in developmental math course sequences were observed following a shortened course length (Hodara & Jaggars, 2014). Modularization through targeting specific areas of student deficiency have also been attempted by developmental programs (Bailey, 2009). The developmental math course in this study featured both acceleration through course design and modularization of content through ALEKS. Even with the additional academic support systems available in the Learning Center and Main Campus Learning Center, a low successful completion rate of developmental math was observed. Considering the high cost of intervention for developmental math, this finding is disappointing from the standpoint of the university.

Limitations

Missing ACT and SAT math scores were the primary limitation of this analysis. The scores were possibly missing not at random due to flexible admissions criteria at the university. Students could create admissions portfolios that did not include SAT or ACT scores, and be considered on other factors. Although multiple imputation was used to fill missing values, limitations exist because there might be confounding reasons for the missing data (Sterne et al., 2009). Some reasons for students not to submit SAT or ACT scores could include avoidance of taking the test due to anxiety or that they received a low score. Either case would likely influence a student's likelihood of passing developmental math.

Other limitations in this study include the normality of tutoring usage at the Learning Center and the Main Campus Learning Center. Although logistic regression holds no assumptions for skew, statistical power of the model can be limited in severe cases (Tabachnik & Fidel, 2013). Issues of normality also existed with ACT math scores. The distribution of these scores had a positive skew. The SAT scores were normally distributed. Since both distributions of scores were combined, a limitation exists regarding the predictive capability of the Index of Prior Academic Achievement in mathematics. Although the SAT and ACT are different tests, the scores were combined in the interest of preserving the sample size.

Although a theoretical counterfactual approach was implemented, an uncontrollable selection bias exists in this study. Students voluntarily enroll in the Learning Center, which is a fee for service program that offers specialized academic support beyond the existing support services at the Main Campus Learning Center. Due to this bias, the findings of this study might not generalize to the general population of students at the university who are also enrolled at the university.

Directions for Future Research

Based upon the findings of this study, future investigations should be conducted regarding outcomes for developmental math students with learning and attention challenges. Since large amounts of resources are expended on remediation, further investigation is needed to understand the unique learning needs of the students who are enrolled in developmental math. Recent instructional interventions designed to reduce math anxiety in developmental math courses (Phelps & Evans, 2006), and increased understanding of rational numbers (Good et al., 2013) have demonstrated promising

results. Researchers also found positive outcomes for incorporating manipulatives into math instruction (Strickland & Maccini, 2012), with approaches that involve bridging concrete mathematical concepts into abstract concepts (Fyfe et al., 2014). An experimental curriculum for developmental math students could be designed and evaluated based upon these findings.

Future studies at the Learning Center could involve a comparison between developmental math students and students who were not enrolled in developmental math on the amount of time taken for graduation, retention, and attrition from the university. A qualitative investigation consisting of interviews and focus groups for some of the students who were in this study might provide nuanced insight of their experience with developmental math.

The course format of developmental math at the university recently changed. The course now follows a 12-week format instead of a 7-week format. Additionally, the entrance exam cutoff score for placement was dropped from 30 percent to 20 percent. A comparison study could be conducted in the future to determine if the longer course format and lower cutoff score is beneficial for students with learning and attention challenges.

Conclusions

The cost and benefit of attempting a developmental math course sequence for students who have learning and attention challenges must be weighed. A controllable indicator of success in developmental math was found to be engagement with academic support services. Developmental math students with learning and attention challenges who do not take advantage of available academic support services at the postsecondary

level might be at greater risk for course completion. Efforts should be made to increase student engagement with academic support services for developmental math. These intervention efforts would involve multiple layers, such as CBT training for learning specialists and the development of SI curriculum. These intervention efforts would be feasible through making adjustments to current systems of instructional delivery and academic support for developmental math.

Regarding individual differences, college students with learning and attention challenges expend large amounts of effort on their coursework compared to their peers who do not have learning and attention challenges (Gray et al., 2016; Lefler, Sacchetti, & Carlo, 2016). Students with specific learning disabilities in mathematics might need to give special consideration to the amount of effort to successfully complete a developmental math course sequence and fulfill a college-level math requirement. Students with specific learning disabilities were found to develop at a much slower rate in mathematics than their peers who did not have learning disabilities (Stevens et al., 2015). Developmental barriers might be problematic for students with learning and attention challenges as mathematical concepts become more abstract.

Fortunately, majors are available for students who cannot complete the developmental math course sequence. Major choice, however, is limited to very few fields of study without college-level mathematics at the university. Early indicators such as math achievement on the SAT or ACT might help students with learning and attention challenges weigh their major choice options prior to entry at the university. Additionally, the implementation of summative math placement exams at postsecondary institutions should be reconsidered. Although a math placement exam can give proximal information

about a given student's ability, other metrics of prior academic achievement in mathematics should be considered in order help with accurate placement (Scott-Clayton, Crosta, & Belfield 2014). The results of this study should be used to guide conversations with future students at the Learning Center who are enrolled in developmental math. Students should be informed of the potential pitfalls and outcomes of not completing college-level math. Students should also be informed about options to complete a college degree without a formal math requirement at the beginning of their postsecondary career.

The current system of academic support and developmental education is designed with the intention to help students who struggle with math at the postsecondary level. Although the effectiveness of developmental education is inconclusive, students and postsecondary institutions might be able to receive more benefit through programmatic adjustments of curriculum and academic support services. Removal of mandatory developmental education at the college level created unintended consequences in the state of Florida following a recent policy intervention. Pain (2016) found that a voluntary remediation policy at the college level resulted in higher student enrollment in college-level math courses with a 10 percent decrease in the amount of students who received grades of 'C' or higher. Students who need remediation in mathematics likely require specialized instructional approaches and academic support. Considering that academic support services and developmental education programs are already in place to help students, effort should be placed on increasing the effectiveness of these interventions.

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