AN ABSTRACT OF THE DISSERTATION OF Annie E. S. Hager for the degree of Doctor of Education in Learning, Leadership and Community presented on June 27, 2018.

Title: How does peer-assisted learning affect math anxiety, help-seeking behavior, and performance in undergraduate mathematics?

Abstract approved:

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Cheryl A. Coker, Ph.D.

Dissertation Committee Chair

Learning support in mathematics (LSM) is widely available at colleges and universities through center-based peer-tutoring and classroom-based programs such as Peer-Assisted Learning (PAL). The purpose of this study was to experimentally introduce a six-week PAL-program in selected first-year undergraduate math courses, in order to determine its effect on students' math anxiety, performance, attitudes, and behaviors toward college math, with a particular focus on highly math-anxious (HMA) students.

An explanatory mixed-methods sequential design (Creswell, 2014) was employed in order to explore the research questions first quantitatively and then qualitatively. Student survey results, course grades, and tutoring records were used to address the research goals of Phase 1. In Phase 2, interviews with highly math-anxious students were analyzed using a grounded theory approach (Charmaz, 2006; Strauss & Corbin, 1998), providing context and meaning for the quantitative results of Phase 1. Quantitative analysis showed no significant effects of the PAL-treatment on math anxiety, performance, attitudes, or help-seeking behavior. However, students' average perceived value of mathematics improved significantly across the entire study sample. Phase 2 interviews provided evidence that the improvement in affect was due primarily to excellent teaching and not the PAL program. Interviews also revealed a "Disconnect" between students' knowledge of what it takes to succeed in math and their own behaviors. Recommendations for future research include exploring implementation strategies to maximize the effect of a new PAL program, examining the qualities of excellent teaching to see how they might influence PAL programs, and engaging stakeholders (students, teachers, and PAL-leaders) to create a culture where all students recognize the value of LSM and do not hesitate to ask for help.

How does peer-assisted learning effect math anxiety, help-seeking behavior, and performance in undergraduate mathematics?

By

Annie E. S. Hager

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I understand that my dissertation will become part of the permanent collection of Plymouth State University, Lamson Learning Commons. My signature below authorizes release of my dissertation to any reader upon request.

Annie E. S. Hager, Author

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“Don't be afraid to ask questions. Don't be afraid to ask for help when you need it. I do that every day. Asking for help isn't a sign of weakness, it's a sign of strength because it shows you have the courage to admit when you don't know something, and that then allows you to learn something new.”

- President Barack Obama, September 7, 2009

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Chapter 1: Introduction

I am the coordinator of an undergraduate peer-tutoring center that offers free drop-in tutoring support for all undergraduate students enrolled in math courses. However, while most centers, like the one I coordinate, offer free and easily accessible services, they do not always reach the students who could most greatly benefit from additional assistance. The avoidance behaviors adopted by highly math-anxious students can prevent them from accessing the services that universities provide to promote success in mathematics (Gillard, Robathan, & Wilson, 2011; Ní Fhloinn, Fitzmaurice, Mac an Bhaird, & O'Sullivan, 2014; Symonds, Lawson, & Robinson, 2008). The question this raises is how to find ways to connect struggling students with the support they need.

Math anxiety is frequently described as the "feeling of tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002). By some estimates, nearly one-fifth of the US population experiences high math anxiety (Ashcraft, Krause, & Hopko, 2007). Similar results have been reported internationally where "30% of [15 year old] students reported that they feel helpless when doing mathematics problems" (OECD, 2013, p. 88).

People who report high levels of math anxiety experience a variety of symptoms when faced with situations where math is involved. Psychological symptoms include a feeling of panic at the thought of doing math, going blank during the test, or feeling helpless while doing homework; physiological symptoms include sweaty palms, elevated heart rate, and nausea (Ruffins, 2007). Further, researchers at the University of Chicago have shown that simply *anticipating* a math task causes a measurable neural pain response in highly math-anxious individuals (HMAs; Lyons & Beilock, 2012).

> Anticipatory anxiety about math is grounded in the simulation of visceral threat and even pain. These results also provide a potential neural mechanism to explain the observation that HMAs tend to avoid math and math-related situations, which in turn can bias HMAs away from taking math classes or even entire math-related career paths (Lyons & Beilock, 2012, p.6).

Numerous studies confirm that undergraduates with negative dispositions toward mathematics tend to avoid tasks, courses, and programs that require the use of mathematics (Ashcraft & Moore, 2009; Ashcraft & Ridley, 2005; Hembree, 1990; Liew, Lench, Kao, Yeh, & Kwok, 2014; Ma, 1999).

Many colleges and universities offer *learning support in mathematics* (LSM). Center-based LSM provides a physical space where students can go for drop-in tutoring assistance (Matthews, Croft, Lawson, & Waller, 2012; Perkin, Croft, & Lawson, 2013). Qualitative and quantitative evidence demonstrates that use of these centers can improve performance, increase retention, build community, and address affective factors such as fear or low self-confidence (Matthews et al., 2012; MacGillivray & Croft, 2011; Solomon, Croft, & Lawson, 2010). However, students who could most benefit from these services do not access them (Gillard et al., 2011; Grehan, Mac an Bhaird, & O'Shea, 2011; Ní Fhloinn et al., 2014; Symonds et al., 2008). In the words of Gillard et al. (2011), "the majority of students using mathematics support centers are the students who are enthusiastic, rather than the students who are considered 'at risk'" (p. 46). If, as demonstrated by Lyons & Beilock

(2012), the thought of doing math causes pain, the avoidance response to math and math-related activities, including accessing free drop-in tutoring support, makes sense.

However, quantitative literacy is considered to be a critical 21st century skill (McCormick & Lucas, 2011; National Mathematics Advisory Panel, 2008; National Research Council, 1989; Wilkins, 2000). While overcoming negative attitudes, behaviors, and emotions toward mathematics is a significant challenge (Newcombe et al., 2009; Royster, Harris & Schoeps, 1999), it may be essential for many students' success in higher education.

An alternative form of LSM brings the support directly to the classroom. Instead of basing the support services in a stand-alone support center that students must take personal initiative to access, programs such as *Supplemental Instruction* (SI) and *Peer-Assisted Learning* (PAL) move away from the LSM center and into the classroom environment. These programs are designed to target high-risk courses rather than high-risk students (Blanc, DeBuhr, & Martin, 1983; Dawson, van der Meer, Skalicky, & Cowley, 2014; Martin & Arendale, 1994). Instead of waiting for students to come to them in an LSM center, tutors attend class meetings and provide additional review sessions outside of class.

Since SI was established in 1973, hundreds of studies have demonstrated specific benefits of embedded peer tutoring programs (for reviews, see Dawson et al., 2014; Martin & Arendale, 1994; U.S. Department of Education, 1995). Examples include higher average course grades, lower failure and course withdrawal rates, increased persistence with undergraduate coursework and higher graduation rates for participants compared with students who do not participate.

Although embedded LSM programs such as SI and PAL have been shown to improve student performance, as measured by grades, retention, and graduation rates (Fayowski & MacMillan, 2008; Kenney & Kallison, 1994; MacGillivray & Croft, 2011) much less research has been done regarding their effect on math anxiety, motivation, self-efficacy, or other affects or behaviors. Is it possible that the mechanism by which embedded LSM improves performance is by helping students lower their math anxiety and develop more productive attitudes and behaviors toward the subject? In PAL programs, the peer-tutor is present in the classroom and regularly provides peer-support to small groups of students all enrolled in the same class. High-risk students are not singled out for extra support because the program is intended to benefit all of the students in a high-risk course. Because drop-in, center-based LSM is underutilized by students with math anxiety (Ní Fhloinn et al., 2014; Symonds et al., 2008), perhaps the embedded support provided by a PAL program may be a more effective intervention for negative affect and poor performance in at-risk first-year undergraduate students enrolled in introductory math courses.

Statement of the Problem

This study addresses the problem of the underutilization of learning support in undergraduate mathematics. Success in math leads to greater educational and career opportunities, yet many students are unsuccessful in their very first college math course. For example, at Plymouth State University, 46% of students who enrolled in College Algebra between 2012 and 2017 did not successfully complete the course with a grade of C- (70%) or higher. PSU, like many colleges and universities, offers tutoring support through a math support center, but frequently those who could benefit the most from the extra help do not take advantage of the service.

Another form of learning support in mathematics, not currently in use at PSU, brings peer-tutors directly into the classroom. In embedded peer-tutoring programs such as Peer-Assisted Learning (PAL) and Supplemental Instruction (SI), peer-tutors attend classes and provide course-specific support. These programs have been shown to improve grades and retention rates of students who participate (Dawson et al., 2014; Martin & Arendale, 1994; U.S. Department of Education, 1995). However, as is the case with center-based learning support, PAL and SI are often underutilized by the students who stand to gain the most by participating (Stone & Jacobs, 2008).

Students with high levels of math anxiety are particularly at risk of failure in undergraduate mathematics. Research shows that math anxiety can develop early in a student's mathematics education, and the effects can be long lasting (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015; Ramirez, Gunderson, Levine, & Beilock, 2013). Undergraduates who are required to take college-level mathematics can be overwhelmed by the anxiety that they have experienced since elementary school. "Math anxiety is related to deliberate avoidance of math, certainly of the math curriculum in high school and college, and also of career paths that rely on math achievement and skill" (Ashcraft et al., 2007, p. 345). More work needs to be done to help connect students to the services they need to be successful in math. A more proactive and holistic educational approach demands outreach and assistance for at-risk students, including those who are highly math-anxious.

Purpose of the Study

The purpose of this study was to examine the effects of a six-week Peer-Assisted Learning (PAL) program on first-year undergraduates' math anxiety, performance, attitudes and perceptions toward college math, with a particular focus on highly math-anxious (HMA) students. A secondary question examined whether participation in a PAL program increased students' help-seeking behaviors.

Research Questions

Five research questions examined the influence of a peer-assisted learning (PAL) program on the math anxiety, help-seeking behaviors, and performance of undergraduate students, particularly those who are highly math-anxious (HMA).

Specifically,

1. Does participation in a PAL program measurably lower math anxiety for HMA students?
2. Does participation in a PAL program increase help-seeking behaviors, as measured by increased usage of drop-in peer-tutoring?
3. Does participation in a PAL program affect student performance in general, and HMA student performance specifically, as measured by exam and course grades?
4. How do HMA students perceive the influence of a PAL program on their experience of math anxiety, and willingness to seek extra help?
5. Does participation in a PAL program influence student attitudes and perceptions toward math, particularly those identified as HMA?

Hypothesis 1: There will be no difference in math anxiety for HMA students from pre- to post- intervention.

Hypothesis 2: There will be no increase in usage of drop-in tutoring services by students in the PAL-treatment group as compared to those in the control group during the six-week intervention.

Hypothesis 3: There will be no difference in exam and course grades between the PAL-treatment and control groups at the end of the six-week intervention.

Key Terms

Learning Support in Mathematics (LSM): Learning support in mathematics is any optional extracurricular support for undergraduate students that is separate from their required coursework. It frequently includes a physical space, or center, from which tutoring is offered on an appointment or drop-in basis. Workshops and group tutoring sessions are also common features of learning support in mathematics (MacGillivray & Croft, 2011).

Peer-assisted learning (PAL): PAL is a form of learning support widely used at universities in the UK, Australia, and Asia. It emphasizes the importance of discussion-based study sessions in which peer-tutors model effective study techniques (Duah, Croft, & Inglis, 2014).

Supplemental Instruction (SI): Originally developed by Dr. Deanna Martin at the University of Missouri-Kansas City in 1973 (Martin & Arendale, 1994), SI is a specific form of PAL that targets high-risk courses by providing peer-led tutoring support. Since its development, it has been implemented across a very wide range of age groups, academic subjects, and physical settings (Dawson et al., 2014, Martin & Arendale, 1994).

Math anxiety: A negative emotional, physiological, or physical response to mathematics, triggered by learning math, doing math, or even thinking about math. Math anxiety is linked to poor performance and avoidance behaviors (Ashcraft, 2002). In this study, students were classified as Highly Math Anxious (HMA) if their scores on a math anxiety rating scale fell in the top quintile of the sample.

Perceived Self-efficacy: An individual's beliefs about his or her ability to control their own actions and experiences. "Efficacy beliefs influence how people feel, think, motivate themselves, and behave" (Bandura, 1993).

Chapter 2: Review of the Literature

Students with high math anxiety (HMA) avoid seeking help. While center-based learning support in mathematics (LSM) is widely available on college campuses around the world, it is underutilized by the students who could most benefit from it. A review of the literature on math anxiety and LSM suggests that programs like Peer-Assisted Learning (PAL) that bring the tutor to the students, rather than requiring the student to actively seek help in a tutoring center, may be a more effective strategy for enhancing student success.

Math Anxiety

Math anxiety has been studied extensively for over 60 years in the United States (Dowker, Sarkar, Chung Yen, Pletzer, & Jansen, 2016), yet there is no single universally accepted definition of exactly what math anxiety is. In 1972, Richardson and Suinn described it as "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). In a more recent comprehensive review of the history of research on math anxiety, Ashcraft et al. (2007) define it as "a negative emotional reaction to math and to situations in which math reasoning or problem solving must be performed" (p. 329). In his meta-analysis of the relationship between math anxiety and performance, Ma (1999) notes that "mathematics anxiety can take multidimensional forms for example, dislike (an attitudinal element), worry (a cognitive element), and fear (an emotional element)" (p. 520).

The first important research paper on the subject (in which the construct was called *"number anxiety"*) was published by Dreger and Aiken in 1957. They outlined three hypotheses that have driven research on math anxiety ever since. These three hypotheses are, (1) Math anxiety is distinct from general anxiety, (2) Math anxiety is not related to intelligence, and (3) Highly math anxious individuals will score poorly on math tests. The validity of these hypotheses is now generally accepted. As noted by Ashcraft et al. (2007),

> It is actually rather remarkable how focused the first empirical study in the area was on what are still viewed as central questions to the field and how its results have been replicated and upheld, without serious modifications, for such a long period of time (p. 332).

So, despite the lack of a universally accepted definition for math anxiety it is now clear that math anxiety is a construct distinct from general anxiety. It is also not related to intelligence, and it effects performance on mathematical tasks. Math anxiety has also consistently been shown to be linked to avoidance behaviors (Liew et al., 2014; Lyons & Beilock, 2012; Ryan & Pintrich, 1997; Turner et al., 2002) and negative attitudes toward mathematics (Dowker et al., 2016; Hembree, 1990; Hoffman, 2010; Pajares & Miller, 1994).

Measuring Math Anxiety

Dreger and Aiken's original (1957) hypotheses were challenging to test, since quantitative measures of math anxiety had yet to be developed. The first widely used measure was Richardson and Suinn's (1972) Mathematics Anxiety Rating Scale (MARS), a 98-item survey that asked participants to rate their level of anxiety when faced with various mathematical tasks in a wide range of personal and academic settings. MARS has been adapted several times to make it shorter and easier to score without decreasing its value as an assessment tool. MARS and other quantitative measurement tools have demonstrated that there is a measurable difference between "learning math anxiety" and "math evaluation anxiety" (Alexander & Martray, 1989; Hopko, Mahadevan, Bare, & Hunt, 2003; Plake & Parker, 1982). In other words, there is an important distinction between *learning* math and taking math *tests.*

More recently, Pletzer, Wood, Scherndl, Kerschbaum, and Nuerk (2016) used factor modeling to further examine the various aspects of math anxiety. Factor modeling is a statistical technique that allows researchers to collapse a large number of variables into a smaller grouping of "factors" that, when grouped, explain a large proportion of the variance in a data set. They administered the MARS30-Brief, an instrument derived from the original MARS (Richardson & Suinn, 1972) by Suinn and Winston (2003), to 491 undergraduate students at the University of Salzburg. They determined that "math evaluation anxiety" is actually made up of two different factors: anxiety about the test itself, and the anxiety that occurs when *anticipating* a math test. This aligns with the findings of Lyons and Beilock (2012), who found a neural pain response in subjects who were *anticipating* a math task. Thus it appears that another important distinction to be made when understanding math anxiety is *thinking about doing* math and *actually doing* math do not affect people in the same way.

Avoidance

Undergraduates who are required to take college-level mathematics can be overwhelmed by the anxiety they may have experienced since early elementary school (Ashcraft, 2002; Hembree, 1990). "Math anxiety is related to deliberate avoidance of math, certainly of the math curriculum in high school and college, and also of career paths that rely on math achievement and skill" (Ashcraft et al., 2007, p. 345). The effects of math anxiety on performance and avoidance behaviors can be particularly debilitating to undergraduate students, as it limits their future degree and career options.

Ashcraft et al. (2007) describe avoidance straightforwardly: "Putting it simply, if one dislikes math and feels that one is poor at math, then one probably does not enroll in math beyond basic graduation requirements" (p. 335). But this may be an over-simplified description of the cause of avoidance. The recent development of brain scanning technology has allowed for a new understanding of math anxiety from a neurodevelopmental perspective (Young, Wu, & Menon, 2012). Students with math anxiety do not demonstrate the same brain patterns as students with generalized anxiety, giving new evidence for Dreger and Aiken's (1957) first hypothesis, that math anxiety is not the same as generalized anxiety. Young et al. (2012) used brain scans to demonstrate that second- and third-graders with high math anxiety showed increased activity in brain regions associated with fear, and decreased activity in regions associated with problem-solving when compared with their low math anxiety counterparts. Lyons and Beilock (2012) conducted a similar study with college students. Twenty-eight students, fourteen with higher than average math anxiety and fourteen with lower than average math anxiety, were selected in a prescreening survey. All participants were also prescreened for general trait anxiety and found to be within normal limits. All participants participated in a math task and a word task while neural activity was monitored using fMRI. The researchers found neural activation in the pain centers of the brains of the HMA students who were anticipating an upcoming math task. The same patterns were not apparent in low math-anxious students, and word tasks did not have the same effect on either group. It appears that the fear and pain responses are quite specific to HMA people when they are faced with the possibility of having to do math. Thus, it is reasonable to hypothesize that the math evaluation anxiety that occurs when *anticipating* a math task may be the sub factor of math anxiety most directly linked to the avoidance response.

These studies (Young et al., 2012; Lyons & Beilock, 2012) also support Dreger and Aiken’s (1957) third hypothesis, predicting that math-anxious students will perform poorly on math tests. They provide a neural basis for the oft-reported experience of math-anxious people who report that the reason they did badly on a test was because their brains just “shut down,” and provides counterevidence for the people who assume the reason a student did poorly on a test is because he or she didn’t study hard enough.

Performance

There is a strong link between math anxiety and performance. In a meta-analysis of 151 studies, Hembree (1990) found a correlation of -0.31 between math anxiety and performance for college students. Ma (1999) conducted a meta-analysis of 26 studies of elementary and secondary school students, reporting an average a correlation of -0.27 in that population.

What is the nature of the relationship between math anxiety and performance? It is not uncommon to encounter people, even math educators, who downplay math anxiety as something that happens to students who have not studied hard enough. In other words, a commonly held belief is that math anxiety arises from poor performance, and math anxiety is just another term for "bad at math" (Beilock &Willingham, 2014). Certainly, the avoidance response of highly-math anxious individuals causes them to avoid doing math when possible, so opportunities to improve their performance become limited.

However, there is substantial evidence that math anxiety has direct effects on performance. In discussing the results of his meta-analysis, Hembree (1990) concluded that high math anxiety leads to poor performance, while finding "no compelling evidence that poor performance causes math anxiety" (p. 44). Evidence that math anxiety interferes with working memory capacity provides a neurobiological explanation for why math-anxious people perform poorly on tests (Ashcraft & Kirk, 2001; Ashcraft & Ridley 2004, Miller & Bichsel, 2004; Ramirez, Gunderson, Levine, & Beilock, 2013). Beilock (2008) even asserts that, because of the effect of math anxiety on working memory, "ironically, those most likely to fail in demanding situations are those who, in the absence of pressure, have the greatest capacity for success" (p. 342).

Recently, Carey et al. (2016) examined the existing research on math anxiety and performance. In their review article, appropriately titled, *The chicken or the egg? The direction of the relationship between mathematics anxiety and mathematics performance*, they propose a new model, called *Reciprocal Theory,* that hypothesizes a bidirectional relationship in which math anxiety and poor performance create a "vicious cycle" (Carey et al., 2016, p. 1). They stress that it is important from the perspective of educational policy to understand the directionality of the relationship: if poor performance causes anxiety, then effort should be placed on improving student performance. If anxiety causes poor performance, then the effort should instead focus on interventions to lower students' anxiety. If the relationship is bidirectional, then both anxiety and performance should be addressed together. They advocate for further longitudinal and mixed-methods studies to provide a deeper understanding of what they propose to be a reciprocal relationship between performance and anxiety.

Chang and Beilock (2016) reached a similar conclusion from their review of decades of research on math anxiety, proposing that the performance-anxiety relationship is not unidirectional, but circular in nature. They emphasize that the negative relationship between math anxiety and performance is most pronounced in high working-memory individuals who, in absence of stress and worry, would have the highest potential for success in math. They also emphasize the role that teachers, parents, and sociocultural environment play in the math anxiety-performance link, stating that "future interventions may benefit from focusing on both math-anxious individuals themselves and those around them" (Chang & Beilock, 2016, p. 33).

If there is a circular nature to the relationship between math anxiety and performance, then it is possible that interventions that improve performance could lower math anxiety, and interventions that aim to lower math anxiety could result in an increase in performance.

Affect

Numerous studies have examined the role of self-efficacy beliefs, motivation, perceived value, and other affective traits on student performance in mathematics. These factors are not all independent of one another, and while most have been shown to have some statistical correlation with math anxiety, they also appear to be distinct constructs. For example, an analysis of data from 250,000 15-yr-old students from 41 countries examined whether math self-concept, math self-efficacy, and math anxiety can be observed as independent constructs across diverse cultural groups (Lee, 2009). The author concluded that the three constructs are empirically distinguishable from each other. The study also pointed to important differences between countries. Asian countries show low math self-concept and math self-efficacy and high math-anxiety. Several Western European countries show high math self-efficacy and low math anxiety. The United States placed in middle for math anxiety, high for math self-efficacy, and highest on math self-concept. "Each of the self-constructs (math self-concept, math self-efficacy, and math anxiety) appears to have an important but different contribution in explaining the math performance at both between- and within country-levels" (Lee, 2009, p. 364).

Self-Efficacy

According to Bandura (1993), individuals' beliefs about what they can accomplish can be an important predictor of what they can actually accomplish. Social cognitive theory predicts that a person's sense of self-efficacy will influence the choices they make, how hard they will work to accomplish their goals, and how much they will persist in their efforts.

> Most courses of action are initially shaped in thought. People's beliefs in their efficacy influence the types of anticipatory scenarios they construct and rehearse. Those who have a high sense of efficacy visualized success scenarios that provide positive guides and supports for performance. Those who doubt their efficacy visualize failure scenarios and dwell on the many

> things that can go wrong. It is difficult to achieve much while fighting self-doubt (Bandura, 1993, p. 118).

It seems readily apparent that undergraduates facing self-doubt and fear of failure are at risk of making poor decisions that will affect their performance in college-level math. But how do self-efficacy beliefs interact with other factors known to affect performance? A path analysis conducted by Pajares and Miller (1994) provided some insights into this question.

Pajares and Miller (1994) surveyed 350 undergraduates at a large public university in the southern US, measuring math self-efficacy, perceived usefulness of mathematics, math anxiety, math self-concept, prior experience, and performance. They found that math self-efficacy was more predictive of performance than any of the other variables that they measured. Regarding the role of math anxiety, they found that self-efficacy was a “stronger predictor of math anxiety than either prior high school math experience or gender” (p. 195).

Akin and Kurbanglu (2011) surveyed 372 undergraduates at a mid-sized state university in Turkey for math anxiety, attitudes toward math, and self-efficacy. Like Pajares and Miller (1994), they used path analysis to interpret their results. They found that self-efficacy and attitude both negatively predict math anxiety. In other words, a high sense of self-efficacy and a positive attitude can reduce math anxiety.

Hall and Ponton (2005) compared the perceived self-efficacy of two groups of first year college students: those who started in calculus versus those who started in intermediate algebra. The calculus students not only had better skills, but they also had higher self-efficacy beliefs. The authors argue that because of the growing number of students entering college unprepared for college-level work, they are setting themselves up for failure unless their low self-efficacy beliefs can be addressed.

Overall, research supports the idea that a high sense of self-efficacy can mediate the negative effects of math anxiety, but students with low self-efficacy combined with high anxiety are at high risk of failure in college-level mathematics.

Perceived Value

Another closely related construct that has been examined for its role in student success is perceived value, or usefulness of the subject. Hendy, Schorschinsky, and Wade (2014) have developed three new scales to measure college students' math beliefs, based on expectancy-value theory (Wigfield & Eccles, 1992), self-efficacy theory (Bandura, 1993), and the health belief model (Janz & Becker, 1984). They found that all three of the new scales compared statistically with the MARS-R. However, the students who most strongly devalued the importance of college math courses were "most consistently and significantly associated with poor math behaviors, providing new insight into why college students may neglect recommended math behaviors" (Hendy et al., 2014, p.1232). They suggest that interventions to improve student success in college math may need to address the students' lack of perceived value of the subject.

> Students are unlikely to invest much time in day-to-day math behaviors (attending class, doing homework, reading textbooks, asking for help, or monitoring one's grade in the class) if they see them as unrelated to their

> understanding of math concepts, their final course grade, graduation from college, future employment, or future financial well-being. (p. 1226)

The work of Hendy et al. (2014) provides further evidence of the effort being put in by educators and researchers to understand why so many students do poorly in college-level math. What matters most? Is it math anxiety, or self-efficacy, perceived value, or motivation? How do the various measures of student attitudes, self-beliefs, and behaviors interact with one another? And most importantly, what can we as educators do to help?

Intervention

There are many self-help books available for helping students overcome math anxiety (Arem, 2010; Oakley, 2014; Tobias, 1993; Willis, 2010). Some techniques include deep breathing, visualization, and positive thinking (Arem, 2010; Brunyé, Mahoney, Giles, Rapp, Taylor, & Kanarek, 2013), self-monitoring (Tobias, 1993), and expressive writing (Park, Ramirez, & Beilock, 2014; Ramirez & Beilock, 2011). Reframing the threatening feelings associated with math anxiety as a challenge has also been shown to be effective (Jamieson, Mendes, & Nock, 2013; Jamieson, Mendes, Blackstock, & Schmader, 2010). As Maloney and Beilock (2012) point out, "when anxiety is regulated or reframed, students often see a marked increase in their math performance" (p. 405).

Highly math-anxious students who tend to avoid anything to do with math are unlikely to seek out and read self-help guides. However, if services directed toward students take some of these strategies into account, due to the hypothesized circular nature of the relationship between math anxiety and performance (Carey et al., 2016;

Chang & Beilock, 2016), they may be more effective than simply providing mathematical content instruction.

Supekar, Iuculano, Lang, & Menon (2015) investigated the effects of an intensive tutoring program on math anxiety and performance in third-grade children. The tutoring intervention improved performance in high-math anxious and low-math anxious children alike. Brain scans on the HMA children in the sample at the beginning of the study showed heightened activity in the amygdala, consistent with the results found by Lyons and Beilock (2012) and Young et al. (2012). Remarkably, after eight weeks of intensive tutoring (three sessions per week, approximately 40-50 minutes per session), the hyperactive amygdalar responses of the HMA students had decreased to levels that were comparable to those of the low-math anxious students. The authors propose that

> The intensive math-tutoring program repeatedly exposes children to what they fear: mathematical stimuli and social situations involving mathematical problem solving. Repeated exposure can make the child feel more in control of situations involving mathematical problem solving, thereby diminishing their math anxiety (p. 12581).

However, the authors did not consider the possibility of other mechanisms by which this intervention lowered anxiety. It is plausible that it was not simply additional exposure to mathematics, but also the interpersonal interaction with the tutor that helped reduce their fear and increase their confidence in their own abilities.

Several studies have provided evidence that math-anxious role models can impact students' performance and attitudes toward math. Beilock, Gunderson, Ramirez, and Levine (2010) demonstrated that female first- and second-grade teachers with high math anxiety negatively impacted the performance and gender-based stereotypes of their female students ("girls aren't good at math"). Gunderson, Ramirez, Levine, and Beilock (2011) assert that "children's math attitudes form as a result of environmental influences, especially those that occur in interactions with parents and teachers" (p. 163). If interactions with role models can cause negative attitudes and decrease performance in math, is it possible that interactions with positive role models could reverse this trend and allow for more productive attitudes and increased performance? The study by Supekar et al. (2015) employed undergraduate students from Stanford University to serve as tutors in the study (K. Supekar, personal communication, October 23, 2017). Perhaps it was not only the increased exposure time to mathematical content, but also the opportunity to learn from a positive role model that decreased the young students' math anxiety levels over the course of the eight-week intervention.

Learning Support in Mathematics

A widely-used intervention to improve undergraduate student success in mathematics is Learning Support in Mathematics (LSM), an umbrella-term for any extracurricular, optional support services provided as a supplement to classroom-based, credit-bearing coursework. Three types of LSM - center-based support, supplemental instruction, and peer-assisted learning - will be discussed in more detail below.

Center-Based Support

The majority of universities in the UK, Ireland, and Australia offer center-based mathematics support (Ní Fhloinn et al., 2014; Perkin et al., 2013). Similar data is not available for US colleges and universities. Studies in the UK (Pell & Croft 2008; Symonds et al., 2008) and Ireland (Ní Fhloinn et al., 2014) have shown that while center-based support has expanded and is now readily available to students at many universities, the resource is underutilized and students who could most benefit from the extra help do not access it.

Pell and Croft (2008) compared 664 first-year engineering students' attendance records at the Loughborough University mathematics support center with their final course grades, and found that students with the highest grades used the center more than students who struggled in the course. Thirty-five percent of students who received an A* (the highest mark) in their math course used the center more than once, compare with 22% of students who received a D grade and were in risk of failing the course. Of students who failed the course, only 15% used the math center. The authors suggest that "this would indicate that fail grade students as well as having ability problems also have attitudinal problems" (Pell & Croft, 2008, p. 171).

At Dublin City University, first-year students who were "at risk" of failing their math course were identified by use of a diagnostic test. The "at risk" students were encouraged to use the mathematics support center "as early and frequently as possible" (Dowling & Nolan, 2006, p. 52). In the first year of the program, 80 students were identified as "at risk." Forty-one of these students visited the mathematics support center at least once. The pass rate for students who visited the center was 53%, versus just 25% for the students who did not take advantage of the mathematics support center. The following year (2005-2006), scoring of the diagnostic test was altered to identify more students as “at risk.” In that year, 95 of the 161 “at risk” students attended math support sessions at the center. Sixty percent of the students who used the service passed their course, compared to 49% who did not attend.

Samuels and Patel (2010) summarize other studies across the UK and Ireland, which when considered along with the aforementioned examples (Dowling & Nolan; 2006; Pell & Croft, 2008) demonstrate two important findings about center-based LSM: first, that students who use the services achieve higher grades in their courses; and secondly, students who are most at risk are the least likely to access these services.

Gillard et al. (2011) distributed an e-mail survey to 40 universities known to offer some form of LSM, and received responses from mathematics support providers at 19 universities in the UK, one in Australia, and one in Ireland. Survey questions were open-ended. The first question on the survey was, “Please describe how you deliver mathematics support. What are the main problems you encounter when providing such support?” (p.46). One of the problems frequently reported was that students who could most benefit from the service do not seek it out. The study authors assert that “the majority of students using Mathematics Support Centers are the students who are enthusiastic, rather than the students who are considered ‘at risk’” (p.46).

Grehan et al. (2010) interviewed seven students at the National University of Ireland Maynooth who had failed a math course and were retaking it, and had never used LSM. Through a grounded theory analysis of the interviews, the major theme to emerge was fear: “fear of failure, fear of showing a lack of knowledge or ability, fear of being singled out, and fear of the unknown" (p. 80). Notably, "students reported that the fear of their own emotional reaction to failure stopped them from seeking help or even from attempting assignments" (p. 80).

However, students who do take advantage of center-based LSM find it helpful. Ní Fhloinn et al. (2014) surveyed 1633 first-year students at nine higher education institutions in Ireland, asking them, "Did you ever consider dropping out of your course/college because of mathematical difficulties?" (p. 956) and, "If yes, has mathematics support influenced your decision not to drop out?" (p. 958). One hundred and twenty-five students reported that they had considered dropping out because of math, and of those students, 69 (62.7%) felt that mathematics support had influenced their decision not to drop out. Several themes emerged from their qualitative analysis of student comments: it was very helpful, it made assignments doable, it improved understanding, and it increased confidence. Fifty-six percent of respondents who had used LSM reported that it had been "helpful" or "very helpful" to their confidence in mathematics.

Mendelsohn (2015) compared the motivational profiles of undergraduate students enrolled in college algebra who used the math tutoring center with the motivational profiles of college algebra students who did not seek tutoring assistance. Students who used the tutoring service were found to have significantly lower self-efficacy and control of learning beliefs than students who did not use tutoring. Differences in performance between the two groups were insignificant. The study author concluded that more research is needed to understand the link between tutoring, performance, motivation, and self-efficacy.

MacGillivray and Croft (2011) reviewed all of the available scholarly work up to 2010 on measuring the effectiveness of LSM. They provide abundant quantitative evidence for improvements in retention and performance for the students who use LSM. Furthermore, they assert that the qualitative evidence is making it apparent that the effects of LSM go beyond higher grades and increased retention. There is now evidence that mathematics learning centers can provide a physical space and academic resource that empowers learners and builds communities. Focus groups conducted with mathematics students at two UK universities showed that mathematics learning centers are being used as physical locations for meeting and building collaborative, peer-based learning communities (Solomon et al., 2010).

Center-based LSM is now widely available on college and university campuses. Qualitative and quantitative evidence continues to grow, showing that use of these centers can improve performance, increase retention, build community, and address affective factors such as fear or low self-confidence. However, the problem still exists that students who could most benefit from these services do not access them. In the words of Gillard et al. (2011), “attracting the ‘right’ students is the most universally shared problem between all support provisions” (p. 46).

Supplemental Instruction

One way to circumvent students’ reluctance to seek help is to bring the help to them. One specific type of peer-led academic assistance is Supplemental Instruction (SI). SI was developed in 1973 at the University of Missouri- Kansas City (UMKC) by Deanna Martin as an academic assistance program that shifted the focus from high-risk students to high-risk courses (Martin & Arendale, 1994). It was first piloted in a human anatomy course for dentistry students, and then implemented in several more rigorous courses in the professional schools of dentistry, pharmacy, and medicine. It was implemented at the undergraduate level in 1981 (Arendale, 2002).

The key structure of SI is based on a collaboration between SI leaders, course instructors, and a certified SI supervisor. SI leaders are students who have successfully completed the targeted course, ideally from the same instructor. The SI leader acts as a model student, attending all class meetings, taking notes, and doing all of the course assignments. The SI leader offers supplemental study sessions outside of class time, in which he or she facilitates discussion and group problem solving. SI leaders do not teach course content, but instead enhance students' learning process by modelling appropriate study behavior and facilitating group learning (Martin & Arendale, 1994). SI in particular emphasizes the development of appropriate study skills, including self-monitoring and self-regulation (Topping, 2001). Course instructors work closely with their SI leader, and the process is monitored by the SI supervisor.

The SI model has been implemented widely and studied extensively (Dawson et al., 2014; Martin & Arendale, 1994). It was validated by the U.S. Department of Education in 1981 as an exemplary program (Martin & Arendale, 1994), and endorsed again in 1995 (U.S. Department of Education, 1995). It has repeatedly been shown to be highly effective when properly implemented in the appropriate settings. Students who participate in SI earn higher average course grades, have lower failure and course withdrawal rates, persist with undergraduate coursework and graduate at higher rates, than students who do not participate in SI (for reviews, see Dawson et al., 2014; Martin & Arendale, 1994; U.S. Department of Education, 1995).

In a comparison between center-based tutoring support and an SI program, Hodges and White (2001) found that SI made a greater difference in GPA than tutoring did. One hundred and three at-risk first-year undergraduates were given access to both SI and tutoring in math and history courses. Attendance was low for both SI and tutoring. Of the 103 students in the study, only 68 attended at least one tutoring session. Of the students who used tutoring, over half (57%) went to fewer than 6 sessions. SI use was also low, with 56% of students attending no more than three sessions. Even with the low participation rates for both interventions, GPA for students who participated in SI was significantly higher than for students who did not attend. There was no significant difference between the students who attended or did not attend tutoring.

The findings of Rheinheimer, Grace-Odeleye, Francois, and Kusorgbor (2010) contradict Hodges and White (2001) in that tutoring was found to be a highly significant predictor of student success. They followed three cohorts of incoming at-risk freshmen at a public university in Pennsylvania, tracking their use of a variety of tutoring services, including one-on-one and small group sessions as well as use of SI. Of the 129 students in the sample, only 25 graduated. The other 104 withdrew from college. Use of tutoring was shown to be a highly significant factor in determining whether a student would persist to graduation. Students who were tutored were 13.5 times more likely to graduate than students who were not tutored. In fact, only one of the 25 students who graduated did not use tutoring at all.

Participation in SI is mainly voluntary, with a few exceptions. Use of center-based LSM is also predominantly voluntary. It is important to emphasize that just as with center-based LSM, students *who participate* in SI have more positive outcomes than students *who do not participate.* Students who choose to participate in any form of LSM may have different characteristics than students who do not participate. Often, affective traits such as motivation and self-efficacy will influence whether or not a student seeks help (Kenney & Kallison, 1994; McCarthy, Smuts, & Cosser, 1997).

For example, Congos and Shoeps (1998) compared non-SI students (n=321) to SI students (n=153) in introductory college biology courses. They found that SI students had significantly higher high school class rankings than their non-SI counterparts. They interpreted this to imply that students who elected to participate showed greater “academic potential and industriousness” (p. 56). However, even when an analysis of covariance was done and prior performance was controlled for, there was still a significant improvement in course grades for SI versus non-SI students.

In the conclusion of their review of 29 studies of SI and related interventions from 2001 to 2010, Dawson et al. (2014) urged future researchers to consider a wider range of aspects of the effectiveness of SI.

> Effects of SI other than on academic achievement as expressed in course grades or course completion would add to the values institutions may attach to this model. Some studies do address social and transferable benefits. There is

> considerable room, however, for this focus of research to be broadened and made more robust (p. 634).

Overall, SI has been shown to improve performance and student retention, but far less attention has been given to its relationship to affective factors such as motivation or self-efficacy. Some studies use proxy measures such as prior GPA to control for the effects of motivation, but none have looked at how participation in SI might actually change students' affect.

Peer Assisted Learning

SI is unique in that it provides a very specific protocol, including training programs and certifications offered through the International Center for Supplemental Instruction at UMKC. However, it is just one model for providing learning support through the use of peer leadership. Many colleges and universities offer programs that are similar to SI, but have not gone through the SI certification process. One example in the US, UK and Australia uses the acronym PASS, for Peer-Assisted Study Sessions, as the name for their SI-inspired programs. SI, PASS, and similar programs may be considered as examples of a more broadly defined form of student support known as Peer-Assisted Learning (PAL). Topping and Ehly (2001) define PAL as "a generic term for a group of strategies that involve the active and interactive mediation of learning through other learners who are not professional teachers" (p. 113). As is the case with SI, most PAL studies measure successful outcomes in terms of grades (Dawson et al., 2014; Drane, Micari, & Light, 2014; Parkinson, 2009) or increased retention (Grillo & Leist, 2013).

More recent studies have reported similar positive impacts on student success. In 2014, Drane et al. evaluated the first 10 years of a “small-group, peer-led, problem-solving model” (p. 211) for science, technology, engineering, and math (STEM) courses at Northwestern University. They found positive effects on grades and retention, with larger effect sizes for women and minorities.

PAL, SI, and Undergraduate Mathematics

The body of research on peer-learning programs such as PAL and SI is extensive, covering many subject areas and educational settings, from elementary classrooms through graduate-level courses. However, there are far fewer studies addressing the effectiveness of SI or PAL in undergraduate mathematics.

Fayowski and MacMillan (2008) conducted a quasi-experimental study of the use of SI in a first-year college calculus class for non-majors. Data were collected from Winter 2002 to Fall 2004, resulting in a sample of 869 students. Of these, 269 students attended five or more voluntary SI sessions and were classified as SI participants. The other 600 students who did not attend SI sessions or attended fewer than five sessions were classified as non-participants. The researchers used students’ prior grade point average (GPA) as a covariate in their statistical analysis in order to take into account students’ background and preparedness. They also argue that prior GPA is not only a measure of ability, but is also influenced by motivation. They found that prior GPA was a statistically significant predictor of student success, but even after taking prior GPA into account, participation in SI resulted in significant increases in performance. On average, the authors note that “Supplemental Instruction can be credited with a two-letter grade increase for students participating in the programme after controlling for selection bias and gender differences" (p. 852).

Parkinson (2009) ran a controlled study of PAL programs in math and chemistry for first year undergraduates in the biotechnology program at Dublin City University in Ireland. Students who participated in PAL had significant and substantial improvements in performance (13% or more) compared to the control group. The results from the pilot were so convincing that the university now offers PAL programs for all first year courses in the biotechnology major.

An observational study of a PAL program in two undergraduate math courses (*College Algebra and Probability* and *Precalculus I*) at the University of Minnesota found that participating in just 3 PAL sessions was enough to predict a significant increase in the probability of successful completing the course. Further, students who attended all PAL sessions had a ten-fold chance of success, as compared to students who did not participate (Cheng & Walters, 2009).

Porter (2010) conducted a quasi-experimental study of SI in college algebra for freshmen at Albany State University in Georgia and found no significant differences between the SI class and the control class. However, there were only 25 students in each class, and confounding factors such as prior performance, ability, and motivation were not taken into account. The author's professional opinion was that the SI sessions were beneficial to the students who attended, even though there was no statistical difference in exam or course grades between the SI and control group.

Theoretical Framework

It is noteworthy that LSM has so often been shown to improve student success. A question that remains to be answered is how it works. There are several possible explanations, discussed below.

Social Constructivism. The philosophical underpinnings of peer-assisted learning are frequently discussed in terms of Vygotskian social-constructivism (Vygotsky, 1978), in which the peer leader (who is a slightly older, more experienced peer) is seen as the *more knowledgeable other* who can reach the student within his or her own *zone of proximal development*. As Topping (2001) states,

> PAL should help to reduce dependency upon the teacher, not least through the proximal and credible modeling of coping by the peer helper (likely to be seen as more attainable than the "expert" performance of the teacher). While teachers always seek to develop strategic metacognitive learning skills, actual practice of these might be more likely within the interaction between peer helper and learner, which should involve personalized cognitive challenge and reflection by both partners, and help develop self-regulation and greater student ownership of the learning process in both (p. 27).

In their observational study of SI in calculus and college algebra, Burmeister et al. (1994) noted that "the peer relationship between the students and the SI leader makes it comfortable for students to take risks" (p. 58). They note the informal, collegial, and often humorous tone of the SI sessions, concluding that "this atmosphere breaks through barriers to risk-taking and to learning" (p. 58). Fayowski and MacMillan (2008) also credit the social context for the success of an SI program in first year calculus, noting that “by attending SI sessions, students are being supported using innovative techniques that emphasize process-related learning through scaffolding, dialogue and breaking down of material into parts to promote learning in a socio-cultural context” (p.852). Congos and Schoeps (1998) assert that “SI empowers students to abandon the “learned helplessness” approach to academics where students perceive grades as an outcome of luck or personality matches with instructors” (p. 52).

Overcoming fear and anxiety. The social-constructivist framework could help explain how LSM helps first-year undergraduate students overcome fear and anxiety, develop self-confidence, and become integrated into campus communities. As van der Meer and Scott (2009) conclude from their survey of students’ experiences and perceptions of peer-supported study sessions (PASS, the Australian equivalent of PAL),

> The format of PASS programs, a relaxed atmosphere with peers, contributes to an environment where students can connect with other students and develop friendships or study groups. Consequently PASS can play an important role in both students’ integration into university life and overall satisfaction with their first-year experience (p.4).

One part of helping students integrate into college life is to help them overcome their fears and anxieties. Longfellow, May, Burke, and Marks-Maran (2008) conducted a two-year pilot study of a newly implemented PAL program for undergraduate English composition courses. Survey responses from students who participated in PAL sessions indicated that two of the main reasons why they found PAL to be beneficial were because they reduced feelings of intimidation and because students felt safe in the small group environment. Reflecting on the survey responses, the authors note,

> Students reported that their engagement in PAL sessions is different from lectures because they are not afraid to ask questions in PAL sessions and do not feel intimidated by the presence of the lecturer. The perceived authority of lecturers, and their power to assess and fail, can be seen by students as threatening. In traditional university learning environments, students can be reluctant to reveal their ignorance and may not seek clarification or help (Longfellow et al., 2008, p. 101).

Many other studies that were focused primarily on measuring performance outcomes also speculate on the possibility that working with a peer is less intimidating than asking questions in a lecture setting or going to a professor's office hours for help. For example, Topping asserts (2001) that "students might have lowered anxiety in the peer-assisted learning situation, with correspondingly higher self-disclosure of misconception, error, and gaps in knowledge" (p. 26).

Development of Problem-Solving Skills. Another factor that may help explain the success of PAL programs is the focus on helping students develop a wider range of problem-solving strategies. SI in particular emphasizes the development of appropriate study skills, including self-monitoring and self-regulation (Topping, 2001). Burmeister et al. (1994) observed SI sessions in college algebra and calculus, and noted that SI leaders modeled active learning strategies such as asking probing questions, using notecards, diagramming problems, and predicting what sorts of questions would appear on an upcoming exam.

Focus on Assessment. On the other hand, some scholars have proposed that tutors are helping students learn to focus on navigating the specifics of assessment, so that they can do well on the tests without engaging in true deep learning. Anastasakis, Robinson, and Lerman (2017) surveyed 201 second-year engineering students at Loughborough University in order to determine what tools they used to succeed in mathematics. In a follow-up series of interviews, they sought to understand why students use certain tools. They found that the primary motivation for choice of tools was based on students' exam-related goals. In other words, they chose tools that they thought would help them do well on exams and get a high grade in the course. In this sample of students, the Maths Learning Centre (MLC) was used at a lower rate than any tool other than social media. Online videos, online encyclopedias, and even instant messaging were used more than the MLC. However, it is important to note that the MLC at Loughborough is staffed by graduate students and lecturers, not by peer-tutors. One of the resources that was ranked in the top five was "other students," right behind online videos.

Ashwin's (2003) mixed-methods study of a "Peer Support" program, based on the principles of SI, in chemistry and mathematics courses at a British university also found that students' exam-related goals took precedence over deeper learning strategies. He found that students' final exam grades correlated positively with the number of Peer Support sessions they had attended. But he also found, through the use of questionnaires and interviews that the quality of learning fell for the students who participated in Peer Support.

> Qualitative evidence suggests that this change in approach was in response to an increased awareness of the assessment demands of the course and that these students had become more strategically orientated in their approach to studying as a result of their attendance at Peer Support sessions (p. 159).

Time on task. Another possible explanation for the success of LSM is that it works by giving the students more time on task. Kenney and Kallison (1994) raised the possibility that students who participate in SI are simply getting more exposure time to course content, implying that improved outcomes are due to nothing more than the fact that they are spending more time engaging with the material. However, working with a peer-tutor may also help students recognize that time-on-task is an important component to academic success. As Burmeister et al. (1994) state,

> One of the crucial ideas that an SI leader communicates to students coming to SI is the amount of quality study time required to do well in a mathematics course. This information is invaluable to freshman students because it comes from a peer, the SI leader. Students often do not appreciate the amount of time needed and the importance of daily work for success in a mathematics course (p. 58).

None of these theoretical frameworks are entirely independent of one another. Just as math anxiety, motivation, self-efficacy, and perceived usefulness all interact with one another to influence student performance, peer-assisted learning programs may effect students for many different reasons.

In summary, this study will seek to measure changes in affective factors including math anxiety, self-efficacy, motivation, and perceived usefulness following a six-week PAL intervention. This study will also measure whether participation in a PAL program reduces avoidance and increases help-seeking behavior as measured by student usage of drop-in, center-based support. If it can be shown that PAL is an effective intervention for math anxiety, self-efficacy, or negative attitudes and perceptions of math, it will provide further support for the importance of this type of LSM as part of a holistic approach to undergraduate mathematics education.

Chapter 3: Methods

The purpose of this study was to examine the effects of a six-week Peer-Assisted Learning (PAL) program on first-year undergraduates' math anxiety, performance, attitudes and perceptions toward college math, with a particular focus on highly math-anxious (HMA) students. A secondary question examined whether participation in a PAL program increased students' help-seeking behaviors.

An explanatory mixed-methods sequential design (Creswell, 2014) was employed, in order to explore the research questions first quantitatively and then qualitatively. In the first phase of the study, quantitative data from a purposeful sample of first-year undergraduates was collected to examine how participation in a PAL program affected students' performance, math anxiety, perceptions, attitudes, and help-seeking behaviors toward mathematics. In the second phase of the study, qualitative data was acquired through intensive interviews with a sample of those students whose survey responses identified themselves as HMA. Interviews were conducted and interpreted using a grounded theory approach, in which students could tell their stories and share their experiences, providing context and meaning for the process that led to the relationships described in the quantitative portion of the study.

Participants

Undergraduate students enrolled in two targeted math courses at a small regional university volunteered to participate in the study. Students under age 18 were excluded from the study as they had not reached the legal age of consent. Prior to their participation, all volunteers signed an informed consent and all experimental procedures were approved by the university's Institutional Review Board.

Target Courses. Targeted courses were college-level math courses populated predominantly by first-year students in their second semester of college and met four criteria. First, at least two sections of the same course were taught by the same instructor. Second, the class pairs had to follow the same course schedule (i.e. MWF or TTh). Third, the course had to be predominantly populated by first year students not majoring in mathematics or mathematics education and finally, the instructor teaching the course agreed to participate in the study. Two courses, College Algebra (N=3) and Finite Mathematics (N=4) met the criteria resulting in seven class sections participating in the study. Two instructors each taught two sections of Finite Math, and a third instructor taught all three sections of College Algebra. Of the qualified class sections, all seven met three times per week, on a MWF schedule. Three sections (Finite Math with faculty A, Finite Math with faculty B, and College Algebra with faculty C) were assigned to the PAL Treatment Group and the remaining four sections were assigned to the Control Group. The labeling for subsequent results and discussion is shown in Table 1.

Table 1

Labeling Conventions Used to Denote the Seven Classes Participating in the Study

Assigned Code	Class
FM-A-T	Finite Math, Teacher A, Treatment
FM-A-C	Finite Math, Teacher A, Control
FM-B-T	Finite Math, Teacher B, Treatment
FM-B-C	Finite Math, Teacher B, Control
CA-C-T	College Algebra, Teacher C, Treatment
CA-C-C1	College Algebra, Teacher C, Control group 1
CA-C-C2	College Algebra, Teacher C, Control group 2

Phase 1: Quantitative

Instrumentation. Four survey instruments were used to measure students' a) math anxiety, b) math attitudes and perceptions, c) perceived value of math, and d) self-efficacy. Each of the instruments is described in more detail below.

Math Anxiety. To measure math anxiety, the 30-question Mathematics Anxiety Rating Scale-Brief (MARS30-Brief) was used (Suinn & Winston, 2003). This is a 30-item survey that students respond to on a 5-point Likert-type scale ranging from 1 (low anxiety) to 5 (high anxiety). Items include "thinking about an upcoming math test one day before," and "figuring out your monthly budget." Adding the responses for each question provides a summary score that can range from 30 to 150. Suinn (2003) found a score of 84 or above as indicative of HMA. Internal consistency of the MARS30-Brief is excellent (Cronbach alpha = .96) as is test-retest reliability (alpha = 0.90) (Suinn & Winston, 2003). The MARS30-Brief is adapted from the original Math Anxiety Ratings Scale (Richardson & Suinn, 1972), and a recent factor analysis (Pletzer et al., 2016) demonstrated that the revised version maintains the overall factor structure of the original longer version. The MARS30-Brief was an appropriate survey instrument for this study because it retains the more complex factor structure of the original MARS survey.

Attitudes and Perceptions. The Math Attitudes and Perceptions Survey (MAPS) (Code, Merchant, Maciejewski, Thomas, & Lo, 2016) is a 31-question survey intended to measure students' views and perceptions of mathematics as compared to the ways in which experts approach and view mathematics. Students answered the questions using a 5-point Likert format ranging from 1 (strongly agree) to 5 (strongly disagree). One intended research use for this survey is to monitor how students' beliefs and perceptions of mathematics change over time. Analysis of the survey responses required assigning a score to each response depending on whether or not it aligned in the same direction as the previously determined "expert response" found through interviews with professional mathematicians. Averaging all responses gave an "expertise index" for each student. The MAPS survey consists of seven factors: confidence, problem solving, growth mindset, interest, real world application, sense making, and the nature of answers to mathematical problems. Cronbach's alpha for the whole instrument was .87, though for the sub-factors, alpha values were lower, ranging from .55 to .70. The study authors suggest this is due to the small number of questions in each of the categories. Some representative questions include "math ability is something about a person that cannot be changed very much (growth mindset)," and "reasoning skills used to understand math can be helpful to me in my everyday life (real world application)."

Perceived Value. The 10-item Math Value Scale created by Hendy et al. (2014) was used to measure students' beliefs about the value of college math courses. Questions were answered on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Example questions include "I can get a good grade in math even if I skip classes," and "getting a bad grade in math will not seriously affect my future employment possibilities." Overall scores are calculated as the sum of responses and can range from 10 to 50. Internal reliability is good (alpha = .85) and test-retest reliability alpha is .76.

Self-Efficacy. The Mathematics Self-Efficacy Scale-Revised (MSES-R) (Pajares & Miller, 1994) was used to measure students' perceived self-efficacy as it relates to mathematics. Specifically, two sub-scales of the MSES-R were used: the Courses subscale, consisting of 10 questions used to measure confidence to succeed in math-related courses, and the Tasks subscale, consisting of 18 questions used to measure confidence to perform math-related tasks. Both subscales have questions that are answered on a 5-point Likert-type scale. Internal consistency is high (alpha = .91 for Tasks and .96 for Courses). An example of a Tasks question is, "how confident are you that you could add two large numbers (eg. 3451 and 70298) in your head?" An example of a Courses problem is, "how confident are you that you could complete a College Algebra course with a final grade of A or B?" The list of courses in the Courses subscale was modified to name courses currently offered at the institution where the study was conducted.

Procedure

At the beginning of the 2018 spring semester, target courses were visited by the researcher during regular class meeting times and students were provided with an informed consent form, informed verbally of the basic nature of the study, and asked to participate. Students who consented to participate signed their informed consent form and returned it to the researcher, at which point they were given a packet consisting of a demographic questionnaire and the four pen-and-paper surveys designed to measure math anxiety, attitudes and perceptions, self-efficacy, and perceived usefulness (see Appendix A). When students completed the packet, they returned it to the researcher. Non-consenting students remained in the classroom and read quietly or worked on homework problems. After the packets were collected, classes resumed normal operations. A total of 116 students in seven math classes gave written informed consent to participate in the study and completed the first survey.

Beginning the following class period, all classes engaged in regular curricular activities with the exception of type of access to peer tutoring for the subsequent six-week period. Each of the three classes in the PAL-treatment group was introduced to their assigned peer-leader, who began attending all class meetings, had access to all course materials, and ran an optional evening review session once a week for the duration of the six-week intervention. Late afternoon review sessions were run as informal study sessions with the PAL-leader facilitating group discussion and problem-solving activities. During the intervention period, the PAL-leader also held weekly meetings with the course instructor and engaged in additional face-to-face and online communication with the instructor as needed.

While only the students in the PAL-treatment group were invited to participate in the evening review sessions facilitated by the peer-leader, all students in all courses involved in the study had unlimited access to free drop-in peer-tutoring services at the university's Math Activities Center throughout the semester.

At the end of the 6 weeks, all students regardless of group were resurveyed using the same pen-and-paper surveys as were given at the beginning of the study, with the exception of the demographic questionnaire. Seventy-nine students completed the second set of surveys. In addition, instructors provided students' exam and homework grades for the first six weeks of the course.

PAL-Leaders.

PAL-leaders (N=3) were recruited from students currently employed as tutors at the university's drop-in peer-tutoring Mathematics Activities Center. Tutors who were selected to participate as peer-leaders were reliable employees who had demonstrated a professional approach to the position and were consistently welcoming, friendly and patient with tutees. Additionally, they had to be able to commit to the time-intensive six-week study, which would add approximately five hours per week to their busy schedules. A list of tutors who matched the criteria was generated, and three tutors who were asked to participate agreed to do so. Peer-leaders were paid an hourly rate for their participation.

PAL-Leader training.

The four-hour PAL-Leader training took place in two two-hour blocks on the Tuesday and Thursday night immediately preceding the start of the PAL intervention. The agenda and training materials are included in Appendix B. Training was based on the *Guide for Peer-Assisted Learning (PAL) Facilitators* developed at the University of Minnesota (Lilly & Arendale, 2016). PAL-leaders were given a brief history and background of Supplemental Instruction and Peer-Assisted Learning, emphasizing that these types of programs were developed to target high-risk courses rather than high-risk students. They were also given resources for understanding the signs and symptoms of math anxiety, along with suggested coping strategies.

Phase 2 Procedures

Phase 2 utilized qualitative research methods to investigate the underlying causes of the observed quantitative results. A series of intensive interviews with students were conducted and processed according to grounded theory methods (Charmaz, 2006; Strauss & Corbin, 1998). Grounded theory is an inductive methodology that allows the researcher to reflect on data and develop conceptual ideas and frameworks that lead to a progressively deeper and richer understanding of the research topic (Charmaz, 2006; Strauss & Corbin, 1998). Intensive interviewing "typically means a gently guided, one-sided conversation that explores research participants' perspective on their personal experience with the research topic" (Charmaz, 2014, p. 56).

Because the study's research questions included a focus on HMA students, interviewees were selected from the HMA students in the sample. Identification of HMA students was done by taking the sum of the MARS-30 survey score results from the first surveys and selecting the students whose scores were in the top 20% of the sample. The cutoff value was a score of 88. This value was slightly higher than found by Suinn (2003) where the 80th percentile corresponded to a score of 84. Twenty-four students (20% of the total sample of 116 students) were identified as HMA using this method. Four of the 24 students did not complete the second survey that was administered in the sixth week of class. The HMA sample was therefore composed of the 20 students who had Math Anxiety Ratings Scores of 88 or above, and had completed the first and second surveys in class.

At the end of week six, personalized emails were sent to all 20 HMA students requesting an interview. Intensive interviews began in the eighth week of the semester and continued for three weeks. In all, 10 intensive interviews were conducted.

Intensive interviews were guided by the questions listed in Appendix C. Intensive interviewing is a process that is designed to be more flexible than a structured interview. As Charmaz (2014) points out,

In short, intensive interviewing is a flexible, emergent technique that:

- Combines flexibility and control
- Opens interactional space for ideas and issues to arise
- Allows possibilities for immediate follow-up on these ideas and issues
- Results from interviewers and interview participants' co-construction of the interview conversation (p. 58-59).

Therefore, the questions in the Student Interview Guide (Appendix C) provided a framework for the interviews, but were not followed verbatim in each individual case. Students were given freedom to describe and reflect on their own thoughts and experiences as much as possible.

Each interview was transcribed and coded within a week after the interview was conducted. The first eight intensive interviews were coded by hand line-by-line, with key passages highlighted, and codes written in the margins. Memos were hand-written and attached to each interview as they arose. After all 10 intensive interviews had been transcribed and coded, a second round of follow-up interviews was conducted in a semi-structured format, in order to develop a deeper understanding of the connections that arose during the process of coding and reflecting on the content of the initial interviews. Six of the students who participated in intensive interviewing were re-interviewed in this second follow-up round. An additional four students were interviewed in order to further verify the findings from the intensive interviews.

Data Analysis

Phase 1: Quantitative

Quantitative data analysis techniques, including descriptive statistics, t-tests, and linear regression were used to analyze the effect of the PAL program on math anxiety, attitudes, performance, and help-seeking behavior. Descriptive statistics were used to compare demographics of the PAL-treatment and control groups to establish that underlying differences between the two groups were minor and insignificant. Once baseline similarities between the groups were established, t-tests and linear regressions were performed to address the first three research questions.

Phase 2: Qualitative

A classic grounded theory approach was used for analysis of the Phase 2 data. Ten intensive interviews were transcribed and carefully reviewed line by line. Open coding (Strauss & Corbin, 1998) was used to identify distinct, separate words and phrases representing the interviewee’s thoughts, ideas, and experiences. At this point in the grounded theory process, categories and themes began to emerge from the open coding of the transcripts. Next, axial coding (Strauss & Corbin, 1998) was used to begin to form connections and relationships between the categories and themes that developed. The grounded theory approach of constant comparison involves simultaneous collection and analysis of data. As Glasser & Strauss (1999) explain, “By comparing where the facts are similar or different, we can generate properties of categories that increase the categories’ generality and explanatory power” (p. 24).

Coding each interview as soon as possible after it was conducted allows the researcher to conduct further interviews with sensitivity to listening and observing how interviewees were contributing to a greater understanding of the emerging categories and themes that might help address the study's fourth research question: How do HMA students perceive the influence of a PAL program on their experience of math anxiety and willingness to seek extra help?

Constant comparison.

Follow-up interviews were also transcribed and coded in two phases (open and axial), allowing for *constant comparison* (Patton, 2014). Constant comparison "refers to constantly comparing each new element of the data with all previous elements that have been coded in order to establish and refine categories (Patton, 2014, p. 169).

Qualitative data analysis software, AtlasTI, was used to assist with the coding process after the first eight intensive interviews had been coded by hand.

Chapter 4: Results

This mixed-method study was carried out in two phases in order to examine the effects of a six-week Peer-Assisted Learning (PAL) program on first-year undergraduates' math anxiety, help-seeking behaviors, performance, attitudes and perceptions toward college math. Phase 1, the quantitative phase, used survey data, course grades, and tutoring records to address the research goals. Phase 2, the qualitative phase, used grounded theory to conduct and analyze a series of interviews with highly math-anxious (HMA) students. The goal of Phase 2 was to gain a fuller understanding of the results obtained in Phase 1, particularly in terms of the research question, "how do HMA students perceive the influence of a PAL program on their experience of math anxiety and willingness to seek extra help?

Phase 1: Quantitative

Phase 1, the quantitative phase of the study, examined the influence of a peer-assisted learning (PAL) program on the math anxiety, help-seeking behaviors, attitudes and performance of undergraduate students who are highly math-anxious. Specifically, it addressed the following research questions:

1. Does participation in a PAL program measurably lower math anxiety for HMA students?
2. Does participation in a PAL program increase help-seeking behaviors, as measured by increased usage of drop-in peer-tutoring?
3. Does participation in a PAL program affect student performance in general, and HMA student performance specifically, as measured by exam and course grades?

4. How do HMA students perceive the influence of a PAL program on their experience of math anxiety, and willingness to seek extra help?
5. Does participation in a PAL program influence student attitudes and perceptions toward math, particularly those identified as HMA?

Participants.

A total of 116 students in seven math classes gave written informed consent to participate in the study and completed the pre-intervention survey during the regularly scheduled class time. Seventy-nine students completed the post-intervention survey, representing a 32% drop in participants from the first to the sixth week of class. The summary of participant numbers by class for pre- and post-intervention is shown in Table 2. Three classes were assigned to the PAL-treatment and the other four were not (control).

Table 2

Number of Students Completing Pre- and Post-Intervention Surveys in Each Participating Class

Class	first survey	second survey
FM-A-T	19	11
FM-A-C	11	6
FM-B-C	18	15
FM-B-T	15	8
CA-C-T	14	12
CA-C-C1	19	14
CA-C-C2	20	13
Total	***116***	***79***

Note. FM=Finite Math, CA=College Algebra.
Teachers were designated A, B, or C.
Treatment classes were assigned a PAL-Leader and Control classes were not.

Demographics.

Table 3 summarizes the demographic characteristics of the 79 students in the final sample. Because the population of interest for Phase 2 of the study was highly math-anxious (HMA) students, the number of HMA students in each subgroup is also included in the table. Reported gender was 59 male, 20 female. Sixty-eight identified as white, 11 as non-white. Twenty-five major courses of studies were represented in the sample. Nine students had not declared a major. Sixty-one of the participants (77%) were first-year students.

Table 3

Demographics of the Study Sample

	PAL-Treatment (*N*=31)		Control (*N*=48)	
	HMA (*N*=7)	Non-HMA (*N*=24)	HMA (*N*=12)	Non-HMA (*N*=36)
Gender				
Male	5	20	8	26
Female	2	4	4	10
Year in school				
Freshman	6	22	10	23
Sophomore	1	0	2	5
Junior	0	1	0	7
Senior	0	1	0	1
Course				
Finite Math	6	13	5	16
College Algebra	1	11	7	20

Effect of PAL on math anxiety.

Students' change in math anxiety was calculated as the difference between the MARS-30 score on their first and second surveys. A positive value indicates an increase in anxiety and a negative value indicates a decrease. A two-sided T-test showed no significant difference between the treatment and control groups ($t(62) = 0.28$, $p = .780$). Figure 1 illustrates that there was little difference between the two groups, and also shows that average change in math anxiety was close to zero for both groups (control, $M = 0.8$, $SD = 13.0$; treatment, $M = 0.0$, $SD = 12.9$).

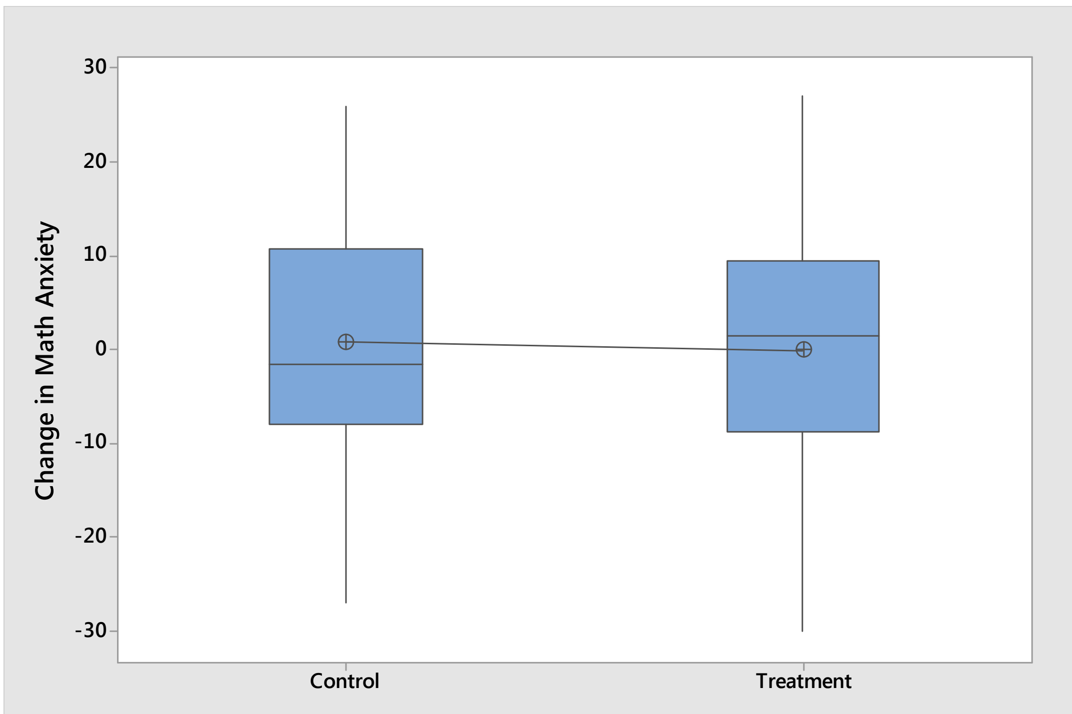

Figure 1. Comparison of the change in math anxiety from pre- to post-intervention for control and PAL-treatment groups.

Comparing the subgroup of HMA students (figure 2), there was no significant difference between treatment and control in terms of their change in math anxiety (control, $M = -8.5$, $SD = 11.13$; treatment, $M = -5.5$, $SD = 17.32$; $t(8) = -0.79$, $p =$

.453). HMA students in both the treatment and control groups showed a decrease in math anxiety from week one to week six. A closer inspection of the difference between HMA students and their non-HMA counterparts revealed that the decrease in anxiety for HMA students was significantly greater than that of non-HMA students.

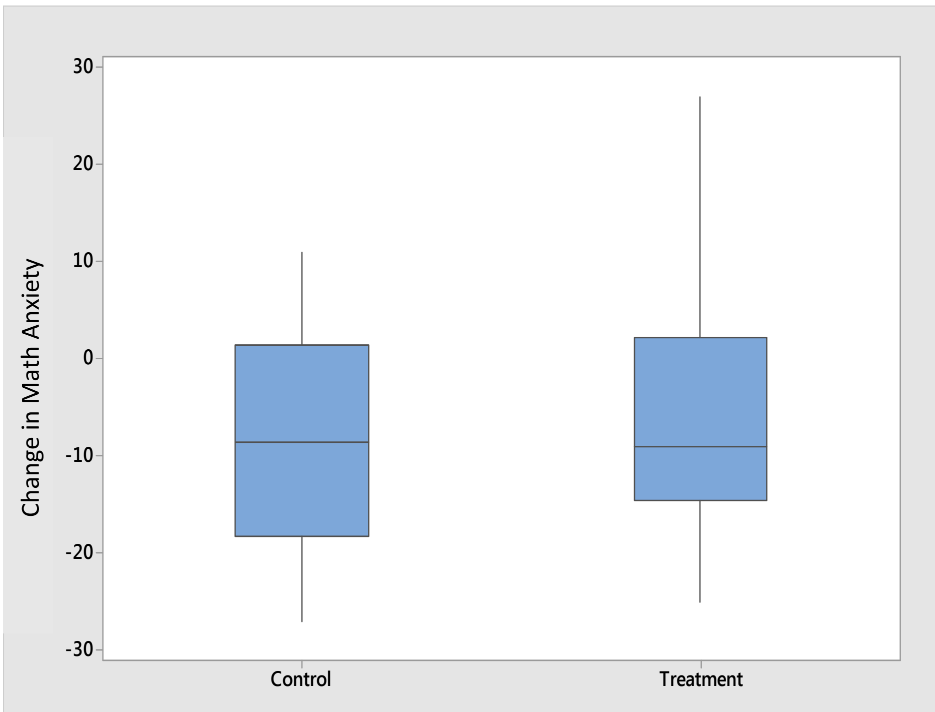

Figure 2. Comparison of the change in math anxiety between control and PAL-treatment groups from pre- to post-intervention for HMA students.

Regardless of treatment group, HMA students had a significantly greater reduction in math anxiety (M = -7.5, SD = 13.1), than their non-HMA counterparts (M = 2.9, SD = 11.9; $t(26)$ = 3.02, p = .006). Figure 3 shows the difference in the change in math anxiety between these two groups.

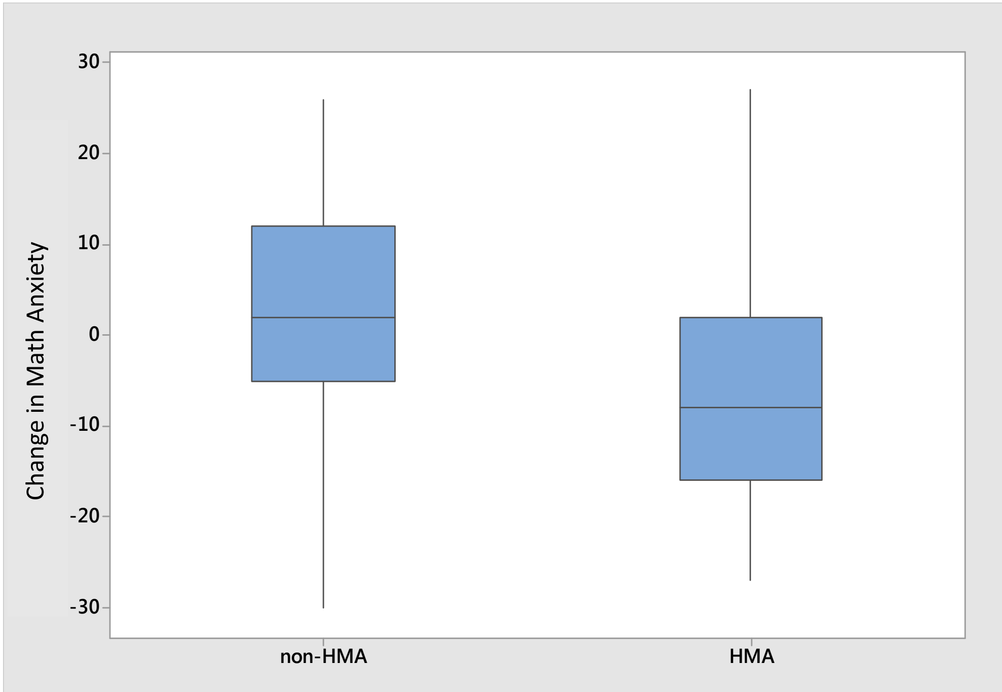

Figure 3. Comparison of the change in math anxiety from pre- to post-intervention for HMA and non-HMA students.

Effect of PAL on help-seeking.

Help-seeking was measured by the number of times students used learning support in mathematics (LSM) provided by the university in the form of drop-in tutoring or optional review sessions run by the PAL-leaders. Overall, students had a low rate of usage of either form of LSM, with a majority of students using neither. Twenty-three of the 79 students regardless of group assignment (29%) used LSM during the first six weeks of class. Eleven out of 31 students in the treatment group (35.5%) used LSM at least once. In the control group, 12 of the 48 students (25%)

used LSM at least once. Table 4 summarizes the data regarding HMA and help-seeking in treatment versus control groups.

Table 4

Comparison of the Use of LSM between PAL-Treatment and Control for HMA and Non-HMA Students

	PAL-Treatment (*N*=31)		Control (*N*=48)	
	HMA (*N*=7)	Non-HMA (*N*=24)	HMA (*N*=12)	Non-HMA (*N*=36)
Help	4	7	5	7
No Help	3	17	7	29

Figure 4, comparing the PAL-treatment and control groups' use of LSM, reinforces the observation that most students, regardless of group, did not seek help from LSM at all, and almost half of those who did use LSM only used it once during the first six weeks of class. Thirteen students used LSM two or more times.

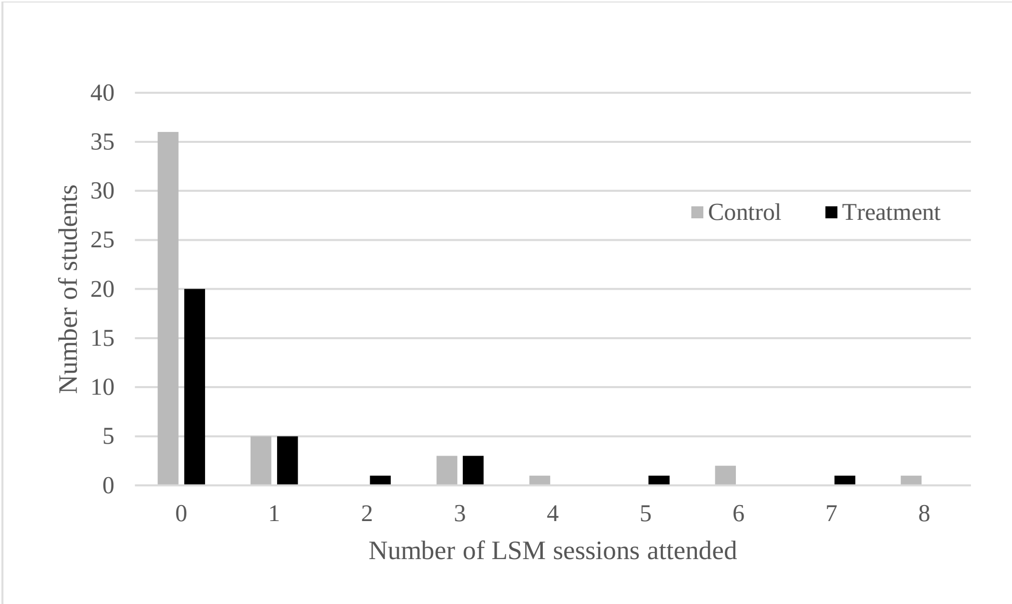

Figure 4. Histogram comparing the frequency distribution for the use of LSM for the PAL-treatment and control groups.

Effect of PAL on performance.

Students' six-week grades were used to measure their performance at the end of the PAL treatment. Final semester grades were also collected and analyzed to determine if there were any longer-term treatment effects. Figure 5 shows side-by-side box plots comparing the six-week grades of the control and PAL-treatment groups. A two-sided T-test showed no significant difference between the control (M = 74.3, SD = 17.2) and PAL-treatment (M = 79.2, SD = 14.4) groups; $t(69) = -1.37$, p = .174. The small sample size limits the ability to control for teacher or course. It is, however, noteworthy that only one of the students in the PAL-treatment group (1/31 = 3.2%) had a failing grade at 6 weeks, whereas 8 of the students in the control group (8/48=16.7%) were failing at the 6 week mark.

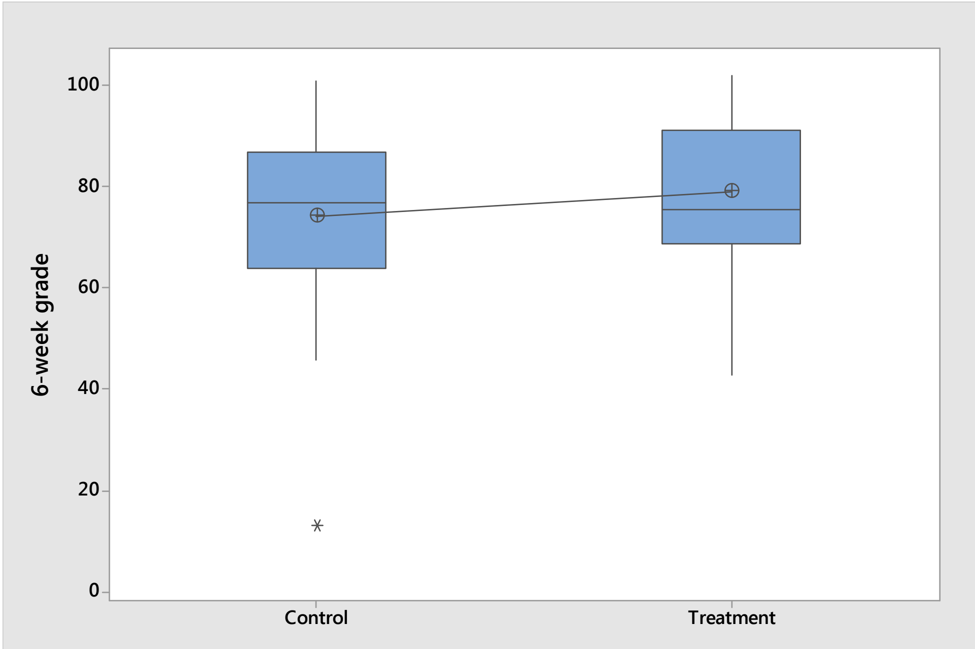

Figure 5. Boxplot comparing six-week grades for students in PAL-treatment and control groups.

Figure 6 illustrates the difference in six-week grades for the HMA students in the sample. Two HMA students in the control group had failing six-week grades, and no HMA students in the PAL-treatment group were failing at the six-week mark. Due to the small sample sizes in both groups, the difference between the two means is not statistically significant; $t(16) = -1.25$, $p = .228$.

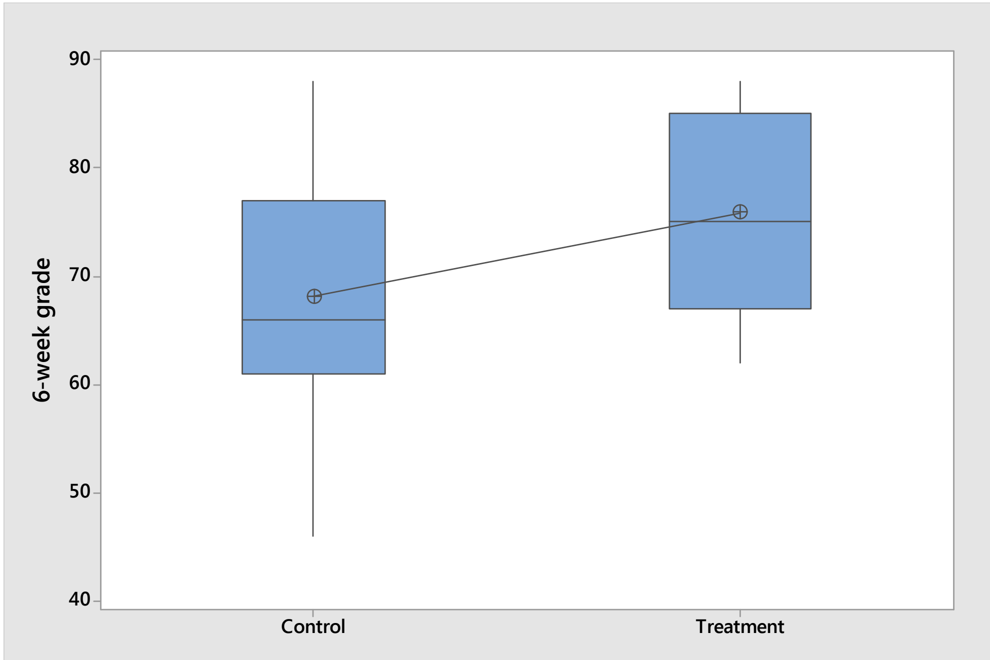

Figure 6. Comparison of the six-week grades of HMA control (*N*=12) versus HMA PAL-treatment (*N*=7) groups.

After six weeks, 58 of the original 116 students (50%) in the study were passing the course with a C- (70%) or better. At the conclusion of the semester, 57 of the original 116 students (49%) in the study passed their course with a grade of C- or better. Of the 79 who completed the second survey, 46 passed (58%) with a C- or better. Pass rates were lower in College Algebra than in Finite Math. Table 5 shows the percentages of students who completed the second survey in Finite Math and College Algebra who were passing with a C- or better after 6 weeks and at the end of the semester. There were no significant differences in pass rates for control versus PAL-treatment at 6 weeks or at the end of the semester.

Table 5

Comparison of Pass Rates (C- or higher) of Study Participants in Finite Math and College Algebra.

	Six-week pass rate	Semester pass rate
Finite Math	68%	73%
College Algebra	56%	44%

Effect of PAL on attitudes and perceptions.

In addition to measuring math anxiety, survey data was collected regarding students' attitudes and perceptions about math, their math self-efficacy, and their perceived value of the subject. The quantitative results of these surveys were intended to partially address the study's fourth research question, "How do HMA students perceive the influence of a PAL program on their attitudes and perceptions toward math, their experience of math anxiety and willingness to seek extra help?"

Math Attitudes and Perceptions.

The Math Attitudes and Perceptions Survey (MAPS, Code et. al., 2016) contains a "filter question" intended to verify that respondents have the questions carefully. More than 10% of the students in this study answered the filter question incorrectly. These individuals' responses to the MAPS survey were therefore removed from the sample, leaving N = 67 (HMA = 16, non-HMA = 51).

Analysis of the survey responses required assigning a score to each response depending on whether or not it aligned in the same direction as the previously determined "expert response" found through interviews with professional mathematicians. Averaging all responses gave an “expertise index” for each student, ranging from 0.00 to 0.79. There was no significant change in the expertise index scores for the entire study group from week 1 (M = 0.384, SD = 0.179) to week 6 (M = 0.375, SD = 0.185; $t(131) = 0.29$, p = .774). Mean differences between groups were also not significant in week 1 or week 6, as seen in Table 6. Expertise indices were not correlated with math anxiety scores at either week 1 ($r(65) = 0.039$, p = .757) or week 6 ($r(65) = -0.054$, p = .667).

Table 6

Mean Expertise Index Scores for Study Subgroups Pre- and Post-Intervention

	PAL- treatment		Control	
	HMA	Non-HMA	HMA	Non-HMA
Pre-Intervention	.3155	.3554	.3786	.4171
Post-Intervention	.3929	.3000	.4143	.4067

Note. No differences were significant at $p < .05$.

Self-Efficacy.

The Mathematics Self-Efficacy Scale-Revised (MSES-R) (Pajares & Miller, 1994) Tasks Subscale was used to measure students’ perceived self-efficacy (SE) as it relates to mathematics. Mean SE scores for the sample as a whole were not significantly different between pre-intervention (M = 59.9, SD = 14.2) and post intervention (M = 62.4, SD = 13.7; $t(128) = -1.05$, p = .297).

HMA students were found to have significantly lower SE than non-HMA students, both pre- and post-intervention. Pre-intervention survey results showed math anxiety was strongly negatively correlated with SE ($r(77) = -0.583$, p = .000) for all students (the higher the students' math anxiety, the lower their SE). In the post-intervention surveys, the negative correlation between math anxiety and SE was slightly less strong, though still significant ($r(77) = -0.502$, $p = .000$). Figure 7 shows the relationship between self-efficacy and math anxiety in both the pre- and post-intervention survey responses. There was a small shift downward on the Y-axis (MA) and a shift right on the X-axis (SE). In other words, a drop in math anxiety and increase in self-efficacy among students in the sample weakened the relationship between these two measures over the course of the intervention.

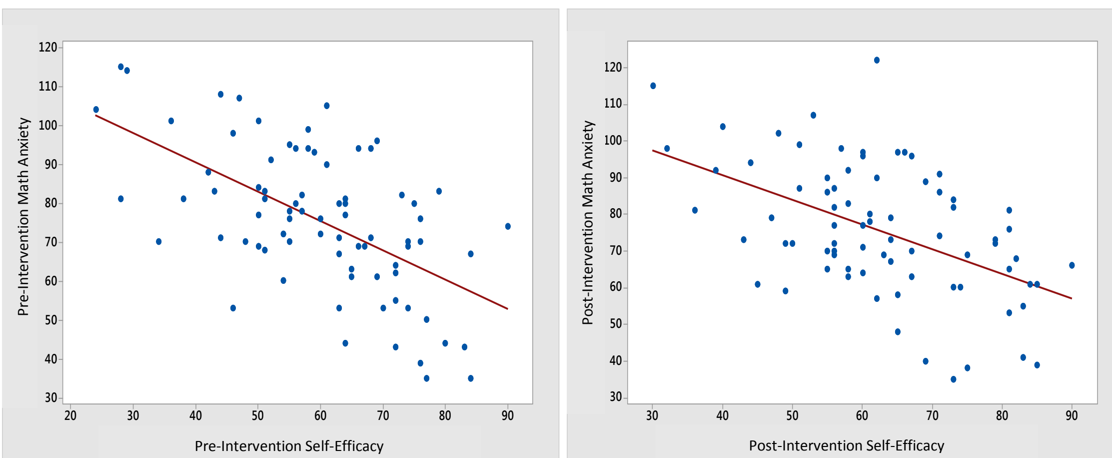

Figure 7. Relationship between self-efficacy and math anxiety, pre-intervention (left) and post-intervention (right).

A regression analysis was used to analyze the relationship between math anxiety and SE pre- and post-intervention. Table 7 shows the results of the analysis.

Table 7

Regression Analysis Comparing Math Anxiety and Self-Efficacy at Pre- and Post-Intervention

	Pre-Intervention	Post-Intervention
Regression equation	MA=120.7-0.7542SE	MA=117.87-0.673SE
S	15.116	15.6385
R-sq	33.99%	24.85%
R-sq(adj)	33.12%	23.85%
F	39.13	24.8
P	0	0.000

HMA students who used help could account, at least in part, for the weakening of this correlation. HMA students who used help showed an increase in self-efficacy and a corresponding decrease in math anxiety over the course of the study. In the first survey, self-efficacy of the HMA students (M = 63.2, SD = 13.2) was significantly lower than for non-HMA students (M = 50.5, SD = 13.7); $t(29)$ = 3.54, p = .001. In the post-treatment survey as well, there was a significant difference in self-efficacy between the HMA students (M = 65.1, SD = 12.4) and non-HMA students (M = 54.8, SD = 13.3); $t(28)$ = 2.98, p = .006) though mean scores had increased in both groups and the gap between HMA and non-HMA had closed slightly. These increases from the pre- to post-survey scores did not reach statistical significance for any of the groups studied (PAL-treatment or control, HMA or non-HMA, help or no help).

However, of the nine HMA students who used help, six had increases in their self-efficacy scores and decreases in their math anxiety scores. Figure 8 shows that just one HMA student reported a decrease in self-efficacy and increase in math anxiety (top left quadrant). The bottom right quadrant of the figure represents the students whose self-efficacy increased and math anxiety decreased from pre-to post-intervention. The majority of students in this quadrant were those who used LSM.

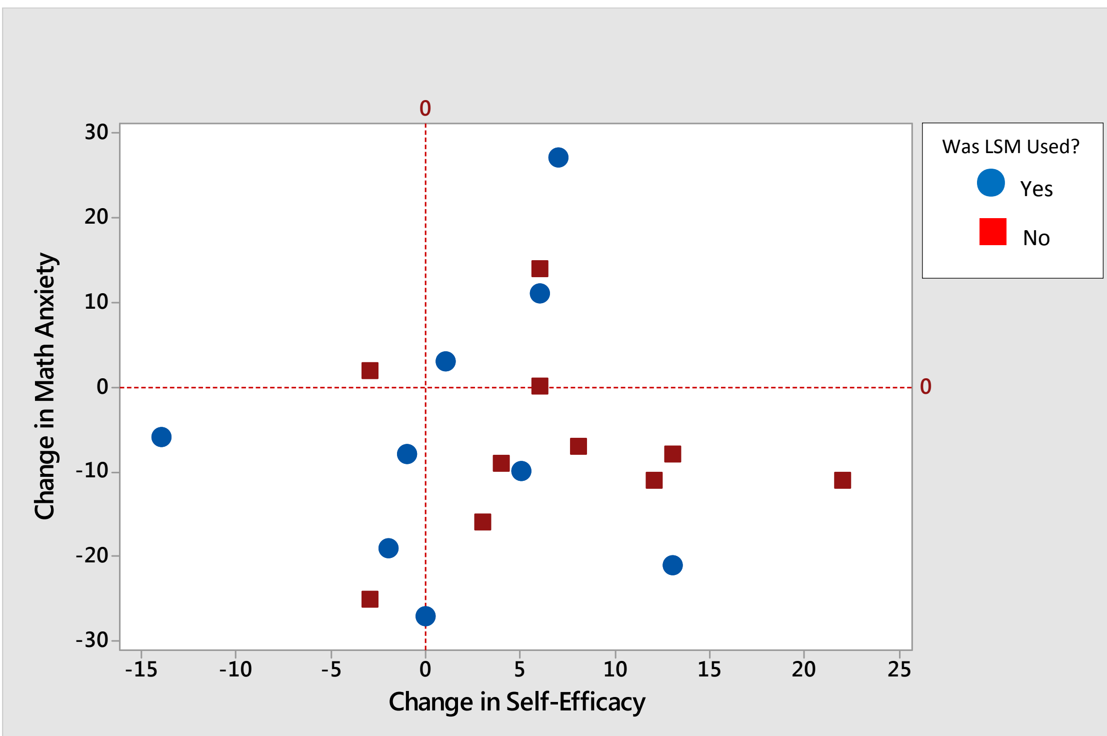

Figure 8. Scatterplot of change in SE and math anxiety for HMA students. The bottom right corner represents the students who improved in both measures (increased SE and decreased MA).

Perceived Value.

Perceived Value (PV) was measured using the 10-item Math Value Scale created by Hendy et al. (2014) to measure students' beliefs about the value of college math courses. There was a significant increase in mean PV scores from the week 1 surveys (M = 20.31, SD = 6.24) to the week 6 surveys (M = 25.01, SD = 7.20); $t(150) = 4.36$, $p = .000$, for the sample as a whole, as seen in Figure 9.

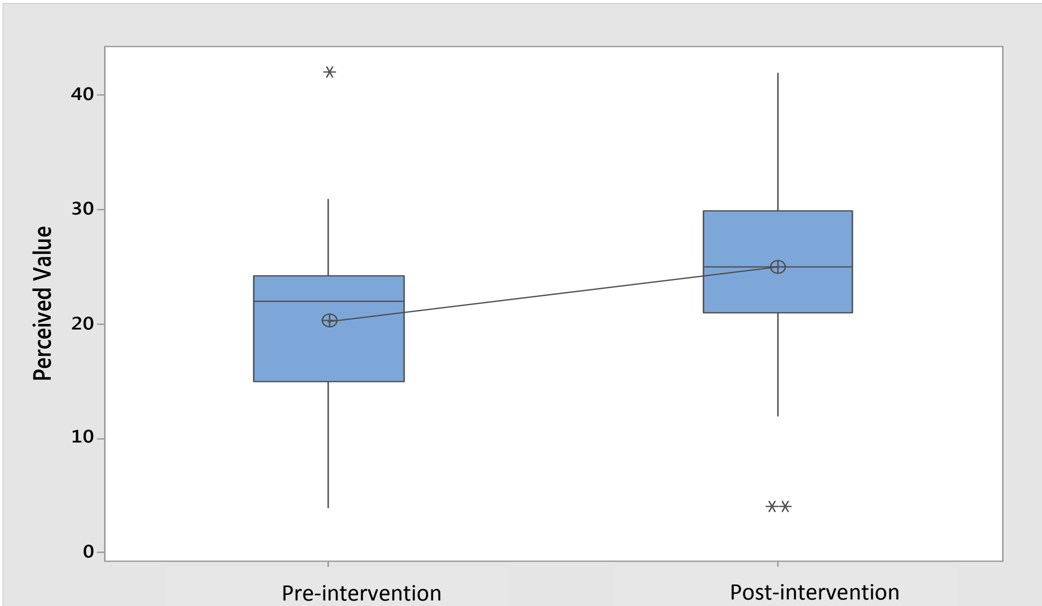

Figure 9: Perceived Value scores for entire sample at pre- and post-intervention.

In the pre-intervention surveys, HMA students had significantly lower PV scores (M = 17.60, SD = 6.63) than the non-HMA students (M = 21.24, SD = 5.88); $t(29) = 2.18$, p = .038. By post-intervention, the gap between these groups had shrunk and was no longer significant (HMA: M = 22.85, SD = 8.06. Non-HMA: M = 25.76, SD = 6.80; $t(28) = 1.45$, p = .159).

A similar trend was observed when comparing students who used LSM. At pre-intervention, their PV scores (M = 17.43, SD = 6.91) were significantly lower than the students who did not use LSM during the intervention period (M = 21.51, SD = 5.58; $t(34) = 2.51$, p = .017). At post-intervention, the PV scores of the students who used

LSM had increased to the point where they were no longer significantly different (M = 22.77, SD = 7.65) from those of the students who did not use LSM (M = 25.89, SD = 6.89); $t(35) = 1.67$, $p = .105$).

Figure 10 shows that Math Anxiety and Perceived Value were negatively correlated both pre- and post-intervention. The strength of the relationship increased in week 6.

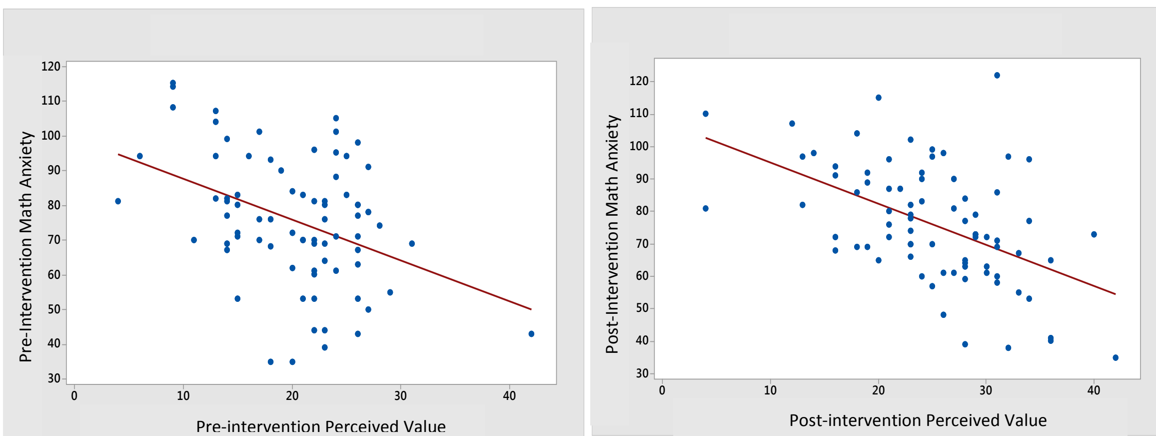

Figure 10. Scatterplots comparing Perceived Value and Math Anxiety pre- and post-intervention.

Regression analysis for pre- and post-intervention demonstrates that the ability of PV to predict math anxiety increased from pre- to post-intervention. The regression equations shown in Table 8 show that the strength of the relationship increased over the treatment period. PV became a better predictor of math anxiety post-intervention.

Table 8

Regression Analysis Comparing Math Anxiety and Perceived Value Pre- and Post-Intervention

	Pre-Intervention	Post-Intervention
regression equation	MA = 99.41 – 1.177PV	MA = 107.97 – 1.271PV
S	17.0717	15.8591
R-sq	15.80%	25.23%
R-sq(adj)	14.69%	24.25%
F	14.26	25.65
P	0.000	0.000

While the correlation between change in PV and change in math anxiety did not reach significance, Figure 11 shows that the HMA students who used LSM had a greater decrease in math anxiety and greater increase in perceived value than the HMA students who did not use LSM. Only one student who used LSM reported an increase in math anxiety and a decrease in PV. As in Figure 8, the bottom right quadrant represents the students who improved in both measures.

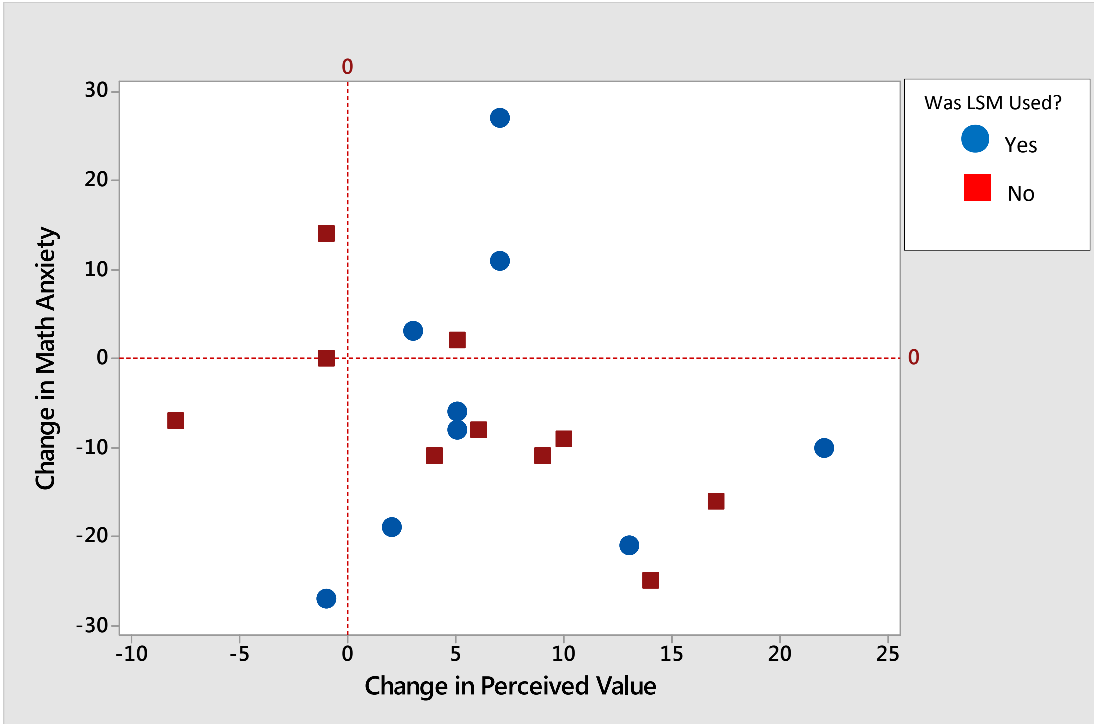

Figure 11. Scatterplot of change in PV and math anxiety for HMA students.

Phase 1 summary

In summary, Phase 1 demonstrated the demographic characteristics of the sample group in terms of age, gender, and race. The major observations were that there was a high attrition rate of students from all courses and there were very small differences between the classes with and without the PAL-leader intervention (PAL-treatment vs. control). Among all students in the sample, both mean self-efficacy and mean perceived value were negatively correlated with math anxiety, and while math anxiety and self-efficacy remained relatively constant over the course of the study, mean perceived value increased significantly. The relationship between math anxiety and self-efficacy weakened from week 1 to week 6, while the relationship between math anxiety and perceived value strengthened for the sample as a whole, regardless of group.

The math anxiety of the HMA students dropped significantly from the first to the sixth week of the study, and part of the drop in anxiety may be explained by use of LSM. While treatment effects were insignificant because of the small sample size, the trend for HMA students who used LSM was for greater drops in math anxiety and greater increases in self-efficacy and perceived value than for HMA students who did not use LSM.

Phase 2: Qualitative

Phase 2, the qualitative phase of the study, used a grounded theory approach to further explore the quantitative findings of Phase 1 as well as to address the study's fourth research question, "How do HMA students perceive the influence of a PAL program on their experience of math anxiety and willingness to seek extra help?" As previously described, only HMA students were included in Phase 2.

Participants.

Highly math-anxious (HMA) individuals were identified by taking the sum of the MARS-30 survey score results from the first surveys and selecting the students whose scores were in the top 20% of the sample. At the end of week six, personalized emails were sent to the 20 students identified as HMA requesting an interview when they returned to campus after spring break (week 8 of the semester). Four students, all enrolled in Finite Math, responded to the initial email request agreeing to be interviewed. Interviews with the four students who agreed to be interviewed were conducted two weeks after the completion of Phase 1. The first four intensive interviews were coded by hand. Memos were hand-written and attached to each interview as they arose. Each interview was transcribed and coded within a week after it took place. By the fourth interview, codes were beginning to repeat frequently and patterns started to emerge. However, all four interviews had been conducted with students in Finite Math. Because no College Algebra students had responded to email requests, the fifth interviewee was recruited in person when he stopped in at the Math Activities Center for extra help. Additional email requests, along with face-to-face requests, yielded five more students for intensive interviews which were conducted from week 9 through week 11 of the semester. In all, 10 intensive interviews were conducted. A transcript of one of the intensive interviews is included in Appendix D. Seven were with Finite Math students and three were with College Algebra students. The first eight interviews were coded by hand, after which all of the coding information was transferred to electronic qualitative data analysis software, AtlasTI. The remainder of the interviews were coded directly in the software. Codes were developed initially by open coding, then more and more frequently by choosing from a list of established codes as the interviews approached theoretical saturation. Some codes were developed "in vivo" by using the interviewees' exact words and phrases (e.g. "I'm bad at math," or "sunny sick."). By the end of week 11, the 10 intensive interviews had yielded over 250 unique codes. Appendix E contains a list of the codes that were developed through this approach to the interview data.

Through coding, constant comparison, and gathering of additional interview data, categories started to form naturally (e.g. priorities greater than math, negative emotions, recognizing the value of extra help) from the codes, and themes began to emerge. Theoretical saturation was reached for some themes rather quickly: for instance, nearly all of the students spoke positively about their instructors, emphasizing that the class was going better than expected because of how helpful and supportive the instructor was.

Some themes needed further development. For example, many students gave advice for success in the class but admitted to not following their own advice. In order to develop a better understanding about why students were not using help even though they recognized that it could improve their grade and lower their stress, a series of short confirmatory interviews with a new set of College Algebra students was conducted. The confirmatory interviews were succeeded by six additional follow up interviews with students who had participated in the initial intensive interviews (5 from Finite Math and 1 from College Algebra).

Table 9 provides a summary of the complete set of interviews, listed by date. Pseudonyms have been assigned to all interviewees to protect their identities while allowing for ease of discussion.

Table 9

Summary of Interviews Conducted for Phase 2 of the Study, by Interview Date

Subject number	**Pseudonym**	**Gender**	**class**	**MARS score (first survey)**	**date**	**type**
108	Ashley	F	FM-A-C	94	27-Mar	Intensive
97	Becca	F	FM-A-T	101	29-Mar	Intensive
150	Carson	M	FM-B-C	93	29-Mar	Intensive
160	Dan	M	FM-B-T	101	29-Mar	Intensive
54	Ethan	M	CA-C-C2	114	3-Apr	Intensive
85	Floyd	M	FM-A-T	108	5-Apr	Intensive
86	Gavin	M	FM-A-T	98	6-Apr	Intensive
133	Hugo	M	FM-B-C	94	6-Apr	Intensive
74	Jim	M	CA-C-C2	99	12-Apr	Intensive
64	Kearney	M	CA-C-C2	91	18-Apr	Intensive
12	Leo	M	CA-C-T	88	4-May	Confirmatory
17	Maura	F	CA-C-T	115	4-May	Confirmatory
50	Natalie	F	CA-C-C1	107	4-May	Confirmatory
75	Pi	M	CA-C-C2	94	4-May	Confirmatory
160	Dan	M	FM-B-T	101	10-May	Follow Up
54	Ethan	M	CA-C-C2	114	11-May	Follow Up
86	Gavin	M	FM-A-T	98	11-May	Follow Up
97	Becca	F	FM-A-T	101	11-May	Follow Up
108	Ashley	F	FM-A-C	94	11-May	Follow Up
150	Carson	M	FM-B-C	93	11-May	Follow Up

I'm so bad at math…

The first major theme that arose from the grounded theory approach to analysis of the interviews was the prevalence of negative emotions toward mathematics. In the intensive interviews, each student was asked to describe their thoughts and feelings about math in general. Nearly all of them described negative emotions they have concerning math. Many quickly proclaimed, as did Jim, "I've always been bad at math!" Students were also quick to share their dislike of the subject, such as when Ethan told me, "Nobody really wants to be in a math class." Others tried to be a bit more tactful, as when Kearney said, "I wouldn't say I hate it, but I certainly don't like it."

Many described bad experiences they had with math in high school or earlier, which seems to have led to their negative emotions and fixed mindset. For example, Hugo recalled enjoying math until high school, but it changed when he had some teachers who "didn't make math fun." He told me,

> I liked math when I was younger, but then I had a couple of teachers that like, you know, like if you had one wrong, they'd be like "don't you know how to do this?" That's like, I feel, when that's you as a student, don't like math anymore, because you're getting like a, like they question your IQ, understand what I mean?

Students described past teachers they had as *uncaring* or *impatient.* Other students described previous math teachers as *drones, zombies,* or *robots,* standing in front of the room and lecturing in ways that made no sense. Gavin summed up the effect that poor teaching can have on student morale and motivation in this way:

> I guess the style of how people teach, that's also big impact on how the kids react to it. Cause I had one teacher in high school, and he would just give you the facts, and that was that, and if you didn't know what was going on, you had to go for extra help, you couldn't stop him in the middle of the course, during class time. And that really, a lot of kids were just mad about that, and so they didn't even want to work for him, and then they'd get lost, they wouldn't really

> know what to do, they wouldn't want to go after with him because they didn't like him as a person at that point, so they just didn't really want to spend any time with him, and that really fell apart.

Ethan described math before college as a series of chaotic scenes in which classroom management and discipline ran amok.

> The big thing in high school was people would run around the classroom, and the teacher would have to yell at them, and then I would get distracted, and I really wouldn't feel that I would be learning as much.

Jim shared a long list of bad experiences in his past, including a story about a teacher he had in high school who would accept cash bribes for good homework grades. His comments in the following excerpt from our interview demonstrate the strong negative emotions associated with math and the fixed mindset he had developed.

> I mean, it's tough, tough class. It probably comes easier to others that *like* math? But, (clears throat) most of the people I sit around struggle, you know, like, (whispers) I hate class, I don't know what the hell I'm doing here, and stuff, you know? (still quiet) and, um, it's not like this math class is going to change your mind, you're gonna love math after this, it's not, it's just not gonna happen.

Many of the students interviewed also commented on how math in college was more difficult than the math classes they had taken in high school. They reported feeling overwhelmed, and feeling rushed to complete material in one semester that may have taken a year in high school. Leo’s observation about math in high school was, “it was like a year long, so it was like more spread out. This is kind of like, five, three or four different things, like, just thrown at you for like the next test."

Negative self-perceptions, combined with negative attitudes toward the subject, were often tied to feelings of helplessness and loss of control. Students spoke of *giving up, falling apart*, or digging themselves into a hole. Maura, a College Algebra student, put it this way:

> I am so bad at math, and like, the second I like know I can't figure out a problem, I just give up. Because I'm like, I can't do it, I can't even like begin to like try to do it, so I'm like, I give up, I can't do it.

Helplessness and loss of control are especially apparent during testing situations. Experiences of panic, blanking out, or *freaking out* on a test were also a common theme, and represent a defining characteristic of math anxiety. As Floyd described it to me, "I kinda like, uh, like blank on math tests. Like, I'll know the stuff, but just cause like, I'm like freaking out a little bit, you just like blank out on it." Ashley describes second-guessing herself in a testing situation:

> If I get a test in front of me and I start doing, like, well and I hit a problem that I don't, like, know the answer to, or don't know how to figure out, that's when I'll just freak out and then I'll second guess everything I just did, I'll like, more often than not go back and change like half the answers on my paper and like I'll usually change them to the wrong answer and they started off right.

During interviews later in the semester, students were aware of the drop in attendance in their classes, but did not know the exact cause of the low attendance. When asked to speculate, they often hypothesized that when students felt like they were probably going to fail, they just gave up and stopped coming to class. Jim and I exchanged the following dialogue on this question.

> Annie: So, would you just like speculate for me about...the people who have stopped showing up for class, and who aren't getting help, and are probably looking at failing, the class, what do you think...is up with that?
>
> Jim: I don't know, I mean (pause)....I understand it? haha, cause they're like, they're in a hole. You know, you know a lot of people once they get in a hole, they're like, (clicking noise) I'm dying here. I'm in the hole and I'm laying in my grave and I'm dying in the hole.

In this group of highly-math anxious students, negative attitudes, emotions, and behaviors were readily apparent. Both external factors (e.g., poor teaching, bad experiences in the classroom) and internal factors (e.g., doubting or second-guessing one's own knowledge and abilities) contributed to the overall sense that math was a subject to be hated and feared.

Math is more fun when you understand it.

In the intensive interviews, I asked each student if his or her attitude toward math had changed this semester, and, surprisingly, most reported an improvement in attitude. The following exchange demonstrates a common theme found throughout the interviews: math is more fun when you understand it.

> Annie: On a scale of 1 to 10, with 1 being I hate it, and 10 being I love it, what was your attitude toward math before you started college algebra?
>
> Ethan: So, 1 to 10, being hate it?
>
> Annie: 1 being I hate it, and 10 being I love it.

Ethan: It was probably about a 2. I absolutely hated math.

Annie: And, what would you say it is, today?

Ethan: I would say, more or less, maybe, 5 to 6, somewhere in there.

Annie: That's a pretty good jump!

Ethan: Yeah. Because, I'm actually understanding it. And it's one of those things that, when you understand it? It almost gives you this excitement and invigoration? That makes you want to push a little bit more and understand more.

Hugo also reported a substantial improvement in his attitude during his finite math course, stating, "I think the math just is more fun now, and I understand it better now than I did before, I just think it's like more fun solving problems when you understand the things you are doing. I think that makes math more fun." Overall, in the ten intensive interviews, seven students reported an improvement in their attitude, two said it was about the same, and only one said her attitude had gotten worse.

Though none of the intensive interview questions were intended to inquire directly about their teachers in the study, more than half of the interviews contained at least one reference to the good teaching they have experienced this semester. Words that students used to describe their current teachers included *nice, engaging, friendly, fun, helpful,* and *understanding.* They told me their teachers encourage them to collaborate with one another, they explain things well, and they are willing to answer questions. Dan was one of six students who credited the teacher as the main reason for feeling better about math.

> Annie: So, talk to me more about what's changed for you in your attitude toward math.
>
> Dan: Um, definitely just the teacher, because she's friendly about it, um other teachers just kinda been like, get frustrated if you don't get something and they have to explain it again, and blah blah blah blah blah?
>
> (Annie laughs)
>
> Dan: she actually takes time to actually, um, go through the problems with you...and just makes life a lot easier. So, it's definitely like, calmed me down, and I'm actually enjoying a little bit more.

Becca had also experienced an improvement in her attitude toward math, and shared that she was starting to become more comfortable with asking questions in class:

> Becca: He like always makes sure that nobody like is left with like questions and everything and like he gives you the opportunity to actually like give the answers but I'm not someone who like usually like tries to give answers but occasionally I'll like, attempt... to speak up...
>
> Annie: uh uh?
>
> Becca: but he's really nice, he's funny, he like makes it fun? And like easy to understand, compared to teachers I've definitely had in the past.
>
> Annie: So, like, you're not afraid to answer a question then?
>
> Becca: Ummm, I am... But like sometimes I like try or I don't know if he always hears me because I kind of mumble but like I'm getting there!

Despite students' negative attitudes and bad experiences in the past, many felt pleasantly surprised by how well math was going for them this semester, when they felt as though material was explained clearly and their teachers cared about their success. Students who had used LSM also reported the positive gains they had experienced. When I asked Gavin how his math class was going, he replied,

> So far, so good. Much better than I expected, when I got into Finite Mathematics, cause math was never been something that I'll, will say I'm good at. But I've put a lot of extra work into it this semester? Like, I studied a lot with (Teacher A's PAL-leader), and whenever I thought the class was really, you know, falling apart for myself and I was completely lost, then I'd just go for extra help and then kind of piece it together...so, I have a much better grade than I was anticipating, so I'm pretty happy about it so far.

Students who had used LSM also spoke of how it gave them confidence and much-needed support. Ethan told me,

> I'm having somebody there to reassure me if I'm right or wrong, almost. And, if I don't know what I'm doing, they can guide me in the right path. So, it's definitely…helpful. Sometimes when I go into the Math Activities Center, I'll sit there, because I just have this weird mindset where, I don't want to ask anybody for help? But I need the help? Know what I mean?

The HMA students that I spoke with came to college with negative attitudes toward the subject. They were anxious and feared failure. They also were hesitant to ask questions or ask for help when they needed it. But many also acknowledged that they liked math when they felt like they understood it, and when they used LSM it was helpful to them. In each of the interviews, I asked students what advice they would give to future students to succeed in the same course.

Do all the work, go to all the classes, and pay attention.

Much of the advice that students offered was what you might expect from any good study skills manual: put time into studying, doing homework, and reviewing for tests. Go to class, pay attention, and take good notes. Keep up with the work and don't fall behind. As Kearney put it,

> Do all the work, go to all the classes, and pay attention. That's really, that's really it. If you don't do any of those things you're not going to succeed I guess. That's kinda, for *me*, that's crucial. Doing all the work and going to all the classes.

He told me that he had learned the importance of paying attention from past mistakes and was following his own advice this semester.

> In high school, I was in a class with *all* of my friends, and I did *horribly* in that class, because I didn't actually pay attention. But now, I don't have anybody, so I sit in the corner all by myself, and actually focus, and don't get distracted or anything, so I think that's pretty big.

Five of the students interviewed described the trouble they have staying focused and paying attention in class. Ethan admitted that this difficulty was not limited to math class for him:

> I can't really sit down in a class, like I have trouble sitting, and listening to something, like, even like a long, long conference at something that I love. I can't do it. I can't sit and I can't just listen for hours, umm, unless I'm actually interacting specifically? Which in classes I don't usually do that anyways? I sit there and I listen.

When I asked Gavin what his advice would be for future students, he replied,

> Umm, probably go to extra study sessions, take notes, and....really just pay attention in class. Cause it's very easy to get distracted. Like, I look out the window *a lot* during class, just cause I get bored, and like I try and look at the board more, but, just gotta pay attention. Get more out of it.

Maura, who told me that she has struggled with ADHD since high school, recommended paying attention as her top piece of advice.

> Definitely pay attention as much as you can, and...(pause) do all the homework, and like, even if you like can't figure it out, like go, and especially come here (gesturing to the MAC). I like only came here once because I usually go back home cause my sister like helps me? But, uh, this is just like so much more convenient? And I like kind of screwed up in that way, because I should have come here instead of waiting until the weekend to go to my sisters? But yeah, definitely to pay attention, study as much as you can for tests, and go to the MAC.

Becca is a hard-working student with attention-deficit disorder and other learning disabilities. She missed our first appointment for an interview because she had to meet with the dean of students about a situation that had occurred with her close friend the day before. She explained that her concern for her friends and their needs often distracts her from staying focused on attending class and extra review sessions:

> I know I should focus on my studies, but for me other people's problems weigh me down a lot, and I like to try to work on that, but it's just very difficult because I get so worried? And then it's just hard for me to like make myself

> like leave and like go try and get help when I need to make sure they're okay, even though I do need to focus on my studies.

Pi's family are refugees who were resettled in the US when he was in middle school. He used extra help resources in middle school and high school, and intended to do so in college as well, but, as he put it, "coming down here (to the MAC) was like, I thought it was going to be easy, but at the same time, like, I just have too much work, other works to put in, I just have to find time." His trouble with time management had a lot to do with his family being a priority. He went back home every weekend to help his parents with household tasks, so he missed the weekend review sessions. A family member got married in Ohio the weekend before final exams, and the expectation was that he would drive with his parents and siblings to the wedding, even though it meant taking 4 days away from school at a critical point in the semester. He ended up failing the course.

In further conversations, students shared many reasons for not following their own advice for success, including work schedules, family events, friends in crisis, a sick horse, forgetting to set an alarm clock, and nice weather. In one particularly telling exchange, Carson, who is on the football team, informed me that the coach calls this "sunny sick," and warned his players to avoid catching it. "That's what my coach always says, if you're not doing what you're supposed to do and it's nice out, you got the "sunny sick." Gavin also appeared to be familiar with the "sunny sick," when he gave me the following explanation for why he thought the attendance in his class had dropped so noticeably:

> I have a 4:00 class on Thursdays, and there are usually parties going on by the time it's just about class time, and if it's really nice out then a party's a better option than a class of course, but, it's just kind of kids' priorities. Some are in school, some are at parties.

Another reason that several interviewees provided for low attendance was that students would rather sleep than go to class. Carson, who is an athlete, rarely missed a class, but he said most days he would rather sleep than go to class. Jim, who ended up failing College Algebra, had this advice to give:

> Jim: It just, it just depends on you as a person, if you want to actually put in the time and effort, you know? Again, I'm not saying I'm like, the most diligent worker, I definitely have missed out on opportunities where I should have come in here (referring to MAC) and, studied more, done more, learned more, I'm not saying that happened, but again, it's....you gotta, you gotta make sure that you're not going to into this class coming out thinking okay, I'm going to love math and I'm going to get an A? You know, if you like math, yeah, you'll do good. But if you don't like it, you gotta make sure you go to the study, go to the studies, like, visit them twice a week or so, you know, talk to (Teacher C), you know, do the whole, do all the homeworks, don't cheat, you know, come do, like do the right steps, that will help you out a lot. But, that's kind of it. Careful, I don't know, it's tough. It's a tough course.
>
> Annie: mm hm…
>
> Jim: Especially for kids that...aren't into it.

Discovering a ”Disconnect.”

In the students’ answers to my question about what advice they would provide, I discovered a “Disconnect” between their advice and their actions. They frequently knew what they needed to do to improve their understanding, but they didn’t always do it. In the intensive interviews, I had not asked them directly if they followed their own advice, so to more fully explore this emerging theme, this was a direct inquiry to the students in the confirmatory and follow-up interviews (refer to Appendix C for intensive and follow-up interview questions). Because one of the major objectives of the study was to understand students’ help-seeking behavior, I was particularly interested in how the “Disconnect” manifested in terms of help-seeking. The “Disconnect” became apparent here as well. Most of the HMA students understood that getting help from the peer-tutors in the Math Activities Center or attending a PAL-leader’s review session was a powerful tool for success in math, but failed to follow through on this understanding.

Get extra help.

The advice most frequently offered in the intensive interviews was to get help when needed. Gavin, who experienced the largest drop in math anxiety of any student in the study, had this advice to give:

> Get extra help. Cause I've noticed the kids that don't get extra help, they're kind of falling apart, but, you keep up with your work, then, you really, have nothing to worry about. If, as long as you get the main concepts, everything kind of translates over and it all builds? So as long as you are sticking with it

> from the start, then you are good to go, really. It's not too much to worry about. Not much math anxiety.

He was in a class with a PAL-leader, and I was interested in learning whether the PAL-leader had anything to do with his drop in math anxiety. Here is an excerpt from our intensive interview.

> Annie: Could you tell me what it was like to have him in the class?
>
> Gavin: Oh, it was awesome. Yeah, he's great. He, um, there are multiple times that I told him that he's the reason I have a good grade, cause like I got a 90 on one test that I was mentally prepared to fail? And then I studied with him for a long time, and he knew everything and all the questions and he was ready to just sit down and help everybody out, because everyone who came in from the class, he just corralled them all into one corner, and then everyone was asking questions. He did a really good job of helping out everybody at one time, so that was really nice. He was a big help. Everyone was pretty bummed that he wasn't coming back? For, um, this part of the year, yeah a lot, lot of kids asked and I asked the professor asked him, but it's nice that he is still down there so we can still utilize him as a resource.

Many students who offered the advice of using extra help, often quickly followed expressing their regrets at not having done so, as when Becca said,

> Um, definitely like, (pause) review the material and like make sure you understand it and like there's probably times where like, if I got confused like I should have come here (referring to the MAC) or like seen (Teacher A) and then it's hard where like I'm doing okay, so like, do I really need to go? Like, I

> could teach myself but at the same time, like, I wish I would have done it more?

The majority of the interviewees specified that the help should be from the Math Activities Center, yet their own help-seeking behaviors did not fall into that category. Instead, they tried getting help from alternative sources or didn't get help at all. As noted in Phase 1, over three quarters of the students in the study did not seek help from the PAL-leader or go to drop-in tutoring in the Math Activities Center. Most of the interviewees did not use these sources of help either, regardless of whether they were in a class with a PAL-leader or not. Table 10 shows the interviewees status as control or PAL-treatment group, the number of help sessions they attended, and their final grades in the course.

Table 10

Interviewees' Positions in Control or Treatment Groups, Final Grades, and Number of Help Sessions Attended

Pseudonym	PAL-treatment or control	final grade	help sessions: first six weeks	help sessions: full semester
Ashley	Control	75	0	0
Becca	Treatment	85	1	1
Carson	Control	76	0	0
Dan	Treatment	63	0	0
Ethan	Control	62	6	15
Floyd	Treatment	61	5	6
Gavin	Treatment	85	3	3
Hugo	Control	73	8	9
Jim	Control	47	3	3
Kearney	Control	63	0	4
Leo	Treatment	55	2	7
Maura	Treatment	65	1	1
Natalie	Control	73	4	9
Pi	Control	59	0	0

Ashley preferred using help sources that were convenient, even if they were not always particularly useful. I asked her if she had gotten any extra help in her current class, and she responded,

> I've definitely thought about it. Like I'm sure it would probably help to like before you get, like, behind...and you just get, you know, stay on top of things, but, I don't know how realistic that is for me and a lot of other students.

In this case, however, her justification for not using LSM was not due to the stress or workload in her other classes. Instead, it was really more a matter of convenience and timing for her.

> I mean I probably should, I mean I know it sounds so stupid, but if I can't go right after the class when I'm already out, like I don't want to have to like, if I'm back in my dorm I'm not going to walk all the way back to Hyde to go to something like that unless I really, really need it, more often than not I'm not going to, you know, if I'm like out, then it's fine, like if I'm already in a day where I have like classes I'll do it, but if I'm not I'm not going to walk back somewhere and get help for it.

She told me that she often Face Timed her sister for help with homework, or watched Khan Academy videos on YouTube to try to understand course material.

> Ashley: I'm not listening to a whole 10 minute video, but, um...usually I can *try* to figure it out, and even if I really can't, I just kind of *hope* they're going to explain it in class? I'm not usually one to like, *ask* to explain it, unless I go, like, after a class, like, but I just kind of hope for an explanation in class.
>
> Annie: You don't ask...?
>
> Ashley: Not during class usually, no.
>
> Annie: Uh, and, have you used, it's like, thinking about your finite class, have you used Khan Academy or facetimed your sister, or...?
>
> Ashley: Yeah, yeah, I call usually my sister, or first, first I google it, see if I can find, like, an explanation there. But if I can't, or I do but I still don't

understand, that's when I'll call my sister. And I've definitely done that a few times. Um...

Annie: and you mentioned your roommate?

Ashley: Yeah, I ask my roommate, but she's not really good at math, so that's not too much of a help, I just figure I'll ask anyways!

Carson and Ashley were both in Finite Math, both ended the semester with final grades of C, and neither used the MAC or PAL-review sessions. While Ashley's go-to helpful resources included Google, YouTube, FaceTime, or her roommate, all of which could be accessed from the comfort of her dorm room, Carson relied heavily on his social network, both in and out of class:

Annie: I'd like to hear a little bit more about how you get help when you are working, like help with math.

Carson: Well, I would obviously, if I'm not in class, I either, I'm lucky with my room, my former room, one of my buddies who lives right down the hall from me, he took (Teacher B's) class last semester, so if I have any questions I can go to him. or, I have, or I can like email her if I have any questions, or, if I just need help in general I just ask around, you know, just see if anyone can if not or just keep trying or look it up on YouTube or something.

Kearney used every resource he could think of when doing the homework.

Kearney: I certainly try to use every resource possible, all the packets, all the notes I have, so…definitely don't just give up.

Annie: So what about if you had a hard problem on a test?

Kearney: Oh, that's, that's a different story. I kind of just leave it, leave that. If I can't use any resources than it's kind of hopeless. I'll try my best. Get down, put down as much as I know and try to get partial credit, but…yeah, I usually can't get all the way through. If, if I don't know it, I don't know it.

Annie: Mm hm

Kearney: There's really no recovery from that.

Even Gavin, who had established a good relationship with the PAL-leader, praising his ability to explain the material and provide extra help to the students in the course, demonstrated a "Disconnect" between his advice for success and his own priorities. When I asked him if he was attending the PAL-leader's review sessions, he responded, "Yes, yeah, he had sessions before or after quizzes, uh, Fridays…Fridays were kind of tough for me because Fridays I usually go snowboarding after class?" He then went on to tell me that on days when he couldn't get a ride to the mountain, he would attend the reviews, joking that it was his "second go-to on Friday afternoon."

Kearney, a College Algebra student, had similar priorities.

Annie: Did you ever go to any of the review sessions that were…

Kearney: I would have liked to have gone to the second one, but it was on a Saturday, and, or, Sunday…and it was the last weekend of skiing, and unfortunately, you can retake a test, you can't necessarily redo the last weekend of skiing.

Annie: Right. Priorities.

Kearney: Yeah, yeah, even though they are in the wrong spot, everybody has them.

Extra help isn’t for everyone.

Though most of the students interviewed spoke positively about the value of extra help or their regret for not using it more, there was another theme that arose as well. This was the belief that LSM is geared toward students who are at risk of failing or would not be able to pass the course on their own. In my interview with Hugo, a non-native English speaker, I asked him to tell me about his experience with the MAC. He replied,

> My experiences there has been very good, there's almost always someone that can help you, and if they can't help you, you just go see teacher after, but I mean, it's good, it's a good resource that the school gives, to be able to help people, uh, who have a little bit difficulties to learn math.

Hugo acknowledged that his difficulties with English, and especially with mathematical terms in English, created a need for him to use LSM.

Dan did not perceive himself to be at risk, believing he was able to understand everything by attending class and taking detailed notes. He did not use LSM at any point in the semester.

> Annie: So, in (Teacher B’s) class, have you used other resources?
>
> Dan: Not, no. I haven't really had to?
>
> Annie: yup
>
> Dan: Um, just writing everything down, just word steps and then labeling everything in the diagrams that she put up on the board so I knew exactly where each piece was and then the time that it was supposed to be put into the problem, so it's pretty self-explanatory.

Dan's final grade in the course was a 63%.

Kearney, who benefitted from the PAL-leader's exam reviews in college algebra (on the days when he wasn't skiing) viewed drop-in tutoring as something different from an exam review. He echoed Hugo's viewpoint of it being something only for students with special circumstances.

> I don't think necessarily, that, the classes should be meant to, like, you need to go get extra help to pass a class. I don't think that's how classes should work. But if you personally, like, one person needs extra help that's fine. But if the whole class was coming here every day after class, I think that would kind of be a problem?

Phase 2 summary

Twenty interviews were conducted with HMA students in College Algebra and Finite Math. A grounded theory approach was utilized to interpret the interviews. Students who used LSM, including the review sessions run by the PAL-leaders, found that it helped improve their attitudes and performance, but most admitted to not using it as much as they thought they should. Some students perceived LSM as primarily geared toward at-risk students. Overall, students spoke of an improvement in their attitude toward mathematics, but the credit for this improvement was most frequently given to their teachers and not to the PAL-intervention. Phase 2 also revealed a "Disconnect" between students' knowledge and their behaviors. Students indicated that they were aware of the types of practices would lead to success (go to class, pay attention, don't fall behind, ask questions, seek help) but admit to not following these practices themselves.

Chapter 5: Conclusions and Suggestions for Future Research

The following chapter uses the data that was obtained through quantitative analysis of student grades, survey responses, and tutoring records, followed by a grounded theory analysis of student interviews, to examine the influence of a Peer-Assisted Learning (PAL) program on the math anxiety, help-seeking behaviors, and performance of undergraduate students, particularly those who are highly math-anxious (HMA). A summary of the study is presented followed by an overview of the research results. Finally, study limitations are addressed, a policy recommendation is made, and suggestions for future research are provided.

Summary of the Study

Every student at Plymouth State University (PSU) is required to take at least one math class as part of graduation requirements. Most PSU students enroll in a math class during their freshman year. The rate of success for first-year students in many math courses is quite low. For example, from 2012-2017, only 54% of PSU students who enrolled in College Algebra passed with a grade of C- (70%) or better. Highly math-anxious students are particularly at risk. Research shows that math-anxiety is negatively associated with performance and retention (Hembree, 1990; Ma, 1999). In addition, students who are HMA have demonstrated an avoidance response to tasks, courses, and programs that require the use of mathematics (Ashcraft & Moore, 2009; Ashcraft & Ridley, 2005; Hembree, 1990; Liew et al., 2014; Ma, 1999).

Learning support in mathematics (LSM) is one method widely used by colleges and universities around the world to help improve performance and retention. At PSU, LSM is provided through the Math Activities Center, a drop-in center staffed primarily by undergraduate peer-tutors. Student usage of LSM, at PSU and elsewhere, is relatively low and is frequently not accessed by students who could most benefit from the service. Avoidance behaviors of HMA students may contribute to the underutilization of LSM.

Many colleges and universities, in addition to offering center-based LSM, offer embedded peer-tutoring programs such as PAL or Supplemental Instruction (SI), in which exemplary students provide additional review and study sessions for students in a particular course. SI has been studied for over 40 years, and has repeatedly been shown to be highly effective when properly implemented in the appropriate settings. Students who participate in SI have been shown to earn higher average course grades, have lower failure and course withdrawal rates, persist with undergraduate coursework, and graduate at higher rates than students who do not participate in SI (for reviews, see Dawson et al., 2014; Martin & Arendale, 1994; U.S. Department of Education, 1995).

For this study, a six-week PAL program was implemented in a small number of math courses in order to explore the effects of a PAL program on first-year undergraduates' math anxiety, performance, attitudes and perceptions toward college math, with a particular focus on HMA students. A secondary question examined whether participation in a PAL program increased students' help-seeking behaviors. Differences between HMA students and their non-HMA counterparts were also explored.

An explanatory mixed-methods sequential design (Creswell, 2014) was employed in order to examine the research questions, first quantitatively and then qualitatively. In the first phase of the study, students completed surveys during the first and sixth week of class. Surveys collected information about students' math anxiety, attitudes and perceptions toward mathematics, self-efficacy, and perceived value of mathematics. Students' grades and demographic information were also collected. Records of attendance at the Math Activities Center and PAL-leader review sessions were tallied to measure students' help-seeking behavior. Descriptive statistics, t-tests, and linear regression were used to measure effects of the PAL-treatment. In the second phase of the study, qualitative data was acquired through intensive interviews with a sample of those students whose survey responses identified themselves as HMA. Interviews were conducted and interpreted using a grounded theory approach, in which students shared their experiences, thoughts, and feelings about math, providing context and meaning for the process that led to the relationships described in the quantitative portion of the study.

Summary of Findings

The purpose of this study was to examine the influence of a peer-assisted learning (PAL) program on the math anxiety, attitudes towards math, help-seeking behaviors, and performance of undergraduate students, particularly those who are highly math-anxious (HMA). The study sought to determine whether participation in a PAL program measurably lowered math anxiety for HMA students, influenced help-seeking behaviors, or affected student performance. An additional research question asked, "How do HMA students perceive the influence of a PAL program on their experience of math anxiety, and willingness to seek extra help?"

The PAL intervention was not shown to significantly influence students' math anxiety, help-seeking behaviors, or performance. However, both phases of the study (quantitative and qualitative) found that HMA students' math anxiety had lowered, and their perceived value of math had increased. Interviews revealed an unexpected positive effect of perceived excellence in teaching on students' attitudes. While overall, LSM was underutilized, students who did use LSM found it helpful. Finally, the grounded theory approach to the interviews revealed a "Disconnect" between students' beliefs and behaviors regarding what it takes to be successful in math.

PAL Intervention

Phase 1 results did not show a statistically significant effect of the PAL-treatment on math anxiety, help-seeking behavior, or performance. The large number of students who chose not to participate in the study, dropped or withdrew from the course, or did not complete the second set of surveys (see Tables 2 and 3) were factors that limited the power of the quantitative analysis of the data. Consequently, the small sample size in this study made it difficult to generalize about the effects of the PAL-treatment on math-anxiety, help-seeking behavior, or performance.

Regarding the use of LSM, there were no statistically significant differences between the treatment and control groups in this study, and thus no quantitative evidence to show that the PAL intervention influenced students' help-seeking behaviors. Over forty years of scholarly evidence has been collected to show that PAL programs (and their close counterparts such as SI or PASS) can be effective ways to improve student performance and retention in high-risk courses. Why was it not effective in this case? Perhaps further consideration is needed to determine what courses qualify as "high-risk." Stone and Jacobs (2008) define high-risk courses as

> those that consistently generate a 30% or higher rate of Ds, Fs, and Ws (withdrawals). These courses are often large classes that provide students little opportunity for interaction with the professor or with other students; have infrequent examinations that focus on complex, cognitively challenging material; include large amounts of reading and information; and have voluntary and or unrecorded class attendance. Such courses are also traditionally taught by instructors who demand a great deal of higher-level critical thinking. (p. v)

The courses in this study met some of these criteria (high DFW rate, cognitively challenging exams) but did not meet others. Small class sizes allow for ample opportunity for interaction with the professor or other students, and while attendance may not be carefully recorded, absences are noticed. Instructors and students may disagree about how much higher-level critical thinking is being demanded, and in fact, research indicates that SI may be difficult to implement unless both students and teachers perceive the course to be difficult (Blanc et al., 1983; Hodges & White, 2001; Martin & Arendale, 1992). While College Algebra and Finite Mathematics are not labeled as remedial courses, they may be more properly considered as entry-level courses with a high proportion of high-risk students than "high-risk courses" as intended by many advocates of the use of SI.

Excellent teaching can still make a difference

In a 2002 study, Turner et al. found that supportive instructional, organizational, and motivational discourse by teachers in sixth-grade math classes had a positive effect on students' avoidance behaviors. The researchers observed that when instructors emphasized mastery goals (learning, improved understanding, intellectual development) over performance goals, students were more willing to participate fully in class and were less reluctant to ask questions or seek LSM. The interviews conducted in Phase 2 provide evidence that this type of teaching can be effective, not only for sixth graders, but for college students as well. Students reported feeling that their teachers cared about their success, and were willing to help them and answer their questions. They appreciated their instructors' clear explanations and step-by-step instructions. When I asked Carson to tell me about why his attitude had improved toward math, he told me,

> I have to say that it has a lot to do with the teacher. She explains, she's not going fast with it, she's going like at a steady pace, so like make sure everyone understands, it's nice. She's very friendly too, so like, you don't feel like, she's always happy, always good vibes, so she's always like, you never feel like, (sighs sadly) "you've got (Teacher B)?" No it's like, (happy voice) "yeah, I've got (Teacher B)!" She's like, awesome. Like I love being in class, like I love, like I actually enjoy going to class just because like she's the teacher.

Bad experiences in the past may have created fixed mindsets for many of the HMA students in the study, but excellent teaching may be the best hope for helping students to overcome their negative attitudes and emotions. Speaking about Teacher A, Becca told me, "he's a lot more understanding than some teachers, like some teachers are scary to even just go to and talk to, but like he is understanding and like he does care." She went on to explain that she was working hard because, "I don't want to disappoint him, like I want him to know I'm trying, like I do care like, I really do like him as a teacher." Carson described his teacher's positive impact, saying, "I can ask her a question on like math or like class or um, I don't need to feel like that *stressed out*, I don't know how to do it, I can just ask her, like I want, like she *wants* us to ask her questions." Other students pointed out that math can be more enjoyable when it starts to make sense. As Hugo put it, "I just think it's like more fun solving problems when you understand the things you are doing. I think that makes math more fun."

The statistically significant change in perceived value scores for the overall study sample may possibly have been due to excellent teaching rather than the PAL-intervention, as it occurred in both the treatment and control groups. In classrooms with such devoted educators, a PAL-leader may play a more minor role than in a classroom with a teacher who is less approachable or easy to understand.

Perceptions, attitudes, and use of LSM

Intensive interviews revealed that students' attitudes improved over the course of the semester, and survey data confirmed that the value that students placed on mathematics had increased in the first six weeks of the semester. The significant improvement in perceived value and attitude, along with the significant decrease in math anxiety among the HMA students, could not be directly attributed to the PAL-treatment. However, interviews confirmed that students who did take advantage of LSM found that it lowered their anxiety and helped them do better on homework and tests.

Students who use LSM find it beneficial.

Many studies have shown that students who used center-based LSM performed better and were less likely to withdraw or fail from the course (Pell & Croft 2008;

Symonds et al., 2008, Ní Fhloinn et al. 2014). In their survey of 1633 first-year students at nine higher education institutions in Ireland, Ní Fhloinn et al. (2014) found that 125 students (7.8%) reported that they had considered dropping out because of math, and of those students, 69 (62.7%) felt that mathematics support had influenced their decision not to drop out. Several themes emerged from their qualitative analysis of student comments: it was very helpful, it made assignments doable, it improved understanding, and it increased confidence. The majority (56%) of respondents who had used LSM reported that it had been “helpful” or “very helpful” to their confidence in mathematics. Supplemental Instruction has also been shown to improve both attitude and performance. For example, Bronstein (2008) found participation in SI in a physical chemistry course reduced anxiety, improved outcomes, and contributed to student persistence in science, math and engineering majors.

Because of the small sample sizes in Phase 1, quantitative results did not show statistically significant effects of LSM on performance or attitude for HMA or non-HMA students. Fewer than 30% of students in this study availed themselves of the PAL-leader review sessions or the drop-in peer-tutoring services at the Math Activities Center, further limiting the statistical power of Phase 1. However, most of the HMA students in the study who did use LSM had a reduction in math anxiety and increases in both perceived value and self-efficacy. In Phase 2, the HMA students who used LSM spoke positively about it, reporting that it helped them do better on homework and tests, and helped lower their feelings of anxiety. In our interview, Gavin described working with his PAL-leader during one of the PAL-led review sessions:

> He was ready to just sit down and help everybody out, because everyone who came in from the class, he just corralled them all into one corner, and then everyone was asking questions. He did a really good job of helping out everybody at one time, so that was really nice. He was a big help.

Students also spoke positively about their experiences with center-based LSM, praising the peer-tutors for being helpful, supportive, and easy to understand. Ethan told me, "First time we came here I was a little iffy on it, I kind of just need the help, I'm just here, and then it was almost a sense that it was…*easier*. So I just kind of kept coming back."

Students who could benefit the most don't use LSM.

This study also confirms research that students who could most greatly benefit from the help are not using it (Ní Fhloinn et al., 2014; Samuels & Patel, 2010). The interviews revealed dozens of reasons why students did not seek LSM, despite their acknowledgement that they might have benefitted from it. Two of the reasons given were scheduling conflicts and the perception that they weren't among the high-risk students who needed to use LSM. A study of high-risk freshmen at a large university in the southern U.S. reported similar findings.

> Some students reported that other commitments, such as class attendance and work schedules, prevented their attendance. These scheduling conflicts apparently occurred in spite of SI sessions being offered at three different times each week and tutoring being offered throughout the day and during evening hours (Hodges & White, 2001, p. 8).

They also reported that some high-risk students “may not seek help based on false feelings of success. This was evidenced by subjects who reported that they did not feel the need to participate in tutoring and SI” (p. 9).

Dan did not perceive himself to be at risk, believing he was able to understand everything by attending class and taking detailed notes. He did not use LSM at any point in the semester.

> Annie: So, in (Teacher B’s) class, have you used other resources?
>
> Dan: Not, no. I haven't really had to?
>
> Annie: yup
>
> Dan: Um, just writing everything down, just word steps and then labeling everything in the diagrams that she put up on the board so I knew exactly where each piece was and then the time that it was supposed to be put into the problem, so it's pretty self-explanatory.

Dan’s final grade in the course was a 63%.

In a study at Loughborough University, Pell and Croft (2008) compared 664 first-year engineering students’ attendance records at the mathematics support center with their final course grades, and found that students with the highest grades used the center more than students who struggled in the course. Thirty-five percent of students who received an A* (the highest mark) in their math course used the center more than once, compare with 22% of students who received a D grade and were in risk of failing the course. Of students who failed the course, only 15% used the math center. The authors suggest that “this would indicate that fail grade students as well as having ability problems also have attitudinal problems” (Pell & Croft, 2008, p. 171). In the context of this study, only one “A” student used help, suggesting that there is a need to create a culture of help-seeking at PSU where LSM is understood to be a resource for all students, not just those at risk of failure.

In a study by Anastasakis et al. (2017), 201 second-year engineering students at Loughborough University were surveyed in order to determine what tools they used to succeed in mathematics. They found that students chose tools that they thought would help them do well on exams and get a high grade in the course. In their sample of students, the Maths Learning Centre (MLC) was used at a lower rate than any tool other than social media. Online videos, online encyclopedias, and even instant messaging were used more than the MLC. In the current study, interviews also revealed a “Disconnect” between understanding that LSM would be beneficial but choosing other sources of help instead, such as YouTube, Google, or a roommate. In this case, convenience often seemed to be the primary factor in students’ decision-making, as when Ashley told me, “I ask my roommate, but she's not really good at math, so that's not too much of a help, I just figure I'll ask anyways!”

The “Disconnect.”

The “Disconnect” revealed in the interviews between understanding the value of LSM and not using it extended beyond help-seeking. Students identified a wide range of additional behaviors (attending class, paying attention, doing the homework, asking questions, and studying for tests) they believed would lead to success in the course, but admitted to not engaging in these behaviors themselves.

Interviews also confirmed the prevalence of HMA students’ negative attitudes, emotions, behaviors, and cognitive responses to mathematics. Fear of failure, fear of asking questions or asking for help, confusion, stress, and hopelessness dominated the descriptions of the students' approach to math. Evidence that math anxiety interferes with working memory capacity provides a neurobiological explanation for why math-anxious people perform poorly on tests (Ashcraft & Kirk, 2001; Ashcraft & Ridley 2004, Miller & Bichsel, 2004; Ramirez et al., 2013). As Floyd described it in his interview, "Definitely when we have tests and stuff, just cause like, I don't know. I kinda like blank on math tests. Like, I'll know the stuff, but just cause like, I'm like freaking out a little bit, you just like blank out on it."

The findings of Young et al. (2012) and Lyons and Beilock (2012) that showed increased activity in brain regions associated with pain and fear and decreased activity in regions associated with problem solving may provide a neural basis for the avoidance response and the "Disconnect." Poor performance on tests can lead students to feelings of helplessness and hopelessness, and may impact a decision to give up. Jim described his reaction to math anxiety as "digging yourself into a hole."

> You know, you try to plug your way through it, and if you hit a wall, you know you really just can't do I'm just like, screw it. Um, I can't, like, I don't know, I don't know how much more I could put into it cause, you keep digging yourself into a hole.

If you perceive yourself as "bad at math," and struggle with the course, the "Disconnect" could occur naturally as other priorities (other classes, work, friends, family, nice weather) arise. The avoidance response of HMA students may make it even easier for them to "dig a hole" instead choosing to engage in the behaviors that are known to lead to success. In this study, a six-week PAL intervention was not enough to make a significant difference in students' abilities to overcome the "Disconnect."

Limitations

Limitations to this study included small sample size, PAL program implementation, intervention duration, an unexpected teacher effect, and researcher participation.

Small sample size

As previously discussed, at the start of the semester, 161 students were enrolled in the seven classes in the study. One hundred and seventeen students agreed to participate and gave informed consent. Seventy-nine students completed the second set of surveys during the sixth week of the semester.

The large number of students who chose not to participate in the study, or dropped or withdrew from the course, or did not complete the second set of surveys, limited the power of the quantitative analysis of the data. The population of greatest interest to the purpose of the study – HMA students who had a PAL-leader in their classroom – had a sample size of just seven students. There were only four HMA students in the treatment groups who used LSM during the first six weeks of the semester. Therefore, statistical inferences about the effect of the treatment for HMA versus non-HMA students, or between students who did or did not use help, were not generalizable.

PAL-program implementation

The primary stakeholder groups in a PAL program are the PAL-leaders, the course instructors, and the students. Because the PAL-intervention was on such a small scale, with just three PAL-leaders assigned to three classes, there was some confusion as to their role in all three stakeholder groups.

Teacher A volunteered to assist in the study, but was never quite clear about the PAL-leader's role, and sometimes referred to him in class as the "TA (Teaching Assistant)." The PAL-leaders were willing participants, but were also somewhat unclear about their roles. In the training, they were informed that they should serve as model students, but were not sure how to effectively engage with other students while also serving as models. When students didn't attend their first weekly review sessions, PAL-leaders were unsure how to promote and encourage attendance.

Most PAL programs recruit students who have performed outstandingly in a particular course in a previous semester. Teacher A's PAL-leader was the only student who had taken the class before serving. Teacher B and C's PAL-leaders were math majors with tutoring experience, but no direct experience with the classes they served.

Students in the classes with PAL-leaders were also unclear on the role of the PAL-leader. The purpose of the study was not explicitly stated to the students, because the researcher was aiming to determine whether the simple presence of the PAL-leader would be enough to make a measureable difference in student performance, attitudes, and behavior. In a full implementation of a PAL-program, those goals should be made explicit. The instructor and/or PAL-leader could tell the students exactly what they were doing there and how the PAL-leader could help. In this study, the goals were too vaguely stated and it left everyone feeling a little confused. As discovered in the interviews, there is still a cultural perception that LSM isn't for everyone and asking for help could be interpreted as a sign of weakness. The philosophy of PAL programs, that peer-assistance is provided for help with high-risk classes, not just high-risk students, was not made explicit to the students in the study.

Intervention duration

In this study, PAL-leaders were present in the classroom for the first six weeks of the semester. They continued to work as peer-tutors in the Math Activities Center for the rest of the semester, but having them there in the classroom and then gone added to the students' confusion over the PAL-leaders' roles and didn't provide them with a constant physical reminder that help was available whenever they needed it. Because the intervention was only six weeks long, it is not possible to know if students would have begun attending review sessions as course content became more challenging, or if an intervention of longer duration would have had a greater effect on math-anxiety, help-seeking behaviors, or performance. While an observational study of a PAL program in two undergraduate math courses (*College Algebra and Probability* and *Precalculus I*) at the University of Minnesota found that participating in just 3 PAL sessions was enough to predict a significant increase in the probability of successful completing the course, and students who attended all PAL sessions had a ten-fold chance of success, as compared to students who did not participate (Cheng & Walters, 2009). It is possible that the intervention duration was not long enough to see an effect in the present study.

Unexpected teacher effect

Current research into the association between math anxiety and performance suggests that the relationship is bidirectional (Carey et al, 2016, Chang & Beilock, 2016). It has been shown that teachers, parents, and sociocultural environment play a role in the math anxiety-performance link, and "future interventions may benefit from focusing on both math-anxious individuals themselves and those around them” (Chang & Beilock, 2016, p. 33). The results of this study support this suggestion.

It seems counterintuitive to call “excellent teachers” a limitation, but in this study it may have been. While the results revealed that the effect of the PAL-treatment was statistically insignificant, there was a significant decrease in math anxiety among the HMA students in the study. Perceived value of math also increased significantly in both the treatment and control groups. Interviews expressed an improvement in attitudes toward math as well. Teachers were credited for these improvements in attitudes and perceptions. In fact, most interviewees spoke highly of their teachers: the clarity of their instruction, their approachability, and their willingness to answer questions. Comparing the treatment group directly with the control group did not tell the whole story in this study, because of the strong positive influences of the three faculty.

Researcher participation

The researcher works as a faculty member in the department where the study was conducted and also manages the Math Activities Center. The students who were interviewed had varying levels of awareness of the researcher’s role in the department. Their answers to some interview questions could have been influenced by a feeling of needing to say the “right thing,” possibly preventing them from entirely candid responses.

Policy Recommendation: Create a culture of LSM

The fact that the results of this study were not consistent with other findings demonstrating that PAL programs improve performance suggests that it is not enough to simply place a PAL-leader in a classroom. It is possible that a culture of LSM is a necessary precursor to a successful PAL-intervention. In other words, students must be encouraged to take advantage of LSM and shown the potential benefits it can provide, and the role of peer-tutors, whether serving as PAL-leaders or LSM center tutoring staff, should be made transparent to students in the classroom, emphasizing the fact that LSM is provided for all students to succeed in mathematics.

LSM providers need to understand that students may not willingly seek out help, even if they know that they should. Because peer-tutors need to actively engage and encourage participation from students at every opportunity, training should strongly emphasize the interpersonal communication and support function, and not just focus on helping students understand mathematical concepts.

Building a culture in which help-seeking is supported and encouraged should start even before the first day of class. During student orientation in the fall, students meet with advisors and residential life staff, tour campus, visit the library, and learn about the support services available to them. When they are forming their initial impressions of what it means to be a college student, understanding that LSM is available to them could become an integral part of the first-year experience. Making it normal and acceptable to ask for help would bring the proven benefits of LSM to a greater number of students, with potential positive implications for student success and retention.

Suggestions for future research

Addressing the "Disconnect."

College Algebra has a DFW rate of 46%, one of the highest rates of any course at PSU. Finite Math students have a higher rate of success, but the DFW rate is still 27%. All incoming first-year students are required to take a placement assessment. Students' placement assessment scores are one way to identify students who need supplemental support. However, more work needs to be done to determine the best ways to identify, advise, and support students who are at risk of failure in their first college math course. The "Disconnect" revealed in this study emphasizes the important of continuing to explore ways to increase at-risk students' engagement with LSM.

Fall versus spring enrollment.

Are students who put off math until spring more math anxious? Are they more likely to drop, withdraw, or fail than students in the fall? Studying trends in enrollment and pass rates in fall versus spring may provide insight into targeting advising and support of at-risk students. Students who dropped, failed, or withdrew from a fall semester course and re-enrolled in spring would be another population of interest regarding their anxiety, help-seeking behaviors, and performance.

Interviews with faculty and PAL-leaders.

This study focused on attitudes, perceptions, and behaviors of HMA students. To gain a fuller understanding about the effectiveness of a PAL-program, conducting interviews with the PAL-leaders and participating faculty is recommended. These interviews could also lead a more complete understanding of the unexpected teacher effects revealed in this study.

PAL-program implementation.

More students, more classrooms, and more PAL-leaders would increase the sample size, allowing for more comprehensive statistical analysis of the effect of a PAL program on math anxiety, help-seeking behaviors, and performance. A semester-long implementation could also help lower confusion about the program and a department-wide adaptation could help integrate it into the culture of the first-year experience. A large-scale effort involving marketing and promotion of the program and its potential benefits to students may provide more information about the relationship between math anxiety, performance, affect, and help-seeking behaviors.

Conclusion

The purpose of this study was to see if an experimental Peer-Assisted Learning (PAL) intervention, implemented for the first six weeks of the second semester, could have a discernible impact on first-year undergraduates' math anxiety, performance, attitudes, perceptions, and behaviors toward college math. Because highly math-anxious (HMA) students are known to have a particularly difficult time succeeding in math, extra focus was placed on them. The original problem this study sought to address was based on the observation that while learning support in mathematics (LSM) is readily available as a drop-in, center-based service, it is underutilized by at-risk students.

The PAL-intervention did not have any statistically significant effect on students' outcomes, either in terms of math anxiety, performance, use of LSM, or grades. Decreases in math anxiety and improvements in affect were, however, observed for the most highly math-anxious students in the study, particularly for those who used LSM. Further, the perceived value of math increased for the study sample as a whole. Qualitative results obtained through a grounded-theory analysis of student interview data revealed that improvements in affect were attributed primarily to excellent teaching and not the PAL intervention.

Student interviews also exposed a “Disconnect” between their understanding of what it takes to be successful in undergraduate math and their personal behaviors. In order to resolve this “Disconnect,” a policy recommendation resulting from this study is for educational leaders to work to create a culture of LSM, where help-seeking is supported and encouraged for each and every student.

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APPENDICES

Appendix A: Student Questionnaire

Please write down the number assigned to you by Ms. Hager: ____________________

How anxious would the following situations make you?

1=not at all, 2=a little, 3=a fair amount, 4=much, 5=very much

	Not at all				very much
1. Taking an examination (final) in a mathematics course.	1	2	3	4	5
2. Thinking about an upcoming mathematics test one week before.	1	2	3	4	5
3. Thinking about an upcoming mathematics test one day before.	1	2	3	4	5
4. Thinking about an upcoming mathematics test one hour before.	1	2	3	4	5
5. Thinking about an upcoming mathematics test five minutes before.	1	2	3	4	5
6. Waiting to get a math test returned in which you expected to do well.	1	2	3	4	5
7. Receiving your final math grade online.	1	2	3	4	5
8. Realizing that you have to take a number of math classes to fulfill the requirements in your major.	1	2	3	4	5
9. Being given a "pop" quiz in a math class.	1	2	3	4	5
10. Studying for a math test.	1	2	3	4	5
11. Taking the math section of a college entrance examination.	1	2	3	4	5
12. Taking an examination (quiz) in a math course.	1	2	3	4	5
13. Picking up the math textbook to begin working on a homework assignment.	1	2	3	4	5
14. Being given a homework assignment of many difficult problems which is due at the next class meeting.	1	2	3	4	5
15. Getting ready to study for a math test.	1	2	3	4	5
16. Dividing a five digit number by a two digit number in private with pencil and paper.	1	2	3	4	5
17. Adding 976 + 777 on paper.	1	2	3	4	5
18. Reading a cash register receipt.	1	2	3	4	5
19. Figuring the sales tax on a purchase that costs more than $1.00.	1	2	3	4	5
20. Figuring out your monthly budget.	1	2	3	4	5
21. Being given a set of numerical problems involving addition to solve on paper.	1	2	3	4	5
22. Having someone watch you as you total up a column of figures.	1	2	3	4	5
23. Totaling up a dinner bill that you think overcharged you.	1	2	3	4	5

	Not at all				Very much
24. Being responsible for collecting dues for an organization and keeping track of the amount.	1	2	3	4	5
25. Studying for a driver's license test and memorizing the figures involved, such as the distances it takes to stop a car going at different speeds.	1	2	3	4	5
26. Totaling up the dues received and the expenses of a club you belong to.	1	2	3	4	5
27. Watching someone work with a calculator.	1	2	3	4	5
28. Being given a set of division problems to solve.	1	2	3	4	5
29. Being given a set of subtraction problems to solve.	1	2	3	4	5
30. Being given a set of multiplication problems to solve.	1	2	3	4	5

Please respond to the next set of questions using the following scale:

1=Strongly Disagree, 2= Disagree, 3= Neutral, 4=Agree, and 5=Strongly Agree.

	Strongly Disagree				strongly Agree
1. After I study a topic in math and feel that I understand it, I have difficulty solving problems on the same topic.	1	2	3	4	5
2. There is usually only one correct approach to solving a math problem.	1	2	3	4	5
3. I'm satisfied if I can do the exercises for a math topic, even if I don't understand how everything works.	1	2	3	4	5
4. I do not expect formulas to help my understanding of mathematical ideas, they are just for doing calculations.	1	2	3	4	5
5. Math ability is something about a person that cannot be changed very much.	1	2	3	4	5
6. Nearly everyone is capable of understanding math if they work at it.	1	2	3	4	5
7. Understanding math means being able to recall something you've read or been shown.	1	2	3	4	5
8. If I am stuck on a math problem for more than ten minutes, I give up or get help from someone else.	1	2	3	4	5
9. I expect the answers to math problems to be numbers.	1	2	3	4	5
10. If I don't remember a particular formula needed to solve a problem on a math exam, there's nothing much I can do to come up with it.	1	2	3	4	5
11. In math, it is important for me to make sense out of formulas and procedures before I use them.	1	2	3	4	5
12. I enjoy solving math problems.	1	2	3	4	5

	Strongly disagree				Strongly agree
13. Learning math changes my ideas about how the world works.	1	2	3	4	5
14. I often have difficulty organizing my thoughts during a math test.	1	2	3	4	5
15. Reasoning skills used to understand math can be helpful to me in my everyday life.	1	2	3	4	5
16. To learn math, the best approach for me is to memorize solutions to sample problems.	1	2	3	4	5
17. No matter how much I prepare, I am still not confident when taking math tests.	1	2	3	4	5
18. It is a waste of time to understand where math formulas come from.	1	2	3	4	5
19. We use this statement to discard the survey of people who are not reading the questions. Please select Agree (not Strongly Agree) for this question. (Filter statement)	1	2	3	4	5
20. I can usually figure out a way to solve math problems.	1	2	3	4	5
21. School mathematics has little to do with what I experience in the real world.	1	2	3	4	5
22. Being good at math requires natural (i.e. innate, inborn) intelligence in math.	1	2	3	4	5
23. When I am solving a math problem, if I can see a formula that applies then I don't worry about the underlying concepts.	1	2	3	4	5
24. If I get stuck on a math problem, there is no chance that I will figure it out on my own.	1	2	3	4	5
25. When learning something new in math, I relate it to what I already know rather than just memorizing it the way it is presented.	1	2	3	4	5
26. I avoid solving math problems when possible.	1	2	3	4	5
27. I think it is unfair to expect me to solve a math problem that is not similar to any example given in class or the textbook, even if the topic has been covered in the course.	1	2	3	4	5
28. All I need to solve a math problem is to have the necessary formulas.	1	2	3	4	5
29. I get upset easily when I am stuck on a math problem.	1	2	3	4	5
30. Showing intermediate steps for a math problem is not important as long as I can find the correct answer.	1	2	3	4	5
31. For each person, there are math concepts that they would never be able to understand, even if they tried.	1	2	3	4	5
32. I only learn math when it is required.	1	2	3	4	5

Please respond to the next set of statements using the following rating scale.

1= strongly disagree, 2=mildly disagree, 3=do not know, 4=mildly agree, 5=strongly agree

1. I can get a good grade in math even if I skip classes.	1	2	3	4	5
2. I can get a good grade in math even if I skip the assigned homework.	1	2	3	4	5

	Strongly disagree				Strongly agree
3. If I miss math classes, I can always catch up later.	1	2	3	4	5
4. If I miss math classes, I can always learn it on my own from the textbook.	1	2	3	4	5
5. If I skip homework assignments, I can always catch up later.	1	2	3	4	5
6. I can learn the math material without coming to class.	1	2	3	4	5
7. Getting a bad grade in math will not seriously affect my future financial well-being.	1	2	3	4	5
8. Getting a bad grade in math will not seriously affect my future employment possibilities.	1	2	3	4	5
9. Being good at math will help me in my future professional life.	1	2	3	4	5
10. Getting a bad grade in math will not seriously affect the completion of my college degree.	1	2	3	4	5

Please rate your confidence in your ability to carry out the following tasks. Please note that you do not need to provide specific answers to the questions posed.

1= not at all confident, 2= somewhat unconfident, 3= neutral, 4= somewhat confident, 5=very confident

1. Add two large numbers (e.g., 5739 + 62543) in your head.	1	2	3	4	5
2. Determine the amount of sales tax on a clothing purchase.	1	2	3	4	5
3. Figure out how much material to buy in order to make curtains.	1	2	3	4	5
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest.	1	2	3	4	5
5. Use a scientific calculator.	1	2	3	4	5
6. Compute your car's gas mileage.	1	2	3	4	5
7. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.	1	2	3	4	5
8. Balance your checkbook without a mistake.	1	2	3	4	5
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.	1	2	3	4	5
10. Figure out how long it will take to travel from City A to City B driving 65 mph.	1	2	3	4	5

	Not at all confident				Very confident
11. Set up a monthly budget for yourself.	1	2	3	4	5
12. Compute your income taxes for the year.	1	2	3	4	5
13. Understand a graph accompanying an article on business profits.	1	2	3	4	5
14. Figure out how much you would save if there is a 15% markdown on an item you wish to buy.	1	2	3	4	5
15. Estimate your grocery bill in your head as you pick up items.	1	2	3	4	5
16. Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.	1	2	3	4	5
17. Figure out the tip on your part of a dinner bill split 8 ways.	1	2	3	4	5
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.	1	2	3	4	5

How confident are you that you could complete the following courses with a grade of A or B?

1= not at all confident, 2= somewhat unconfident, 3= neutral, 4= somewhat confident, 5=very confident

1. College Algebra	1	2	3	4	5
2. Statistics	1	2	3	4	5
3. Calculus	1	2	3	4	5
4. Business Management	1	2	3	4	5
5. Philosophy	1	2	3	4	5
6. Composition	1	2	3	4	5
7. Computing Fundamentals	1	2	3	4	5
8. Accounting	1	2	3	4	5
9. Environmental Science	1	2	3	4	5
10. Biochemistry I	1	2	3	4	5

You are almost done! Please just tell us a little bit more about yourself.

Age:

Gender:

Race:

Year in School:

Major:

Math placement score (if you remember it):

Name of high school you graduated from:

Name of highest level math course successfully completed in high school:

Grade obtained in that course:

All of your responses will be kept confidential.

Thank you for your participation!

Appendix B: PAL-Leader Training Materials

PAL-Leader Training Workshop

AGENDA

Day 1: Tuesday, February 06, 2018 4-6 pm

4-4:30

Brainstorming discussion: what are the advantages of having a PAL-leader in the classroom?

4:30-4:45

Introduction to the 8 guiding principles of PAL

4:45-5

Break

5-5:30

Math Anxiety

5:30-6

Organizational structure of PAL project

Logistics:

- Access to course content
- Communication with instructors
- Review session scheduling
- Announcement scheduling/communications
- Record keeping

Day 2: Thursday, February 08, 2018 4-6 pm

4-4:15

Check in, Q & A arising from Day 1

4:15-4:45

Discussion of research articles

Ashcraft, M. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

Dawson, P., van der Meer, J., Skalicky, J., & Cowley, K. (2014). On the effectiveness of supplemental instruction: A systematic review of supplemental instruction and peer-assisted study sessions literature between 2001 and 2010. *Review Of Educational Research, 84*(4), 609-639

Lyons, I. M., & Beilock, S. L. (2012). When math hurts: Math anxiety predicts pain network activation in anticipation of doing math. *Plos ONE, 7*(10), 1-6. doi:10.1371/journal.pone.0048076

4:45-5

Break

5-5:30

In depth coverage of 8 guiding principles

5:30-6

Scenarios and troubleshooting

The Eight Peer-Assisted Learning Principles

To create engaging PAL sessions, the facilitator uses a wide variety of learning activities and grouping strategies that fit the subject content and profile of students attending PAL. The eight principles of peer-assisted learning (as developed by David Arendale) described below provide a solid foundation upon which individual PAL sessions can best be planned and conducted to attain desired outcomes.

PAL Principles	Principles in Action
1. Educational theory guides the selection of effective learning activities.	• **Educational theories guide the selection of activities best suited to attain mastery of the content.** • **The affective domain and social learning are as important as the cognitive domain.** • **Self-regulation and executive function are critical to becoming an expert learner.**
2. Multicultural competency is a learned and valued process that improves the learning environment.	• **Understand your own culture and know that culture exists as a set of overlapping and sometimes conflicting identities.** • **Use active listening skills with sensitivity to the impact of culture on communication.** • **Choose a wide variety of culturally sensitive activities in PAL sessions.**
3. Session plans are designed with specific learning objectives in mind.	• **Select activities based on the goals for the session, difficulty of the content, and the limited time of the session.** • **Design plans that are flexible and responsive to the needs of students.** • **Use informal assessments to measure student learning and guide future PAL session activities.** • **Reflect on and evaluate previous sessions when planning the next one.**
4. PAL session activities vary according to the learning tasks of the subject matter.	• **PAL sessions appear and operate differently depending on the subject matter (e.g. chemistry course vs. psychology).** • **Select learning strategies that fit the course.** • **Choose activities that reflect the cognitive demands of the course: problem solving, learning vocabulary, analyzing texts, memorizing, and applying concepts.**

PAL Principles	Principles in Action
5. PAL sessions are opportunities to model, share, and practice productive learning behaviors.	• **Draw on personal experience to preplan a set of learning strategies useful to mastering the course content.** • **Look for “teachable moments” to demonstrate and apply learning strategies to course material.** • **Provide opportunities for participants to practice and share their strategies with each other.**
6. PAL participants are actively involved with the course material and with each other.	• **Use cooperative learning activities that require students to work with one another.** • **Observe students actively participating by taking notes, reading material, discussing, and solving problems.** • **Monitor progress within small groups, provide support, and gauge when to transition to the next activity.**
7. PAL students develop greater skill in self-monitoring their comprehension of course material.	• **Ask students to reflect on their exams to discover error patterns and to prepare more effectively for the next exam.** • **Provide students with practice using metacognitive strategies to self-test their comprehension of course material.** • **Model self-monitoring skills so students can select effective learning strategies for various tasks.**
8. Authority and ownership of the PAL session shifts from facilitator to participants as the academic term progresses.	• **Use questions to prompt student learning and to decrease their dependency on you.** • **Establish routines and procedures that direct students to each other for answers and explanations.** • **Observe students sharing their knowledge without directions. By the end of the term, it should be difficult for outside observers to detect who is the PAL facilitator.**

Appendix C: Student Interview Guide

Initial Open-ended Questions

Tell me about your math class. How has it been going?

In what ways, if any, has math in college been different from other math classes you have taken?

Could you describe your thoughts and feelings about math in general?

When you encounter a difficult problem in math, how do you handle it?

Do you ever get help with your math work?

Intermediate Questions

You have a peer-tutor in your class. How would you describe his/her role in the class?

Have you ever gone to one of the evening review sessions that is run by the peer-tutor?

If yes, what prompted you to go? Could you describe your experience? Did you go back again? (Why or why not?)

If no, could you tell me what has prevented you from going?

Can you tell me what the MAC is?

Have you ever gone to the Math Activities Center for help in math?

If yes, could you describe your experience?

If no, have you ever considered going?

Where do you usually go to get help with math?

Do you consider yourself abnormally math-anxious? How do you see it manifest?

Closing Questions

On a scale of 1-10, with one being “I hate it,” and 10 being “I love it,” what was your attitude toward math before you started this class? What would you say it is, on a scale of 1-10, today?

What, if anything, has changed for you about your attitude toward math so far this semester?

What would be your advice for future students who take this same course to succeed in it?

Do you have any questions for me?

Is there anything else you would like to share with me?

Follow-up interview questions

What are three things you recommend for future students who take this course in order to succeed in it?

Did you follow your own advice?

If yes, explain.

If no, what barriers do you feel prevented you from following this advice?

Have you noticed the dwindling attendance in your class?

What do you think might be causing this?

Is there anything else you would like to share with me about your math class?

Appendix D: Sample Interview

Interviewee 86, “Gavin,” was a Finite Math Student in “Teacher A’s” PAL-Treatment class. Our Intensive Interview was conducted on April 11, 2018.

A: So, this is an "intensive interview," which sounds a little scary, but it just means I'm gonna ask you open-ended questions and let you talk about math.

S: Okay.

A: So, how is your math class going for you so far?

S: Hmmm. Um, so far, so good. Much better than I expected, when I got into Finite Mathematics, cause math was never been something that I'll, will say I'm good at. But I've put a lot of extra work into it this semester? And last semester too, like I studied a lot with Cam, and whenever I thought the class was really, you know, falling apart for myself and I was completely lost, then I'd just go for extra help and then kind of piece it together...so, I have a much better grade than I was anticipating, so I'm pretty happy about it so far.

A: Last semester too, so does that mean you took it and failed it in the fall?

S: No, no.

A: No? Did you take a different math class?

S: No, I meant this semester.

A: Oh,

S: yeah

A: you're thinking like, pre- and post- spring break?

S: yeah, no, yeah, exactly, mini-semesters. yeah, exactly, mini-semester.

A: ok. So is this your first college math class?

S: yes, yeah, I took an engineering course last semester that counted as a math course, but this is my first legitimate, strictly math course.

A: So you took the one from (names Teaching Lecturer)?

S: Yup, yeah, and that was a lot of fun, it was very interesting. I had, a, A: Great

S: I had, it was nice to have something other than math count for math, cause that was more like, critical thinking and, more, well, that's the only thing offered for engineering at Plymouth so far, so, that was a cool feel to kinda..(pause)

A: be on the ground floor of that?

S: yeah, so I enjoyed that. It was a fun course.

A: What's your major?

S: Marketing. Marketing, and then I'm going to try and double major in communications or get a minor in professional communications.

A: Great. Uh, so, how would you, what would you say is the big difference, what are the big differences, or maybe similarities between college, the math you've had in college, and the math you had in high school?

S: Ummm...actually, I haven't seen most of the things we've done in college back in high school? But um, some of the, like, core concepts translate over? So, I've just used the information that we have back from high school. But after all the time, I don't remember everything we got in high school? So, just kind of going straight off from what we're learning in college, and doing my best to piece all that together. Keep the grades up.

A: And you're, you're doing that.

S: Yeah, yeah.

A: Good, good.

S: Yeah, pretty well so far.

A: Uh, so, in...talk to me about your thoughts and feelings about math in general.

S: In general?

A: Yeah.

S: I wouldn't consider myself a fan of math, but um, as of late, I think it's more interesting...I think it's more satisfying, we, we're going through the Simplex algorithm, which, when we first started, that was one of the days where I gave up for a good 40 minutes, and then...when we got back the next class that I really, decided that I needed to learn it because there was no other option?

A: mm hm?

S: And, I think it's nice, it's good when you get the answer, and you know it's right? So that's what I've always enjoyed about math...but it's just tough getting to that point once you have a concrete answer, you can say that that's it, feel confident, like...

A: Like you know it's right?

S: Yeah, exactly, and once you're comfortable with what you've done and you don't second guess yourself on half of it.

A: mm hm?

S: But, yeah, I think now I'm more of a fan of math, just cause I know that it’s going to be a big key in my life, throughout everything. Because it's one point that doesn't really go away.

A: Yeah, so true. (laughs)

S: Yeah.

A: So, that's interesting. It sort of leads to my next question, your story about having given up for 40 minutes on simplex, when you encounter a difficult problem in math, how do you typically handle it?

S: Ummmm, it depends if it needs to be solved at that moment, or if it's a long term problem? Cause if it's at that moment, then I'll panic for like a couple minutes, and then I'll just buckle down and I'll ask questions, and ask my peers and see what they've got, cause I have a couple kids in front of me that really know what they're doing in finite mathematics, so I refer to them whenever I have questions. If, um, professor's just doing his own thing on the board and still running the rest of the class and I'm still kind of caught up in what we've already done (clears throat) but um, sorry, what was the question?

A: How do you handle a difficult problem in math?

S: Oh, um…

A: So you're talking about the ones that don't need an immediate answer, but...

S: yeah, then just kind of break it down from step to step, I focus on one part, cause you kind of have to build...at least on simplex algorithm, so if I know what I first put down is correct, then I can go on to the next thing confidently and just go step by step and break it down piece by piece, rather than looking at it as a whole, cause then I get overwhelmed.

A: mmm. So, if you're, like, doing your homework, by yourself, and you get to a problem that's just a total killer, what, what happens then?

S: Um, I usually look at the back of the book, because that usually has the answers, and I can map, I won't like directly copy the answers, but I'll see that and then, find out how to get to that point? Or um, YouTube, Google, it's kinda the teachers that you don't directly have but are out there for you that you can use. I try to utilize my resources as best as possible. But I come here a lot to the Math, uh, learning center, and get a lot of extra help because I know I need it for math, so I try to do my best to hold myself accountable and keep the grade up.

A: So you, you come here quite frequently? It's a regular habit now?

S: yeah, yeah, whenever I have homework, they're, I'll start out and I'll get like three questions that are easy peasy, it's quick and done, then I'll get to the fourth one and its just, I have no idea how to go about it, so I'll come down here and then they can usually point me in the direction. And then after I get one or two, it's just basically, the things we are going over, they are all the same, so once you get one problem you can just about get all of them, if you are confident in it? so...

A: mmm hmm

S: that usually helps out, and I can do the rest of my homework by myself. But, I usually just finish it in here because it's convenient, and if I do have questions then I can ask, really anyone, cause everyone's good in math there.

A: (laughs) oh, that's great. So, did you, were you in the class that, ARE you in the class that had Cam?

S: yes.

A: Okay. Could you tell me what it was like to have him in the class?

S: Oh, it was awesome. Yeah, he's great. He, um, there are multiple times that I told him that he's the reason I have a good grade, cause like I got a 90 on one test that I was mentally prepared to fail? And then I studied with him for a long time, and he knew everything and all the questions and he was really to just sit down and help everybody out, because everyone who came in from the class, he just corralled them all into one corner, and then everyone was asking questions. He did a really good job of helping out everybody at one time, so that was really nice. He was a big help. Everyone was pretty bummed that he wasn't coming back? For, um, this part of the year, yeah a lot of kids asked and I asked the professor asked him, but it's nice that he is still down there so we can still utilize him as a resource.

A: mm hm

S: cause he knows what he's talking about with math, but... Yeah he was great, he was a lot of fun to have him in there, and it's cool to just have like another *student* in there, rather than a professor you could go to that knew that what they were talking about, so it's nice,

A: I feel like, that answer, I planted you to say those things. Hahaha. It's so nice to hear, it really is, it's great. Did you ever go to any of his extra sessions?

S: Yes, yeah, he had sessions before or after quizzes, uh, Fridays, Fridays were kind of tough for me because Fridays I usually go snowboarding after class? But, uh, when I couldn't get a ride to the mountain and I would come and do the math.

A: (haha)

S: that was like, my second go-to on Friday afternoon.

A: almost as fun, huh?

S: yeah, just, just about there.

A: hahaha..ah, let's see. Umm, what, why do you think you, (pause) well, here's what I wrote. What prompted you to go? Um, could you describe, go, work, you know, go to the extra sessions?

S: Um, just kind of knowing that I needed it? And if I didn't go, then it would be, doing more harm than good? cause, I could skip it and just be lazy, but, once I'm actually taking the test, I'd regret it, so I knew that I'd kind of have to go, because extra help has been a good thing for me, throughout high school and everything?

A: hhmm

S: Cause I don't always need it, But when I need it, then I get it, and it works out great, cause everybody's usually very helpful, when they actually offer for a study session, you go to the study session, you get answers to whatever you like and teachers look at it better, so there's a lot of Pros to it, and it outweigh the cons so,

A: mmhh

S: I was always willing to go, and study and get a better grade then I would without it.

A: So it's worth your time.

S: Yeah, definitely.

A: Good investment.

S: Yeah.

A: Great, do you know what math anxiety is? Have you heard of that term?

S: No, but I bet I've had it before.

(both laugh)

A: So yeah, it's like an emotional, psychological, even physical response to the thought of doing math.

S: Yeah, yeah I've had that before. Even in like, we had, the CMT? Where I'm from? in Connecticut, Connecticut Mastery test?

A: Okay?

S: and the math sections used to terrify me. I would get really stressed out, I'd feel sick, and I wouldn't want to go to school, but then I learned one day that it didn't even count for us, it was more for the teachers? And students were just, they got average grades for the entire state. And then they devalue at the teachers. So that took the pressure off of me, so that was really my worst case of math anxiety, but, then it was instantly lifted away once I realized the scores didn't reflect on me whatsoever.

A: interesting. How old were you?

S: I was in 6th grade, so I was pretty young.

A: so like 11 or 12?

S: Yeah

A: yeah. huh. so, there's ah, the math anxiety research actually sort of divides into 2 different things. There's test anxiety, and then there is just, like, learning math. So you have described test anxiety

S: mm hm

A: Do you ever feel those same feelings just at the thought of doing math in general?

S: No, not really. I don't usually get too overwhelmed too quickly? I like to believe that I got, kind of a level headed mind set on most things, but definitely going into tests, There are times where I will, I know that I know what's on the test, and that I've studied all of it, but once I physically have the test the numbers are just, scrambled, and It's tough to kind of figure it out, even though I know that I've done many problems like that.

A: mmhm

S: So, I guess it's just the moment. It stresses me out. But,

A: but it sounds like you have, you're pretty resilient about recognizing that and just sort of, I don't know, sucking it up and

S: yeah, yeah, cause I've dealt with anxiety for a long time. It used to be public speaking, but then I did a lot of different things for public speaking. I'd speak for my church, I was in the school musical, just cause I was terrified of being on stage so I figured I might as well do it in high school because that's when it's easiest. So, I kind of, I know how to recognize anxiety and know what to do about it, at least for myself? So I'm better at it? I'm still not great. If I had to present in front of a hundred people I would still be terrified, but..

A: mm hm

S: I might be able to piece my way through it.

A: So you are not afraid to face your fears.

S: Ummm, Some of them. But public speaking I will face, because I know I need it. And like, I'm going into marketing, so sales, presentations and everything, and talking in front of groups is very important, and you've kind of got to be pretty persistent at it.

A: yeah.

S: To do well in your field. So I know that I have to take care of that now, rather than later.

A: And, would you say the same thing about math? Like, you know it's something that you have to...

A: yeah, yeah, I know that I need to go through the course, I, I know when people drop, I don't really, that's not really my style I guess, cause I know that I'll eventually have to take something like it, and I don't want to fail a course. Some of my friends, they have failed a course, that's whatever, but I know how I have to take it again and I have to pay for a whole nother course, so, there's more initiative in college to really get everything taken care of.

S: Mm mh

A: Because I really don't want to be paying for more than I need to. Because College is already pretty expensive. So.

S: Yeah, no kidding.

(conversation strays off topic)

A: okay! I'm on to my closing questions.[00:13:49]

S: awesome.

A; On a scale of 1 to 10 with 1 being I hate it intending I love it what is your attitude towards math before you started this class

S: before? Like 4? Maybe a 3?

A: and what would you say it is today?

S: 6 or 7? Yeah especially with Professor Hett.. He's a lot of fun. He makes it more interesting, and it's more captivating, and it keeps you on your toes with whatever he's going to say next, so it makes you pay more attention.

A: (laughs) So, Mr. Hett has helped you change your attitude toward math this semester.

S: Yeah, him and Cam both. Yeah, they're a dynamic duo right when we go there, so they made it much more entertaining, more interesting.

A: That's great. What would be your advice for future students who take this course?

S: uhhh...get extra help. Cause I've noticed the kids that don't get extra help. they're kinda falling apart, but, you keep up with your work, then, you really, have nothing to worry about. If, as long as you get the main concepts, everything kind of translates over and it all builds? So as long as you are sticking with it from the start, then you are good to go, really. It's not too much to worry about. Not much math anxiety.

A: So, you're in good hands with Hett.

S: Mm hmm. Yeah, especially if you are coming down here, because we have so many resources that you can utilize, I mean you can get a solo tutor, you can just come here, you can get just about whatever you need to really be as successful as possible.

A: Let alone YouTube and Google, and...

S; yeah, exactly. Even when you don't think you have any options, you can still use the internet, cause that has *endless*, I could learn calculus, but I wouldn't be any good at it, but I could probably learn off of YouTube...

A: right? MIT has a ton of free courses

S: yeah

A: it's just the motivation to get it done.

S: Exactly, yeah, it's a lot of time, but it's worth it in the end.

A: That's great. Uh, do you have any questions for me?

S: Mmmm, what's this all for?

A: I'm so glad you asked! (laughs) So, um, I am really interested in math anxiety, and I also, because I run the tutoring center, think that peer-tutoring is a, possibly a good intervention.

S: mm hmm

A: so I'm studying the effects of the peer-tutoring like Cam, putting them in the classroom, on performance, and help-seeking behavior, and math anxiety. So, my hope was that having him in the classroom would encourage people to, you know, seek help when they needed it,

S: oh, it totally did.

A: possibly lower their anxiety,

S: yeah

A: and help them get better grades.

S: Yeah, no, I think that was great. And then, he got, like a credit for it? or he was getting paid or something?

A: He got paid.

S: Yeah, that's awesome. cause then there's initiative for them, and initiative for everybody. If everyone is involved and wants to actively do it, whether it's money or grades, that's really the top two things at this point in our lives that we're really concentrated on, then why not?

A: Right? It's um, it's funny though how...well I guess, at a lot of bigger universities they have a peer-tutoring program like this already there, and so,

S: oh yeah, yeah, yeah

A: and so there's a *culture of it,* like if you take the class and you do well, then you want to be the next peer-tutor,

S: mm hm

A: so it sort of self-replicates?

S: Yeah, I've even thought about it and I don't even really like math!

A: (laughs)

S: but it's been a thought. Because, I don't know, I like helping other people, and if I can help them through it, and then, it doesn't look bad on a resume.

A: Great, we can talk!

S: Sure!

A: So, I think, I, I, the results have been a little bit disappointing to me. There's a lot of people who, like out of the 120 people I surveyed, only 30? have gotten any help at all? In any way? Like gone to the math center or gone to an extra tutoring session, or anything.

S: Missing out.

A: Yeah, they're missing out, right? And I think it's partly because there's not the culture here? To recognize that that's a thing?

S: mm hm

A: But I also, you know, I just am so endlessly curious about why the students who need the help the most are the least likely to get it.

S: It's usually those kids that are most eager to leave. Like, if they have a class on like a Friday, today, then they're ready to just get out of there. If they're confused and they're not happy about their class, they'll just deal with it next week. And that's how I am with some classes, but I know that I have to do it eventually, so I might as well do it now.

A: And then next week rolls around and they don't do it then either.

S: (laughs) yeah, yeah, that's usually how it goes.

A: yeah.

S: But, I don't know, it's not a *good* thing to do, but it's just what happens sometimes.

A: So what, what would you, I'd love your insights into that. Why do you think...

S: into kids like, not doing their work?

A: yeah.

S: um, it's just, procrastination's a big thing lately, even for myself, like, it's hard to stay concentrated on one thing for a really long time, there are just so many distractions nowadays, especially in college, there are enough distractions itself no matter what year you are in, but the amount of media we are surrounded by, if you get like one SnapChat, and you're doing your math homework, you have everything laid out, all your, like your book, calculator and whatnot, pencil in hand, you get one SnapChat, and you look at that, and then you'll check the weather, and you'll go to Instragram, and you'll be on your phone for an hour or two and not even notice it. And that's when everything falls apart. I've had to, really like throw my phone on my bed when I'm over at my desk, and just do all my homework and then deal with my phone later. But it's tough because some people want you to respond quickly, and then other things you need to respond to quickly, so you kind of always need to have it there nowadays? So, it's just kind of distractions. It's hard to stay focused.

A: Yeah, that's a great description. I banned cell phones from my classroom about 4 or 5 years ago.

S: mm hm

A: Because it got to the point where nobody was paying any attention to anything.

S: Exactly. Yeah, and it's tough, especially from a teacher's standpoint. But, some teachers, they just think, if it's your money, then, you can throw away the class if you're not going to pay attention. It's like, $80 a class or something?

A: right?

S: Yeah, for out of state, it's ridiculous, coming from CT, I just try to make the most out of what I'm getting

A: You probably know (business prof)?

S: mmmm (indicates no)

A: She's in business?

S: Maybe.

A: Anyway, one time she said to me, um, I think it was her? (pause) She says okay, here's what you should do. Take, uh, go to the bank, get out $80, put it on your bedside table. And then, when you wake up and you decide not to go to class, get a lighter and light that money, and burn it up. And then, when you get up, go to the bank, get $80, put it next to your bed, start over.

S: phew. Yeah, cause that's really how it is! And kids don't realize that, a lot of people are just skipping, they're just like yeah, whatever, but it's a lot of money. And it's valuable information, because everything compiles on top of each other, and just to get your degree, like, thinking of some important classes that I could have missed, like when we started going over simplex algorithm, if I missed that I'd be completely lost for everything, probably do bad on my test, but luckily I've made it. That's why, it's all about scheduling everything, like my 8 am, I have financial accounting? And that's already my hardest course, no matter what time it is, and it's at 8 am?

A: right?

S: so, it's, it's almost impossible some mornings, cause...

A: now, do you get help in that class? Do you have a tutor?

S: Um, the tutor didn't work out for me as well as did in Finite Mathematics, but I tried. But now, I'm just doing it with a, um, my neighbor. Cause he's right across the hallway from me, and he has the exact same course, and we sit together, so

A: oh great

S: usually know what's going on, and we can do the online tests together, so...

A: great

S: we've been getting good grades through that, with a little bit of teamwork.

A: Teamwork, I like it. Um, okay, any other questions for me?

S: Um, no, that's all I really got.

A: Okay, and is there anything else you would like to share with me?

S: Uh...no, I think math's fun, if you can make it fun, yeah. Basically just, I don't know. I guess the style of how people teach, that's also big impact on how the kids react to it. Cause I had one teacher in high school. and he would just give you the *facts*, and that was that, and if you didn't know what was going on, you had to go for extra help, you couldn't stop him in the middle of the course, during class time, and that really, a lot of kids were just mad about that, and so they didn't even want to work for him, and then they'd get lost, they wouldn't really know what to do, they wouldn't want to go after with him because they didn't like him as a person at that point, so they just didn't really want to spend any time with him, and that really fell apart. So I guess, communicating with your students, and *knowing their name.* Knowing kids' names is a *very big part.* I have a, I think her name was (omitted). She teaches business? And uh, she learned everybody's name and we're in class with like 30 kids within a week. And that was one of my favorite courses just because you could talk to her, and it was very, it was one-on-one because she knew your name right away.

A: mmhm

S: It's a very big difference for most teachers, when they actually know who you are and a little something about you, like even where you are from, just so you can have a conversation piece, and, that's a really big thing in college, because there are so many kids, so, it's harder to remember names, but it's definitely a game-changer.

A: Yeah, I think that's a good point. I have a good friend who is a senior researcher at Gallup, and she came and did a guest lecture in my Statistical Literacy class last week, and one of the things that the Gallup reserach into Higher Education has recently found is that the, they took a bunch of um, alumni, and asked them about their college experience, and so the alumni who are happiest and most successful, what happened, the number one predictor of that, based on their college experience, was they had a faculty or staff person who they felt cared about them.

S: Exactly, yeah. Cause then it pushes you, cause even with Mr. Hett, he uh, he'll tell you when he thinks you are doing a good job, and even like, at the beginning of a test, he'll be like, hey Andrew, you did good on the last one, make sure you do good on this one. It's like, just nice to have that little bit of personality show every once in a while.

A: I ended up with, for this study, three super nice teachers. And so, in these interviews I've heard this a lot, that like the teachers really matter and it's been a good experience because of the teacher?

S: Yeah, definitely.

A: So, my biggest regret, you know, 20/20 hindsight? I really wish I could have put a peer-tutor in with a mean teacher. (laughs) you know?

S: Yeah, definitely, It's a good control group.

A: Yeah.

S: You can tell, it's all that initiative. Kids don't care about a mean class, then you really know. But you'll always have kids that are very passionate, no matter who they have teaching, and will seek out help, but

A: that's true

S: I think, over all, it's different

A: just like you'll always have students who won't be engaged no matter how nice the teacher is

S: exactly. Yeah, Even if they know you well, if you are family friend, they still won't care.

A: yeah.

S: It's always, always one, but...you can't really do too much about that.

A: Well, I really appreciate your time. It's great talking with you.

S: Yeah, no, that was fun. I was happy to help.

A: Great. And um, seriously, you know, I'll keep you in mind for a peer-tutor if we do this again next fall.

S: Oh yeah, I mean, really only Finite Mathematics, that's all my experience in college, but it you need it for Finite...

A: but that's the whole, that’s sort of the concept of it, is you take a student who did well in the class and have them be a peer-tutor next time around.

S: Yeah, yeah.

A: So keep up the good work!

S: Yeah, yeah definitely!

A: All right!

Appendix E: List of Initial Codes

accepting a bad grade
admitting to not taking
advantage of resources
another set of eyes
anticipatory anxiety before test
appreciating a teacher who is engaged
appreciating that math can be beautiful and practical
attendance is important
attending help session to gain favor from teacher
avoidance
avoiding independent learning
bad at math
bad at tests
bad experience in high school
Bad teacher
bad test grade brings down course grade
blah blah blah
blaming the teacher
career choice requires math
caring teacher
choosing to attend class
class notes as a resource
close enough
coping with anxiety
counting on homework grade to offset test grades
digging into a hole
disliking online learning
distraction
doing better than expected
doing the work
dynamic duo
easy to get help from teacher
effort should count toward grade
enjoyed an application-based course
enjoying this math class
equating math anxiety with general anxiety
experiencing pleasure at success
experiencing test anxiety
expressing non-expert view of math
external motivation
extra help has been a good thing for me
extra help improves grade
extra help is not for everyone
failing classes
failing the course
falling behind
fear of sounding rude
fear of spiraling downward
feeling a false sense of confidence
feeling ambivalent about math
feeling confused
feeling confused about the PAL-leader's role
feeling distracted
feeling distracted in class
feeling frustrated
feeling ineffective
feeling less stress in a low-stakes situation
feeling lost
feeling more positive about math
feeling overwhelmed
feeling pleasantly surprised
feeling pressure from family
feeling pressure from parents
feeling scared by math
feeling sick before a test
feeling stressed out before a test
feeling stressed out during a test
feeling terrified before a test
feeling uncomfortable asking questions
feeling uncomfortable speaking in class
finding test review session helpful
fixed mindset
forgetting during a test
forgetting to do homework
freaking out
Friend as a resource
gathering courage to ask questions
getting bad test grades
getting extra help from teacher
getting good homework grades
getting help makes homework easier
getting help saves time
giving up
Google as a resource
hands-on
hanging in the air
having to work hard to grasp concepts
having trouble remembering material
he's the reason I have a good grade
high school was more slow-paced
hoping for a good grade
hoping for explanation
hoping for the best
hoping to pass
I don't like math
I prefer just using paper and pen

if I don’t know it, I don’t know it.
if you don't know it you don't know it
I'll just end up falling apart.
I'll just try my best
I'm not good at math
I'm not good at taking tests
I'm not good with numbers at all
I'm not really good at algebra
intending to get extra help
internet as resource
issues with advising
it is what it is
it’s not my favorite subject
it's been fun.
it's definitely my worst class
it's kind of pointless
I've always been bad at math
I've always struggled with math
just do it cause I have to
Khan Academy as resource
knowing help is available
lacking confidence
laziness as reason for not seeking help
learning better one-on-one
learning by doing
learning disability
like a zombie up there on the board,
losing concentration
low anxiety for everyday numerical tasks
MAC as a place for people with "difficulties"
MAC as a resource
math anxiety in the past
math builds up from a solid foundation
math has always been my worst subject
math has always been very difficult
math is hard for me
math is harder than other classes
math is never my strong point
math isn't like my best subject
math just is more fun now
mentally prepared to fail
needing extra time on tests
no help available on tests
nobody really wants to be in a math class
not admitting to math anxiety
not asking for help
not being aware of PAL-leader
not feeling a need for extra help
not giving up
not knowing about the MAC
not knowing where to start with a math problem
not learning from a math book
not seeing the practical applications
not understanding
not wanting to fall behind
not wanting to interact in class
not wanting to teach oneself
noticing low attendance
overthinking
PAL-leader
PAL-Leader as helpful resource
PAL-leader didn't make a difference
parents not helpful
planning to attend review sessions
planning to study hard
planning to transfer
preferring direct instruction from the teacher
preferring individual attention
preferring interactive learning
preferring to learn from the teacher than independently
pride
Priorities>help seeking
priorities>math class
priority: family
priority: good grades
priority: horse had cancer
priority: laziness
priority: making money
priority: nice weather
priority: other classes
priority: parties
priority: skiing
priority: sleeping
priority: snowboarding
priority: weekend activities
priority: work
procrastination
questioning relevance of the content
recognizing convenience of MAC
recognizing extra help can lower frustration
recognizing extra help can reduce math anxiety
recognizing extra help improved performance
recognizing financial cost of coursework
recognizing it's a requirement
recognizing need for extra help

recognizing relevance of math
recognizing the importance of learning the content
recognizing value of attending class
recognizing value of review sessions
second-guessing oneself
seeking clearer explanations
she loves that we're helping each other
sister as helpful resource
slacking
social media
some students don't need to study
spacing out
starting to give up and then persevering
step-by-step
struggling
Sunny sick
surprised at getting it wrong
taking my time
teacher encourages participation
teacher encourages questions
teacher encourages students to collaborate
teacher explains things well
teacher is a drone
teacher is a robot
teacher is engaging
teacher is friendly
teacher is fun
Teacher is good
teacher is hard to follow
teacher is hard to understand
teacher is helpful
teacher is nice
teacher is understanding
teacher knows students' names
teacher more accessible than in high school
test anxiety
the teacher doesn't make math fun.
the teacher doesn't matter
they question your IQ
trouble paying attention
trying hard
trying to catch up
trying to maintain a positive attitude
trying to pay attention
trying to stay focused
trying to transfer
tuning out
tutor explains things well
uncaring teacher lowers motivation
understanding math
unsympathetic teacher
using all available resources
using help to gain confidence
Wanting to pass
wanting to please the teacher
WebAssign
WebAssign as a resource
you could pay him for homework
you don't want to teach yourself math.
YouTube