

THE RELATIONSHIP BETWEEN MINDSET AND DEVELOPMENTAL MATH AT A
COMMUNITY COLLEGE

by

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ABSTRACT

Community colleges are tasked with the challenge of educating students of all academic levels. This quantitative research study investigated the use of a growth mindset intervention as a mechanism to improve success in developmental math at a large, midwestern community college. The research design included a pre-test, growth mindset intervention, and post-test administered to the experimental group and a pre-test and post-test to the control group. Statistical analysis was applied to determine if a statistically significant relationship exists between the growth mindset intervention administered to the experimental group and a change in mindset, successful completion of a developmental math course, and progression into the next level of math. The findings from this study were not statistically significant, largely due to sample size. Recommendations for future research include expanding the volume and demographics of the sample size to determine if a growth mindset intervention has the potential to be a cost-effective curriculum infusion that improves success rates in developmental math.

Key Words: growth mindset, developmental math

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CHAPTER1: INTRODUCTION

Problem Statement

In the United States, underperformance in math has become a significant issue (Boaler, 2009; Glenn, 2000). The United States has dropped below average in mathematical literacy when compared to other countries and now places behind many advanced industrial nations (Desilver, 2017; National Center for Educational Statistics, 2017b). The 2015 Program for International Student Assessment (PISA) indicated that the United States ranked 30th in math out of the 35 members of the Organisation for Economic Co-operation and Development. Additionally, the administration of the 2015 PISA shows no improvement in mathematics performance over the previous three years (Organisation for Economic Co-operation and Development, 2016). The National Center for Education Statistics (NCES, 2017a) showed that in 2015 only 25% of eighth graders performed at or above a proficient level.

The United States no longer has the most educated workforce in the world, like it once did (White House, 2015). In order to remain competitive in a global society, former president Barack Obama proposed to make community college as affordable and accessible as high school. Community colleges are uniquely positioned to offer programs that lead to a skilled workforce as they offer affordable tuition, part-time enrollment, and remedial courses. Due to the United States' lagging performance in math and science, this proposal also focuses on the need to improve performance in STEM courses and programs (White House, 2015).

Community colleges are democratizing institutions in the United States. They provide access to education and a pathway for social mobility (Goldrick-Rab, 2010). In particular,

community colleges provide access to higher education to students who are academically unprepared for college coursework (Cohen, Brawer, & Kisker, 2014). Bahr (2008) states that community colleges provide “opportunities to rectify race, class, and gender disparities generated in primary and secondary schooling; to develop the minimum skills deemed necessary for functional participation in the economy and the democracy; and to acquire the prerequisite competencies that are crucial for negotiating college-level coursework” (p. 420).

Nearly two-thirds of graduating high school students from public schools are not academically prepared for college-level coursework. (Developmental Education, 2013). A significant percentage of community college students place in remedial or developmental coursework, courses below college-level, when entering college. Data from the 2004/09 Beginning Postsecondary Students Longitudinal Study and its associated 2009 Postsecondary Education Transcript Study indicated that 68% of entering community college students took at least one developmental course during their enrollment within the studies’ time period (Chen, 2016). This trend is increasing, and students are entering college less prepared for college-level math. The National Assessment of Educational Progress report shows an increase of 72% in 2013 to 75% in 2015 of twelfth-grade students performing below proficiency level for their age group in mathematics (NCES, 2017b).

Community colleges educate the many students who are academically below college-level who attend college to gain credentials for employment opportunities (Goldrick-Rab, 2010). Community colleges face the difficult task of meeting students at their academic level and providing a pathway for them to reach college-level coursework. However, it is critical that community colleges address the low success rates of these students. Students who begin college academically below college level are at risk for not completing their intended program (Attewell,

Lavin, Domina, & Levey, 2006; Bahr, 2010). Community colleges struggle to address low-completion rates in students who place into developmental courses. Only 49% of students complete their developmental course sequence and move into credit-level coursework in that subject (Chen, 2016).

In particular, students who place into developmental math have difficulty reaching credit-level math. The 2004 Community College Research Center study of 250,000 community college students from 57 colleges showed that only 20% of students who placed into developmental math go on to pass a credit-level math course (Bailey et al., 2010). Additionally, only 28% of those students complete a college credential within 8.5 years (Attewell et al., 2006).

Remediation is an expensive undertaking. College remediation has an estimated annual cost of over \$2 billion (Strong American Schools, 2008) to nearly \$4 billion (Schneider & Yin, 2011). On average, the cost of developmental education is one-third of the instructional budget at community colleges (Cohen et al., 2014). Opponents of community colleges bearing the responsibility of remediation argue that the cost of developmental education makes it difficult to justify offering education for academic preparation that students should have received in high school (Strong American Schools, 2008).

The mission of community colleges is to provide accessible education for all who want to continue their education beyond high school (American Association of Community Colleges, 1998). As community colleges are dealing with tightening budgets, it is necessary for developmental education programs to substantiate their existence through data and outcomes.

Supporters of remedial education advocate for providing curriculum that facilitates a progression from different academic levels to college-level programs (Cohen et al., 2014). To ensure the continued support and funding for remedial education programs, it is critical that these

programs are effective and display outcomes of improved completion rates.

One factor that can affect academic performance in developmental coursework is student mindset. Students' understanding of their intelligence and potential to grow their abilities fall on a spectrum from believing they have no potential for growth to believing they can improve their intelligence and abilities (Dweck, 2008b). This understanding of intelligence demonstrates the difference between a fixed and a growth mindset. Carol Dweck (2008b) indicates that individuals with growth mindsets believe they can change and grow abilities with effort. Students placed into developmental math with a fixed mindset do not believe that they can improve their abilities in math, whereas a student with a growth mindset understands the value of effort as it leads to improvement in ability in math.

According to Paunesku et al. (2015), mindset interventions that influence a change from a fixed to a growth mindset have a positive influence on students' motivation and attitudes toward challenges and struggle. Growth mindset interventions teach students that intelligence can grow when effort is put in to overcome a challenge, and that struggle is an opportunity for growth, not an indicator that a student is incapable of succeeding (Paunesku et al., 2015). Studies have shown that when faced with a challenge, students who have a fixed mindset are more likely to give up than those with a growth mindset (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 1999; Dweck & Leggett, 1988). Therefore, completing a developmental math sequence and progressing to college-level math is a challenge that students with a growth mindset are likely more equipped to overcome.

The lack of college success for students who enter college needing developmental math is a significant issue (Attewell et al., 2006; Bahr, 2008, 2010; Bailey et al., 2010). Students who need remediation in math before entering credit-level courses are unlikely to complete a

credential (Bahr, 2008; Cohen et al., 2014). Significant resources are allocated for and lost by community colleges and students through non-completion of developmental sequences (Strong American Schools, 2008; Schneider & Yin, 2011). The problem statement of this study is: How can a community college create an environment that develops growth mindset and motivates developmental math students to progress through their remedial math sequence?

Significance of the Study

Just over 25 years ago, the United States was ranked number one in college education attainment. In 2013, the United States slipped to 12th place in educational leadership (U.S. Department of Education, 2013). There is a direct link from the education attained by a country's citizens and economic progress (Barro & Lee, 2013). Barro and Lee (2013) note that a higher educated population leads to a more skilled workforce and favorable social conditions such as lower child mortality and better income distribution. The Center on Education and the Workforce found that 95% of jobs created since the recovery from the 2008 recession have gone to those with some college education (Carnevale, Jayasundera, & Gulish, 2016). In addition, associate degree holders gained 3.1 million jobs, while those with a high school education or less only gained 80,000 jobs (Carnevale et al., 2016). It is critical for higher education in the United States to allow for accessible pathways toward credential completion.

Community colleges uniquely provide access to education for individuals who may have academic difficulties, financial constraints, or are place-bound and unable to move away to attend college (Goldrick-Rab, 2010). For many students, their college choice is between attending a community college or not enrolling in college at all (Roderick, Nagaoka, Coca, & Moeller, 2009). Community colleges offer certificates, career and technical associate degrees, and associate degrees designed to transfer to a four-year college or university (Cohen et al.,

2014). Cohen et al. (2014) assert that these programs are aligned with the job market and allow students to gain credentials that lead to better employment opportunities.

Postsecondary education is essential, both for individuals as a pathway to economic stability, but also the country as a whole as having educated citizens and a skilled workforce leads to economic growth (Paunesku, 2013). The majority of Americans believe that it is important to attain a post-secondary degree. According to the 2015 Gallup-Lumina Foundation poll on American's opinions on higher education, 70% of adults believe that obtaining a degree or certificate beyond high school is very important (Gallup-Lumina, 2015). Further, there is a significant discrepancy in pay between high school graduates and college graduates (Economic Policy Institute). The Economic Policy Institute (2017) states that in 2016, college graduates made 56.6% more than employees whose highest degree was a high school diploma.

However, although community colleges provide access to education, a large percentage of students do not complete the credentials that would lead to better job opportunities or higher earning potential (Bailey, Leinbach, & Jenkins, 2006). Only slightly more than one-third of students enrolled in a community college complete a credential within six years of beginning college (Calcagno, Bailey, Jenkins, Kienzl, & Leinbach, 2006). According to the National Education Longitudinal Study (NELS), less than 25% of students who enroll in developmental education complete a degree within eight years of beginning their college education (Bailey, 2009). This statistic is particularly concerning when considering that 70% of students entering community colleges begin with the expectation that they will complete at least a bachelor's degree (Bailey et al., 2006).

Although the offering of developmental education allows access to college education for academically unprepared students, many students do not persist through their developmental

coursework and progress into college-level, or graduation required courses, especially in math (Bailey, 2009). Nearly 60% of entering community college students take at least one remedial math course (Chen, 2016). Of colleges included in Achieving the Dream, a non-profit organization committed to improving student success in community colleges, approximately 30% of entering students placed into the lowest level of developmental math and only 16% of those students completed their full sequence of developmental math (Achieving the Dream, 2018; Bailey, 2009). Out of all students who place into developmental math, only 31% complete their sequence. Progression rates from one developmental math course to the next in the sequence are also a concern. Approximately 25% of students who complete a developmental math course drop out before entering the next level course (Bailey, 2009). The lack of success in student completion of developmental math impacts the overall completion rates of community college students and urgently needs to be addressed.

Many students who begin their developmental math sequence are unsuccessful in completing it. According to NELS data, only 30% of students pass the developmental math courses in which they enroll (Bailey, 2009; Attewell et al., 2006). At the Midwestern suburban community college in this study, student success in developmental math is defined as receiving a grade of C or better and has averaged 52% each year between fall of 2012 and 2016 (Harper College, n.d.c.). This statistic applies to an individual course; many students need to complete a sequence of developmental math courses to progress into college-level math. Out of 28 community colleges partnering with the Carnegie Foundation to improve success rates in developmental math, historically, only 6 percent of students complete a college-level math course within one year of enrollment (Silva & White, 2013).

Improving success rates of students who initially place into developmental courses is a

significant challenge for community colleges. The premise behind placing students into developmental math is that it will successfully prepare students to move into credit-level math courses (Boylan, Bliss, & Bonham, 1994, 1997; Lazarick, 1997). Students who are taking developmental courses are investing time and money into remediation but are not receiving degree-applicable credit (Bettinger, Boatman, & Long, 2013). Developmental math sequences may require multiple semesters before a student can enroll in credit-level math, which extends time to completion.

Increasing persistence or progression through a developmental math sequence increases student success rates, more so than increasing completion rates in developmental math courses (Bailey et al., 2010; Ngo & Kwon, 2015). This is due to the sequential nature of math courses and the necessity of progressing to college-level math to meet credential requirements.

Numerous studies seek to understand the causes behind the low success rates of developmental education programs and identify efforts that will improve them. Students face a variety of barriers in community colleges, including those related to socio-economic or psychological factors (Silva & White, 2013). Factors associated with student success include strong high school preparation, college enrollment immediately after high school, having parents who attended college, coming from a family with a high income, and attending college full-time with no interruptions (Bailey, Calcagno, Jenkins, Kinzl, & Leinbach, 2005).

However, community college students commonly possess factors negatively associated with student success such as being a single parent, having financial issues, delaying college enrollment, being a first-generation college student, commuting, and attending college part-time (Achieving the Dream, 2006; Astin, 1985; Community College Survey of Student Engagement, 2005). In fact, nearly 70% of community college students embody at least one of these factors

(Achieving the Dream, 2006). Despite providing access to students with these factors that may prohibit them from attending other institutions, completion of credentials at a community college aligns with socioeconomic advantage (McIntosh & Rouse, 2009). Individuals from higher socioeconomic backgrounds are more likely to benefit from enrollment in a community college and incur higher completion rates and more successful transfer experiences (Dougherty, 1994; Leigh & Gill, 2003; Rouse, 1995, 1998).

Stereotype threat also creates a barrier to academic performance. Stereotype threat exists “when one is in a situation for doing something for which a negative stereotype about one’s group applies” (Steele, 1997, p. 614). When facing negative stereotypes about academic ability, students perform at a lower level (Bandura, 1997). An additional threat exists in the perception that others’ judgment of their performance will further the stereotyping of their group in that subject area (Steele, 1997). African American students struggle with negative stereotypes in many academic areas and women experience it in math and science (Steele, 1997; Riegler-Crumb, Moore, & Buontempo, 2017). Stereotype threat affects the performance of both African American students and women in math and can affect performance in developmental math courses.

Numerous organizations have invested in the research and launch of new initiatives to address the challenges of developmental education. In particular, the Lumina Foundation for Education, Achieving the Dream, the Bill and Melinda Gates Foundation, and the Carnegie Foundation for the Advancement of Teaching are working toward increasing completion rates of underprepared students (Chen, 2016). The attention on developmental coursework by these lead foundations and organizations demonstrates the significance of the issue of developmental coursework completion and progression into college-level coursework.

The Lumina Foundation is a private foundation focused on success in learning beyond high school to meet workforce needs (Lumina Foundation, 2018). Their goal is to increase the number of Americans with a college credential to 60% by 2025. Part of their work includes addressing barriers to success as seen with low completion rates in developmental coursework. As a result of the Lumina Foundation's research, multiple schools redesigned their developmental education programs to offer clear, accelerated pathways with advising support.

Achieving the Dream is a leading nonprofit organization that supports the use of data and evidence in informing initiatives designed to improve success rates in community colleges (Achieving the Dream, 2018). One area of major focus is developmental education; 140 Achieving the Dream colleges identified 315 developmental education interventions ranging from accelerating developmental pathways, improving academic advising, and providing learning support. Within these interventions, multiple schools have incorporated a growth mindset approach. For example, Bunker Hill Community College provides professional development training for their developmental math faculty on how to incorporate growth mindset messaging within their courses (Achieving the Dream, 2016).

The Bill and Melinda Gates Foundation focuses on improving quality of life by identifying ways to make healthcare and education more accessible, particularly to those living in poverty (Gates Foundation, n.d.). In the United States, the Gates Foundation supports solutions that ensure high school students graduate academically prepared for college coursework and post-secondary programs align with workforce needs. The Gates Foundation provides funding in the form of grants to initiatives to improve developmental education. Additionally, funding has been provided to the Manpower Demonstration Research Corporation (MDRC) for a study on "the impact of a low-cost, scalable growth mindset intervention on the

academic outcomes of 9th grade students in a national sample of U.S. high schools” (Gates Foundation, 2017). MDRC is an organization “committed to finding solutions to some of the most difficult problems facing the nation – from reducing poverty and bolstering economic self-sufficiency to improving public education and college graduation rates” (MDRC, n.d., para. 1).

The Carnegie Foundation for the Advancement of Teaching aims to address educational inequities through use of improvement science, data, and communities of partnership (Carnegie Foundation, n.d.). In particular, they provided a report on developmental math pathways with evidence supporting accelerated pathways with demonstrated higher success rates. The Carnegie Foundation supports the addition of a growth mindset approach as seen in publications written to educate providers on academic mindset and its impact on struggling math students.

In addition to the work to redesign developmental math pathways, multiple studies show that psychological interventions can be effective at improving academic achievement with long-term effects (Aronson, Fried, & Good, 2002; Blackwell et al., 2007; Cohen & Sherman, 2014; Good, Aronson, & Inzlicht, 2003; Walton, 2014; Yeager et al, 2016; Yeager & Walton, 2011). Students can learn that there is scientific evidence behind individuals’ potential to grow characteristics and abilities (Yeager & Dweck, 2012). Additionally, they can learn how to apply this information in a meaningful way to their own lives (Blackwell et al., 2007; Yeager, Trzesniewski, & Dweck, 2013). Influencing this shift in mindset has a positive influence on resiliency and persistence (Yeager & Dweck, 2012).

Evidence suggests that mindset has a direct correlation with performance in math (Boaler, 2009; Dweck, 2006; Dweck, 2008a; Hall & Ponton, 2005; Silva & White, 2013; Wheland, Konet, & Butler, 2003). Carnegie Foundation researchers asked faculty what factors lead to student success in developmental math (Silva & White, 2013). Silva and White (2013)

state that the faculty reported that students who believed in their potential to learn math were persistent even in the face of challenges or failure.

Psychological factors such as mindset can also play a role in academic success, particularly in math. Students who believe that intelligence can be developed rather than it being a fixed quality tend to have higher course completion rates in challenging math courses (Yeager & Dweck, 2012) and have what Dweck (2008) describes as a growth mindset. Students with a growth mindset are more resilient in the face of challenges and more likely to overcome adversities in their life, including those related to socioeconomic status (Yeager & Dweck, 2012). Studies have shown that brief interventions to teach students that intelligence and abilities can improve with effort are effective at changing mindsets (Dweck, 2008b; Yeager et al., 2016a).

Poor persistence and success rates in developmental math are a major challenge for community colleges. Students who place into developmental math are at risk and unlikely to complete their developmental math sequence and, as a result, a credential such as a degree or certificate (Bahr, 2008, 2012). Research suggests that a mindset intervention may impact students' perceptions of their ability to be successful in math and, in turn, increase effort that students put forth to learn math.

Growth Mindset

Two mindsets toward intellectual ability exist (Dweck, 2008). A growth mindset actualizes through the belief that the brain is malleable, and intelligence can grow (Master, 2015). The belief in growth mindset extends to the ability to increase intelligence and abilities throughout life (Dweck, 2008). Individuals with a growth mindset are open to honestly evaluating their current abilities with the belief that they can develop. An individual with a fixed mindset believes that ability and intelligence are fixed traits that cannot develop or change

(Master, 2015). The fixed mindset viewpoint indicates that a person is limited to the same level of intelligence throughout their lives (Dweck, 2008).

According to Dweck (2008), these mindsets can also affect an individual's approach toward goals. Those with a fixed mindset tend to set performance goals that will make them appear to be competent without requiring effort or developing a new ability (Dweck & Leggett, 1988). An individual with a fixed mindset does not take charge of the process to reach a goal but prefers to set goals that are reachable without challenge (Dweck, 2008). Individuals with a growth mindset see effort as positive, as it is the vehicle for improvement and growth (Master, 2015). Therefore, they set learning goals where the focus is on the process of achieving their goals and the learning or abilities that develop while working toward the goal (Dweck & Leggett, 1988).

Growth and fixed mindsets present through implicit theories of intelligence (Dweck & Leggett, 1988; Molden & Dweck, 2006). Students' implicit theories are either entity or incremental theories of intelligence (Yeager & Dweck, 2012). An entity, or fixed theory of intelligence, refers to the belief that individuals have a stagnant, unchangeable level of intelligence throughout their lives (Yeager & Dweck, 2012). The entity theory of intelligence embodies fixed mindset characteristics such as having an interest in the appearance of being smart, the tendency to give up when facing a challenge, and stagnant or decreasing grades (Yeager & Dweck, 2012). Those with an incremental, or growth, theory of intelligence believe that intellectual ability can grow over time (Yeager & Dweck, 2012). An incremental theory is also displayed through an interest in learning, working harder and smarter when faced with a challenge, and an upward trend in grades (Yeager & Dweck, 2012). In fact, two students with similar intellectual aptitude may display significantly different academic performance due to

differing implicit theories of intelligence (Dweck, 1999, 2006).

As implicit theories, students' beliefs in their intelligence are rarely expressed and often go unaddressed (Yeager & Dweck, 2012). Therefore, a student's implicit theory results in long-term patterns of vulnerability or resilience (Dweck, Chiu, & Hong, 1995). However, psychological interventions can change mindsets through a targeted approach (Aronson et al., 2002; Blackwell et al., 2007; Yeager & Walton, 2011). These interventions target growth mindset by teaching students about neuroplasticity, or the malleable quality of the brain, positive consequences of effortful practice, and potential to increase intelligence through effort (Dweck, 2008).

Purpose of the Study

The purpose of this study is to determine the relationship between a growth mindset and performance in developmental math at a large Midwestern suburban community college. The study includes the use of a growth mindset intervention to determine whether a short lesson plan can change students' mindsets from fixed to growth and whether those students with a growth mindset have a higher likelihood of successfully completing Algebraic Modeling (MTH 065) with a grade of C or better and progressing to the next course in their math sequence. The 45-minute lesson plan includes a pre-intervention mindset assessment, growth mindset content in the form of videos, discussion questions, and application activities. The post-intervention mindset assessment 10-12 weeks after the lesson plan completes the experiment.

There are few studies related directly to developmental math coursework in community colleges and the use of growth mindset interventions or theory. Therefore, this study adds to the body of research on the relationship of growth mindset and persistence in developmental math. Additionally, this study tests the effectiveness of a short growth mindset lesson plan on

influencing a shift from a fixed to a growth mindset. Results showing that the growth mindset lesson plan has a positive impact on progression into the next level math course would indicate that it would be a useful and cost-effective supplemental tool to classroom instruction in developmental math courses.

Research Questions

The purpose of this study is to determine the impact of a growth mindset intervention on progression from Algebraic Modeling (MTH 065) to the next level math course at a large Midwestern suburban community college. The research questions are:

1. What is the impact of the intervention in changing mindset?
2. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students in the experimental group and the control group?
3. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students with a growth mindset, students with a fixed mindset, and those unsure of mindset?
4. What is the difference in successful completion of MTH 065 between the experimental group and the control group? (A grade of C or better indicates successful completion.)
5. What is the difference in successful completion of MTH 065 between students with a growth mindset, students with a fixed mindset, and those unsure of mindset? (A grade of C or better indicates successful completion.)
6. What is the difference in successful completion of MTH 065 of students who face a stereotype threat (female and historically underrepresented students) between the experimental group and control group?

This study seeks to determine the efficacy of a growth mindset intervention as a modality to increase student success and progression in developmental math coursework. The need for this type of research stems from community colleges' struggle to address low completion rates in students who place into developmental courses. The hypothesis for this study predicts that a

mindset intervention that is effective in developing a growth mindset in students who placed into developmental math will increase the percentage of students who successfully complete MTH 065 and progress into the next course in their math sequence. The null hypothesis states that the growth mindset intervention has no impact on success and progression from MTH 065 to the next level of math.

Overview of the Study

This quantitative, experimental research study seeks to determine if there is a relationship between mindset and student performance in a developmental math course as well as progression from a developmental math course into the next math course in the sequence and the efficacy of a short growth mindset intervention in changing students' mindsets from fixed to growth. Students enrolled in six sections of MTH 065 (Algebraic Modeling) comprised the research sample. Chapters 3 and 5 provide the limitations and delimitations found in the study. The small number of participants ($N = 54$) is of note, as it limits the researcher from applying statistically significant findings to the general population with confidence.

Organization of the Study

Chapter 1 introduces the importance of developmental education in the context of United States academic performance and explains the significance of studies on the impact of a growth mindset and performance in developmental math. Chapter 2, a review of literature, includes an overview of developmental education in community colleges, the challenges faced by developmental math students, student development theory, psychological factors that influence math performance, studies of psychological interventions, the concepts of implicit theories, neuroplasticity and a growth mindset, and academic mindset interventions within a community

college and math context. Chapter 3 describes the research methods, design, instruments used, limitations and delimitations of the study. Chapter 4 analyzes the data gathered for each research question to determine if there is a statistically significant correlation between mindset and performance in developmental math. Chapter 5 provides an overview of the study, implications from the results pertaining to each research question, and recommendations for future research.

Conclusion

Community colleges provide access to education for students who may be unable to attend other institutions of higher education due to academic, financial, or other barriers (Cohen et al., 2014). The United States has dropped in ranking in education levels from 1st to 12th place (U.S. Department of Education, 2013) in recent years. Community colleges offer an avenue for many students to continue their education and, as proposed by Obama, are critical in improving the educated workforce in the United States (Cohen et al., 2014; White House, 2016). Students who attend community colleges because they are academically unprepared for college coursework often place and begin their education by taking developmental courses in math or English (Levin & Calcagno, 2008). Unfortunately, success rates in developmental course sequences, for math in particular, are low (Bailey et al., 2010). Few students progress from developmental math into college-level math and then on to complete a credential (Silva & White, 2013).

Students with a growth mindset are more likely to be academically successful (Blackwell et al., 2007). Studies on growth mindset have shown that students with a growth mindset are more likely to persist in their education (Dweck, 2008). There is evidence that short, inexpensive growth mindset interventions have been able to move students toward a growth mindset (Aronson et al., 2002; Blackwell et al., 2007; Yeager & Walton, 2011). Therefore, this study

tests the effectiveness of a growth mindset intervention on changing students' mindsets from fixed to growth and compares the success and progression rate of students with growth mindsets versus fixed mindsets who are enrolled in MTH 065 at a large, Midwestern suburban community college.

CHAPTER 2: LITERATURE REVIEW

Introduction

This study focuses on the impact of a growth mindset intervention on performance and progression in developmental math. The literature review begins with a brief overview of developmental education in community colleges and the challenges faced by developmental math students. Next, relevant student development theory is reviewed to create context for impact of psychological interventions. Then, research on psychological factors that influence math performance, implicit theories of intelligence, neuroplasticity, psychological and academic mindset interventions within a community college, and math context.

Academic research on growth mindset and its relationship specifically to performance in community college developmental math courses is sparse. However, there is a significant amount of research on developmental education in general, developmental math, and, separately, growth mindset and its relationship to academic performance. This study intends to add to the body of research on growth mindset and its potential impact on performance in math, especially for students who are academically unprepared for college-level math coursework.

Much of the research on growth mindset is on the K-12 sector of education (Dweck, 2006). However, current research and the development of growth mindset interventions for college students is being done through the Project for Education Research That Scales (PERTS, n. d.), a Stanford University-based research group. This research focuses on four-year colleges and universities as well as community colleges.

Developmental Education

Developmental education programs in community colleges make college accessible to the millions of students academically unprepared for that level of coursework (Chen, 2016). More than 2 million students would not be enrolled in a postsecondary education program if not for developmental education programs (McCabe & Day, 1998; Chen, 2016). Developmental education is a valuable service when considering that a general decline in high school academic achievement occurred in the United States from the mid-1960s to the early 1980s with no significant increases since (Cohen et al., 2014). Specifically, enrollment in remedial math courses increased from 441,000 students in the 1980 to 1,150,000 students in 2010 (Blair, Kirkman, & Maxwell, 2013) (see Table 1).

Table 1: Estimated Enrollment in Thousands in Remedial Mathematics Courses in Two-Year Colleges

YEAR	# STUDENTS ENROLLED IN REMEDIAL MATHEMATICS
1980	441
1985	482
1990	724
1995	800
2000	763
2005	964
2010	1150

(Blair, Kirkman, & Maxwell, 2013, p. 155)

Additionally, there is a socioeconomic component to academic unpreparedness. According to Cohen et al. (2014), a significant, positive correlation between a higher family income and SAT scores exists. Students with financial constraints are also more likely to attend a community college, leading to the need for remedial education to bridge the gap from academic preparedness at onboarding in a community college to college-level (Cohen et al., 2014).

Placement into developmental coursework is also more common among African American and Hispanic demographic groups, first generation, and female students (Chen, 2016). However, the need for remediation is widespread among advantaged and disadvantaged. Of students from high-income families who began their education at a community college, 59% began in remedial coursework (Chen, 2016).

Students need developmental education for multiple reasons. Bailey (2009) and the National Center for Public Policy and Higher Education and the Southern Regional Education Board ([NCCPPHE & SREB, 2010) show the percentage of students needing developmental education to be significant, around 60% (Bailey, 2009; NCCPPHE & SREB, 2010). A percentage of students perform poorly in all subjects and need remediation in multiple areas (Bailey, 2009). Alternatively, other students are deficient in one subject only. Adult students who were proficient in subjects at one time may need refreshing in specific areas due to disuse of those skills. Additionally, students with learning disabilities or language barriers may also need remedial education. Typically, community colleges offer developmental education for remediation in reading, writing, and arithmetic, and students place into appropriate levels of instruction based on entrance or assessment testing. These courses usually do not earn college credit toward a degree or certificate but are likely required to move into the credit-level courses required by a degree (Cohen et al., 2014).

Fields and Parsad (2012) report that 100% of community colleges use a math placement test and 94% use a reading test. These placement tests determine if a student places into coursework below college-level, or developmental. Developmental coursework develops preparedness in students with weak academic skills, so they progress to college-level coursework. The need to place students into appropriate levels of coursework is established, but

continued research of student progression and success in developmental sequences is necessary (Bailey et al., 2010).

Students who place into developmental coursework and display greater deficiencies may be required to complete multiple courses over the course of two, three, or more semesters in order to move into college-level work. Bailey et al. (2010) gathered data from Achieving the Dream's Community Colleges Count Initiative and the National Education Longitudinal Study of 1988 to study student progression in developmental coursework. The results of this study indicated that although students complete the majority of developmental courses, only 33 to 46% of students complete their full developmental sequence (Bailey et al., 2010).

Completion of the full remedial course sequence associates with positive outcomes. Students who completed their full remedial sequence were more likely to earn college-level English and math credit, transfer to a baccalaureate college or university, and graduate with a bachelor's degree than their non-completing counterparts or students who did not take any remedial coursework (Bailey et al., 2010; Chen, 2016). Remedial completers are also less likely to drop out of college than those who did not complete their developmental sequence or take any remedial coursework (Chen, 2016). In fact, overall, students who completed remedial coursework and progressed into college-level coursework had the same or even better outcomes than those who did not take any remedial courses (Chen, 2016). Students with the poorest outcomes were those who did not complete remedial coursework (Chen, 2016).

The overall cost of this type of remediation is expensive for community colleges and taxpayers. The annual cost of developmental education in the United States is approximately \$7 billion (Scott-Clayton & Rodriguez, 2012) and \$4 billion for community colleges, alone (Scott-Clayton, Crosta, & Belfield, 2014). There is also a significant cost for students, both financially

and psychologically. Students accumulate debt, lose earnings, spend a significant amount of time on these courses, and are often discouraged when they realize they cannot move directly into college coursework (Scott-Clayton & Rodriguez, 2012; Chen, 2016). In essence, they must redo high-school level coursework again before they can move on. However, developmental education is in place to fulfill the mission of community colleges, access to education, especially to underprivileged populations. Therefore, supporters argue that developmental education is necessary, and the value outweighs the cost. The controversy about the cost and value of developmental education has led to an emphasis on research exploring the efficacy of these programs (Bailey et al., 2010).

Developmental Math

The United States lags behind in mathematics achievement when compared to other industrial nations (NCES, 2009). Despite various reforms such as No Child Left Behind, Every Student Succeeds Act, and Common Core State Standards for Mathematics, the United States continues to struggle to compete with other countries, especially in math and science (Dossey, McCrone, & Halvorsen, 2016). The United States participates in the Programme for International Student Assessment (PISA), which studies the mathematics and science literacy of 15-year-olds in 64 countries (Dossey et al., 2016). On the 2012 PISA, U.S. 15-year-olds scored significantly lower than the average country mean score. The data from the 2012 PISA indicates that students in the United States struggle with mathematics skills that require complex cognitive demands (Organization for Economic Cooperation Development (OECD), 2012). The more recent 2015 PISA showed no improvement in math scores compared to other countries (OECD, 2016).

In 2009, President Barack Obama encouraged Americans to prioritize education to reclaim the United States' status as the best-educated nation in the world (Lee, 2012). Having a

highly educated nation is critical for the national economy as more occupations than ever require skills and education beyond the high school level (Carnevale et al., 2016). For students to take advantage of education, especially in countries where community colleges make higher education accessible and affordable, students must be academically ready to benefit from college coursework. SAT or ACT standards-based educational assessments or placement testing done at entry into a college typically determines college-level academic preparedness. It is also worthwhile to consider the K-12 math pathway into college-level coursework (Lee, 2012). There are a significant proportion of high school graduates entering higher education unprepared for college-level math coursework (Chen, 2016; Bailey et al., 2010; Attewell et al., 2006). Community colleges are a gateway for these students to move into higher education, yet they struggle in completing their math sequence (Bahr, 2008). More than half, or 59.3%, of all students entering community college are required to take at least one developmental math course (Chen, 2016).

Students who complete their remedial math sequence were the most successful at completing college-level math credit. Of students who completed a remedial math sequence, 71% of them took college-level math courses, and 62% of them received credit for college-level math toward their degree requirements (Chen, 2016). This is a significantly higher rate than students who did not complete a remedial math sequence; of those, only 32% attempted college-level math, and 18% received credit (Chen, 2016). Surprisingly, it is also a higher rate than for students who did not take any remedial math; 53% attempted college-level math, and 48% received college credit (Chen, 2016). These statistics demonstrate the value of remedial education, especially for those students who persist through an entire sequence and enroll in credit-level math coursework.

Student Developmental Theory

Student developmental theory provides insight into the experience of academically unprepared college students. Chickering (1969), Astin (1985b), and Tinto (2012) describe the barriers that at-risk or academically unprepared students face and the developmental process that occurs during college. The insight provided by these student development theories provides context to surrounding the student experience as well as the academic and non-academic factors that influence student success.

Arthur Chickering (1969) identified seven vectors of college student development. These include achieving competence, managing emotions, developing autonomy, establishing identity, freeing interpersonal relationships, clarifying purpose, and developing integrity (Chickering, 1969). Students develop many of these vectors at once, creating competing demands on students' time and effort. Students are developing intellectual and interpersonal competencies as they adjust to college. They are also coming to terms with their academic identity and thinking about who they are as a student. Finally, students are establishing their purpose; at this stage, they are contextualizing how college fits within their ultimate career and life goals.

Astin's (1985a) student involvement theory indicates that there is a positive correlation between the amount of energy and time that a student dedicates to the academic experience and their success. Involvement includes time studying, time spent on campus, participation in campus organizations, and interactions with college faculty and staff. Although Astin's research focuses on four-year institutions rather than community colleges, the majority of community college students embody at least one factor such as being a single parent, commuting, or attending college part-time (Achieving the Dream, 2006; Astin, 1992b; Community College Survey of Student Engagement, 2005) that make it difficult to dedicate enough time to

involvement activities. Community college students commute to campus which creates a challenge for community colleges to develop an environment that promotes involvement and engagement. Astin's theory also stresses the need for educators to nurture students' talents, especially in developmental education. Astin (1985b) states that the purpose of higher education is to develop talent rather than produce.

Tinto's (2012) theory of student departure identifies the primary reasons students do not persist in college. The quality of students' interactions with their college influences student retention. Students enroll in college with different characteristics that affect the level they would be considered at risk for not persisting. Colleges are also composed of different characteristics, which may be supportive and align with an individual student's needs or may be in conflict with the student's characteristics. Tinto (2012) argued that there are three primary causes of student departure. These causes are academic problems, failure to integrate socially and intellectually with the college, or a low level of commitment to the college.

Psychological Factors that Impact Academic Performance

Academic performance in math is influenced both positively and negatively by psychological factors. Boylan and Saxon (1998) found that effective developmental education programs encompass both the academic and noncognitive factors that influence student success in college. Psychological barriers often occur due to students' perception of their ability (Boylan & Saxon, 1998). Noncognitive or psychological factors that can be influenced by educators include self-efficacy, locus-of-control, grit, and mindset toward learning (Boylan & Saxon, 1998).

For math specifically, past performance, stereotypes, and low placement in math shape students' perspective of their ability (Bandura, 1977). Bandura (1977) notes that if a student

receives a poor grade in math and makes the assumption that the grade indicates that he/she is bad at the subject, the student will not be motivated to put forth the time and effort to improve math ability or grades. Noncognitive or psychological factors related to students' beliefs toward their abilities in math influences this perception.

In a study of freshman college students, Hall and Ponton (2005) found that students enrolled in calculus had a higher belief in their ability to succeed in college math coursework than students enrolled in developmental math. They suggest that developmental math students benefit from self-efficacy enhancing instructional methods. "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Having high self-efficacy in math indicates a strong belief that one can do what is needed to learn math. "Academic self-concepts, attitudes toward success in mathematics, confidence in ability to learn mathematics, mathematics anxiety, self-efficacy, and locus of control are all variables that affect student goals, performances, and attainments in mathematics" (Hall & Ponton, 2005, p. 26).

Students who place into developmental math are likely to have lower self-efficacy toward math because they see their placement into remedial coursework as evidence of their lack of skills needed to perform math-related tasks (Hall & Ponton, 2005). For developmental math teachers to be effective, they must address noncognitive factors along with academic content. Hall and Ponton (2005) suggest giving students achievable goals for small success in math, showing students the practical applications and significance of math, and encouraging questions and discussion about math topics as ways to increase self-efficacy toward learning math.

Locus-of-control is a noncognitive factor that relates to performance in college coursework. Locus-of-control refers to the belief that actions will result in intended outcomes

(Bandura, 1997). Internal locus-of-control exists when there is a high belief that actions affect outcomes, whereas one with an external locus-of-control believes that their actions do not impact outcomes to the same extent as external forces (Bandura, 1997). According to a study of factors perceived by students in a developmental math course at a public university, students attributed poor performance to factors that were not under their control such as having an instructor who is a non-native English speaker or by having a graduate assistant teach their course (Wheland et al., 2003). Both factors were determined to not correlate with performance, indicating that students were placing the blame for their lack of success in math on external forces that were not actually impacting their performance rather than taking ownership of their performance, or having an internal locus-of-control.

Placement into remedial coursework can have a negative impact on students' self-esteem, lower their educational expectations, and increase frustration, all of which may influence their persistence in college (Chen, 2016). In fact, more than 68% of students placed into developmental math had an entity or fixed theory about their math ability (Yeager & Dweck, 2012). These students believe that they have a fixed or unchanging ability toward learning math and placing into coursework below college-level substantiates their inability to do well in the subject. Students with a fixed mindset toward learning math do not believe that they can change their math abilities which, in turn, demotivates a student to put forth effort (Dweck, 2008b).

Grit, the perseverance and passion for long-term goals, and growth mindset are examples of psychological factors that have a positive influence on academic performance, whereas the lack of grit or a fixed mindset have a negative influence (Duckworth, 2016; Dweck, 2008b). Additionally, evidence shows that stereotype threat can also hinder academic performance, although interventions have been shown to successfully limit the effects of the threat (Inzlicht,

Tullett, Legault, & Kang, 2011; Steele, 1997).

Duckworth, Peterson, Matthews, and Kelly (2007) define the noncognitive trait grit as “perseverance and passion for long-term goals” (p. 1087). Duckworth et al. (2007) sought to answer the question, “Why do some individuals accomplish more than others of equal intelligence?” (p. 1087). They suggest that grit is a factor that is shared by successful people across all fields. “Grit entails working strenuously toward challenges, maintaining effort and interest over years despite failure, adversity, and plateaus in progress” (Duckworth et al., 2007, p. 1087-1088). Growth mindset is connected to grit through the understanding that effort leads to progress over time despite obstacles (Dweck, 2008b). Students with grit and growth mindset are more resilient to challenges such as completing developmental math courses because they are persistent in their efforts to achieve their goals (Dweck, 2008a; Duckworth, 2016).

Duckworth et al. (2007) created a questionnaire called the Grit Scale to assess self-control, perseverance of effort, and consistency of interests over time. Their validation study of the Grit Scale found that those who assessed higher in grit were more educated than those who were found to be lower in grit. The validation study also indicated that participants with an associate degree were higher in grit than those with a bachelor’s degree. Duckworth (2016) surmises that community college graduates exhibit grit by defying the odds and completing their degree despite high dropout rates. A correlation exists between grit and the willingness to engage in remedial coursework and the use of learning strategies to reach an academic goal (Hong, Chiu, Dweck, Lin, & Wan, 1999).

Stereotype threat is an additional psychological factor that creates a barrier toward academic performance. Steele, Aronson, and Kruglanski (1995) developed the foundational theory on stereotype threat which later was identified as “the apprehension targets feel when

negative stereotypes about their group could be used as a lens through which to judge their behaviors” (Inzlicht et al., 2011, p. 227). This perception creates a barrier by leading to a self-fulfilling prophecy. If a student feels that they are being judged based on stereotypes that imply their group is unlikely to perform at a high level academically, they internalize that stereotype and accept a low expectation for academic performance.

Steele et al. (1995) performed one of the initial studies of the relationship between stereotype threat and test performance of African American students. The focus of their studies was on “the broad dissemination of negative stereotypes about one’s group – the threat of possibly self-fulfilling such a stereotype” (Steele et al., 1995, p. 798). The amount of preparation does not explain the achievement gap between majority students and African American students; Steele et al. (1995) note that African American students have lower achievement even with the same high-level amount of preparation. Stereotype threat interferes with performance by directing focus to unnecessary worries, creating self-consciousness that distracts from education, increasing over caution, or fostering expectations for low performance that causes students to withdraw effort (Steele et al., 1995).

The study performed by Steele et al. (1995) consisted of a 30-minute test given to African American and majority college students that was designed to be challenging for all participants. The researchers told the experimental group that the test was “diagnostic of intellectual ability, thus making the racial stereotype about intellectual ability relevant to Black participants’ performance and establishing for them the threat of fulfilling it.” (Steele et al. 1995, p. 799). The first control group was told that the same test was a “laboratory problem-solving task that was non-diagnostic of ability” (Steele et al., 1995, p. 799). The second control group was told to view the test as a challenge. African American students performed more poorly on the test in the

experimental group but matched performance when the test did not link to ability.

Evidence shows that stereotype threat, especially for women and African American students, has an adverse effect on standardized test scores and academic performance and interventions that reduce this threat can minimize the impact (Steele, 1997). Steele (1997) explored “how societal stereotypes about groups can influence the intellectual functioning and identity development of individual group members” (p. 613). The two populations Steele (1997) identified as being susceptible to stereotype threat included women and African American students. Steele describes the assumption behind stereotype threat: “To sustain school success one must be identified with achievement in the sense of its being a part of one’s self-definition, a personal identity to which one is self-evaluatively accountable” (p. 610). If a student has a positive relationship with school and feel that they have the interests, skills, resources, opportunities, and a sense of belonging, they will have a stronger belief in their ability to do well (Steele, 1997).

According to Steele (1997), African American and female students have historically had limited access to education because of “socioeconomic disadvantage, segregating social practices, and restrictive cultural orientations” (p. 613). For example, female students have historically had few role models in math and science fields and often face low expectations from teachers, family members, and societal gender roles on performance in these subjects. These factors limit their ability to form a connection or identify with an educational institution which according to Chickering (1997), Astin (1985b), and Tinto (2012), are critical for academic success, retention, and persistence. In an educational context, African American and female students have faced the additional barrier of being in an environment where a negative stereotype for their group exists. An association exists between these groups and low academic performance

in some or all subject areas which influences group members' perception of their ability in those areas.

According to Inzlicht, Aronson, Good and McKay (2005), self-monitoring can reduce stereotype threat and improve resiliency. Self-monitoring is "the desire and ability to control one's self-expressions in order to cultivate a desired public image" (Inzlicht et al., 2005, p. 325). High self-monitoring counteracts the effect of stereotype threat in that rather than conceding to the perceived stereotype of that group, a highly self-monitoring individual is better equipped to manage how they present themselves. As long as coping ability is greater than the perceived threat, students view academic situations as challenges and opportunities for improvement.

Inzlicht et al. (2005) performed two studies to test the relationship between self-monitoring and the effects of stereotype threat, particularly in environments where majority students outnumbered those susceptible to stereotype threat. The first study tested how self-monitoring relates math performance for female undergraduate students. Participants took a challenging 20-minute math test with questions taken from the Graduate Record Examination (GRE). Participants in the experimental group took the test in groups of one female and two males, and the control groups took the test in groups of three females. Participants took a self-monitoring scale questionnaire to assess their level of self-monitoring. The hypothesis stated that high self-monitoring females in the mixed-gender groups would perform at a higher level than low self-monitoring females and that performance would be the same in the all-female groups. They found that high-self monitors performed higher in both groups.

Their second study replicated most of the conditions of the first study but tested the relationship between self-monitoring and performance for African American undergraduate students on a word-fragment completion test. They hypothesized that high self-monitors would

perform at a higher level than low self-monitors in the groups where majority outweighed minority students. The results suggested that self-monitoring has a similar impact on coping with stereotype threat for minority students as it did for female students. The results indicate that high-levels of self-monitoring counteract the adverse performance conditions of being in the numerical minority.

Inzlicht et al. (2011) found that stereotype threat has long-lasting effects and is present beyond stereotyped domains. This spillover leads to a reminder that even if a student is not currently in an environment that fosters a negative academic stereotype, having been in such an environment leads to lasting perceptions of ability unless addressed. It is also important to note that someone who is under stereotype threat can perform at the same level as someone who is not facing a threat but will likely need to use additional strategies or coping mechanisms to do so.

Psychological or noncognitive factors are common barriers for students who place into developmental math (Bandura, 1977; Hall & Ponton, 1995). The actual placement into coursework below college level can cause lower self-efficacy, an external locus-of-control, lower self-concept, and a fixed mindset toward learning math (Bandura, 1977; Yeager & Dweck, 2012). Many of these students are also affected by stereotype threat (Stele et al., 1995). Effective teaching of developmental math balances academic content with methods to increase self-efficacy, develop an internal locus of control, develop grit, and encourage a growth mindset toward learning math. At-risk students such as those who place into developmental coursework are better able to overcome barriers if psychological factors are addressed along with the teaching of content.

Implicit Theories of Intelligence

Implicit theories encapsulate beliefs about the malleability of the brain, abilities, and

personal characteristics (Dweck & Leggett, 1988; Molden & Dweck, 2006). Theories of intelligence are typically internalized, hence the use of the term, “implicit” (Yeager & Dweck, 2012). Studies show that implicit theories of ability and intelligence impact students’ motivation to learn and improve performance. (Blackwell et al., 2007). Two polarized implicit theories exist, entity and incremental, which present in the belief that intelligence is fixed or can grow (Dweck, 2008b).

The study of implicit theories began with the description of two patterns of behavior, the maladaptive helpless response and the adaptive mastery-oriented response (Dweck, 1975). The helpless response presents through avoidance of challenge and a decrease in performance whereas the mastery-oriented response results in the seeking of challenges and effective performance. Students with initial equal ability will perform differently depending on whether they present with the helpless or mastery-oriented response (Dweck & Leggett, 1988).

Dweck and Leggett (1988) tested and supported the hypothesis that two types of goals exist which foster the two different response patterns. Performance goals are those which are created out of concern for the judgement of performance or competence. Learning goals are those created out of concern for increasing competence. Dweck and Leggett (1988) discovered an association between the perception that intelligence is malleable and setting learning goals and seeing intelligence as fixed with setting performance goals.

Performance goal orientation relates to the perception that ability is stable, or fixed, and can result in learned helplessness (Dweck & Leggett, 1988; Schunk, Meece, & Pintrich, 2014). Students with a performance goal orientation focus on displaying their competence and are concerned with how others judge their abilities. They actively avoid judgment on low ability and seek recognition for high ability (Dweck & Leggett, 1988; Schunk et al., 2014). They evaluate

their performance on standards such as grades or being the best performer in a class. Students with a performance goal orientation see ability and effort as inversely related; the need to put forth effort shows low ability (Schunk et al., 2014). Additionally, the perception exists that the need to seek help is a demonstration of low ability. This mindset leads to a helpless pattern when performance goal-oriented students avoid effort and seeking help to protect their perception of their ability (Dweck & Leggett, 1988; Schunk et al., 2014).

Learning or mastery goal-orientation presents in students who focus on learning, mastering tasks, and developing their competence (Dweck & Leggett, 1988; Schunk et al., 2014). Students with a learning goal-orientation evaluate themselves on their progress and how much they have improved their understanding of a topic. They see effort and ability as a positive correlation; more effort results in a higher increase in ability (Dweck & Leggett, 1988; Schunk et al., 2014). Seeking help is an avenue to improve progress and increase learning and is therefore utilized. Students with a growth mindset are more likely to set learning goals rather than performance goals (Dweck, 1999). See Table 2 for a comparison of learning vs. performance goal orientations.

Table 2: Characteristics of Learning Versus Performance Goal Orientation

FACTORS	LEARNING GOAL ORIENTATION	PERFORMANCE GOAL ORIENTATION
Focus Toward Learning	Focus on learning new skills/concepts.	Focus on appearing more capable or intelligent than others
Mindset	Growth	Fixed
Attitude Toward Risk-Taking	Willing to take risks.	Prefer easy or familiar tasks with anticipated outcomes.
Attitude Toward Mistakes	See mistakes as learning opportunities.	See mistakes as evidence of lack of ability and avoid them.

(Adapted from Schunk et al., 2014)

The belief that intelligence is fixed and unchangeable is considered an entity theory of

intelligence (Dweck & Leggett, 1988). Those with an entity theory of intelligence have what is considered a fixed mindset. Students with a fixed or entity theory of intelligence believe that when they encounter academic challenges through coursework that is difficult, it is a sign that they are dumb or have fixed, low intelligence (Yeager & Dweck, 2012). This belief has a demonstrated negative impact on resilience in academic settings, as students do not believe that they can improve their intelligence or abilities and, therefore, lack the motivation to put forth the effort to attempt to overcome a challenge (Blackwell et al., 2007; Hong et al., 1999; Nussbaum & Dweck, 2008).

Students with an entity theory see challenges, obstacles, and effort as factors that measure their ability and are defensive or threatened by difficulty (Dweck, 2006, 2008b; Yeager & Dweck, 2012). It is necessary for them to appear smart, and they will seek out easy opportunities to succeed (Dweck, 1999). They see effort as only needed by those who do not have ability and retreat when they feel they do not naturally have the ability to accomplish a task (Dweck, 2008b).

Conversely, the belief that intelligence can grow through effort is called incremental theory of intelligence (Dweck & Leggett, 1988; Yeager & Dweck, 2012). Those with an incremental theory of intelligence have what is considered to be a growth mindset. Students who believe that intelligence develops throughout life are more resilient during academic transitions and are more likely to complete challenging math coursework (Yeager & Dweck, 2012). Students with an incremental theory of intelligence see challenges, obstacles, and effort through a lens learning, growth, and opportunities to improve (Yeager & Dweck, 2012). They believe that positive change despite academic adversity is possible (Blackwell et al., 2007). Additionally, those who believe in the incremental theory of intelligence understand that people have different

abilities and skill levels but agree that everyone can develop and improve those abilities and skills through effort (Dweck, 1999).

An incremental theory of intelligence has a positive influence on resilience and performance through students’ goal-setting, beliefs about the outcome of effort, and learning strategies (Yeager & Dweck, 2012). Students with an incremental theory of intelligence display learning goals and are eager to learn as opposed to having a primary focus of appearing smart with a fear of seeming unintelligent (Dweck & Leggett, 1988). Students with a growth mindset care about their grades but care more about learning new material (Dweck, 2008a). They believe that effort is worthwhile as it leads to outcomes of success and growth. In fact, students with an incremental theory of intelligence embrace challenges as they provide an opportunity for growth (Mueller & Dweck, 1998). Therefore, they develop learning strategies to overcome setbacks or challenges and display resilience, rather than giving up. Moving from an entity theory of intelligence to one of incremental is possible and leads to positive changes in academic behavior, especially in how students set goals, perceive effort, and develop learning strategies (Aronson et al., 2002; Blackwell et al., 2007; Good et al., 2003; Yeager & Dweck, 2012). (See Table 3.)

Table 3: Growth and Fixed Mindset Comparison

FACTORS	GROWTH MINDSET	FIXED MINDSET
Response to Challenges	See challenge as opportunity to improve abilities and persist in the face of setbacks.	See challenge as threat to intelligence and give up easily.
Perception of Effort	Leads to improvement	Not worth putting forth
Response to Feedback/Criticism	Learn from feedback/criticism.	Ignore feedback/criticism.
Perspective on Success of Others	Learn and find inspiration from the success of others.	Threatened by success of others.

Note. Adapted from infographic created by Nigel Holmes.

According to Dweck (2008a), approximately 40% of students are classified as having a fixed mindset, 40% have a growth mindset, and about 20% are unsure. However, the percentage of students with a fixed mindset toward math is higher than other subjects. One reason for this is that parents and educators praise intellectual ability in math, or conversely, relieve a student of their responsibility for doing well in math by telling them they are not a “math person.” Both of these approaches can lead to a fixed mindset as they deter a student from making the connection that effort can lead to growth in abilities (Dweck, 2008a).

Giving students praise for their intelligence rather than praising the process or effort leads them to believe that their intelligence and abilities are stagnant, or fixed (Cimpian, Arce, Markman, & Dweck, 2007; Kamins & Dweck, 1999; Mueller & Dweck, 1998). This type of praise motivates students to avoid challenges as, from a fixed-mindset perspective, experiencing a challenge runs counter to being perceived as having natural ability or intelligence in that area. Students who receive praise for their intelligence are likely to lose motivation and confidence when a task becomes difficult (Dweck, 2008a). In contrast, praising the process of working hard toward a goal or improvement of an ability leads students to recursively continue to put forth effort and see the results of growing abilities (Dweck, 2008a).

According to the Project for Education Research That Scales (PERTS, n.d.), a Stanford University-based research group, specific tactics or messages influence students’ adoption of a growth mindset. They recommend the avoidance of simply telling a student to adopt a growth mindset or “just try harder” (PERTS, n.d.) as both potentially cause an adverse reaction. Rather, they suggest the following as evidenced in the research group’s studies on growth mindset.

Celebrate mistakes and challenges:

Many students fear making mistakes. They think mistakes mean they are not smart. But research shows that conceptual mistakes are an important part of learning. Having to

work through a difficult problem and try different strategies is the best way to get better at a subject. Tell your students that you like mistakes and show them how to learn from them. (PERTS, n. d., para. 1)

Praise the process, not the person:

Our intuition is to often praise students for being smart. This sends the wrong message. When students later encounter a setback, they conclude: “If my past success made me smart, my current struggle makes me dumb.” Instead, praise students when they work hard to accomplish a difficult task. This implies that you value hard work and that hard work is the cause of success. (PERTS, n.d., para. 2).

Give growth mindset encouragement: “When students are struggling, remind them that challenges are the best way to growth their brains. Help them picture their brains getting stronger as they work through a difficult problem” (PERTS, n.d., para. 3). Give tasks that are open to interpretation: “Give tasks with multiple steps and multiple right answers. This encourages students to learn concepts instead of memorize lists of facts or rules (PERTS, n.d., para. 4).

Assess learning, not just performance: “Are students engaged in the learning process? For example, in group work: Are students leaning in? Is everyone participating? Are students asking each other questions?” (PERTS, n.d., para. 5).

These tactics and messaging are a result of multiple studies administered by the PERTS research group studying a range of participants as part of the Changing Mindsets to Raise Achievement project (PERTS, n.d.). Since 2012, they have administered interventions to high school students, community college students, and through Khan Academy.

Neuroplasticity

Understanding basic concepts of neuroplasticity, which is the brain’s ability to develop and adapt (Ricci, 2013), can build students’ confidence about being able to overcome a challenge, and significant evidence supports neuroplasticity and the brain’s malleability. Many

students feel that they have limited math abilities (Bandura, 1977; Hall & Ponton, 1995). Understanding the science behind the brain's ability to form new connections and develop substantiates the concept that individuals can improve their math ability. Connecting the concepts of neuroplasticity with the focus on learning goals rather than performance goals can motivate students to put forth the effort needed to experience improvement in ability (Blackwell et al., 2007).

The concept of neuroplasticity is over 200 years old, originating from evidence showing that mental exercises lead to brain growth (Costandi, 2016). According to Costandi (2016), “physical activity, environmental enrichment, and learning tasks enhance the proliferation of neural stem cells and, in some cases, promote the survival of newborn neurons” (p. 77). Participating in learning exercises affects the actual make-up of the brain. Additionally, “training optimizes the brain areas and neural pathways involved in performing a given task: as a result, the individual's performance on that task improves, and the task eventually becomes automatized and effortless” (Costandi, 2016, p. 96). By putting forth persistent effort toward a task, the brain is altered, and the task becomes more effortless.

Neuroplasticity is “the capacity of the nervous system to modify its organization” (Sagi et al., 2012, p. 1195). Neuroplasticity includes the strengthening of neural pathways and the formation of long-lasting neural connections (Sagi et al., 2012). Sagi et al. (2012) studied structural changes in brain tissues of individuals after they had performed a spatial learning and memory task based on a computer car race game. Their study included 46 participants divided into a learning group and two control groups. The learning group played the computer car race game 16 times running the same track with the objective of learning the track and improving their race time. The control groups played the race game for the same amount of time but were

given different tracks for each trial and, therefore, not expected to memorize the track.

The learning group improved their race times significantly, whereas the control group did not improve their times. MRIs of both groups showed that this short-term learning exercise led to significant differences in MRI indicators. Structural aspects of neuroplasticity attribute to this difference (Sagi et al., 2012). This study shows that even short-term learning affects the brain's structure. Sagi et al. (2012) further hypothesize that this short-term effect can have long-lasting electrophysiological effects and supports the recursive nature of teaching students that intelligence is malleable. As students put forth effort toward learning, they experience the effect of neuroplasticity by being able to overcome progressively more difficult challenges which will, in-turn, substantiate the relationship between effort and success.

Diamond, Barnett, Thomas, and Munro (2007) studied how executive functions, or cognitive control, can be taught to preschoolers. Diamond et al. (2007) define executive functions as inhibitory control, memory, and cognitive flexibility. The study included a total of 24 classrooms of preschool students. Teachers in the experimental group spent approximately 80% of their day incorporating 40 executive functioning promoting activities. Teachers in the control group taught the same academic content but did not incorporate executive functioning promoting activities. The results showed that students in the experimental group performed significantly better on accuracy and memory exercises. This study shows that ability develops through the teaching of strategies that relate directly to cognitive functioning rather than the teaching of material alone.

Psychological Interventions in Math

Recent findings have shown that school-administered psychological interventions can have a positive and lasting impact on student achievement (Cohen & Sherman, 2014; Garcia &

Cohen, 2012; Walton, 2014; Yeager et al., 2016a; Yeager & Walton, 2011). These interventions do not provide academic instruction, but address students view of their abilities, their experience with education, and their relationships in school (Yeager et al., 2016a). For example, motivation is increased when students are led to perceive that they have the potential to improve their abilities and see that putting forth effort leads to results (Dweck, 2006; Yeager et al., 2014). The following psychological interventions are a sample of studies relevant to and supportive of academic mindset interventions.

These types of interventions are lasting because they become self-confirming (Yeager et al., 2016a). When students do poorly on a math test, they may believe that this is proof that they are simply bad at math and will continue to act in ways that provide further evidence of this being true. They are likely to study less and avoid challenges involving math. However, by changing behaviors and showing students that effort can result in positive changes in math ability, students will experience continual positive reinforcement for their behavioral change (Cohen & Sherman, 2014; Garcia & Cohen, 2012; Walton, 2014; Yeager et al., 2016).

Several aspects of psychology have been used to create interventions to address barriers to math performance. For example, Bol, Campbell, Perez, and Yen (2015) studied the effects of an intervention on self-regulated learning training and metacognition on 116 students at an urban community college in Virginia. Self-regulated learning consists of “a proactive process whereby individuals consistently organize and manage their thoughts, emotions, behaviors, and environment in order to attain academic goals” (Ramdass & Zimmerman, 2011, p. 198). They found significant improvement in math achievement in the experimental group that received a self-regulated learning and metacognition intervention, suggesting that training in self-regulated learning influences positive behaviors toward time management and self-regulation. These

positive behaviors result in improved math achievement in developmental math coursework.

Walton and Cohen (2011) studied the effect of a social-belonging intervention on academic performance of minority high school freshmen over three years. According to Walton and Cohen (2011), social belonging is a psychological factor and a fundamental human need. Having social belonging as an unfulfilled need can lead to lower intellectual achievement. Students who face stereotype threat often feel uncertain about their social belonging in academic settings.

Walton and Cohen (2011) designed an intervention for students transitioning to college, a time when students can feel a lack of social belonging. The goal of the intervention was to encourage an interpretation of adversity that does not lead a student to feel that they do not belong. They hypothesized that the intervention would trigger long-term results, especially for minority students. By changing the way students process social interactions and developing a mindset that assured feelings of belonging, early gains would reinforce the feeling of belonging and create a positive recursive cycle that would result in long-term effects.

The population administered the intervention consisted of 49 African American students and 43 European American students in the second semester of their freshmen year at a four-year college. The experimental group participated in an intervention that taught them that social adversity is not attributed to fixed traits the students embody but is a typical component of adjusting to college. The grade point averages of African American students in the experimental group rose over time, whereas African American students in the control group saw no change in grade point average.

Sense-of-purpose interventions are also effective psychological interventions. They require students to reflect on how hard work and learning can help them reach their goals with an

emphasis on how they can contribute to their community or help other people (Paunesku et al., 2015). The scope of this type of intervention extends beyond an academic framework to students' lives in general. However, they can increase academic performance by maintaining students' motivation by increasing students' awareness of the purpose of learning and its relevance to their goals and purpose.

Academic Mindset Intervention Studies

Interventions with a purpose of changing academic mindsets from fixed to growth or implicit theories of intelligence from entity to incremental have had positive results on academic performance. According to Paunesku et al. (2015), this type of psychological intervention can be effective despite being brief if students are active participants in the intervention. However, Yeager and Walton (2011) stress although many psychological interventions have lasting effects, they are not magic. These interventions only have results if they change the way students feel about their abilities and their attitude toward school and this change in belief creates a self-reinforcing recursive process. Psychological interventions that trigger this type of recursive process result in academic improvement even if they are brief and do not need to occur multiple times. Additionally, they only impact students whose performance is affected by psychological issues, not external forces.

Often, psychological interventions are effective because they address students' abilities to overcome barriers or restraining forces (Yeager & Walton, 2011). For example, concerns about negative stereotypes or ability can hinder student success. Teaching a student that they can overcome these concerns leads to improvement in academic performance.

Yeager and Dweck (2012) assert that mindset interventions teach students that intelligence can develop. Students can learn the science that proves that abilities can be improved

and incorporate this knowledge to their own lives (Aronson et al., 2002; Blackwell et al., 2007; Good et al., 2003). Specifically, academic mindset interventions can reverse the impact of a fixed mindset on achievement in math over time as well as reduce the discrepancies in math performance for women and minority students (Dweck, 2008a).

Dweck (2008a) defines the difference between a fixed and growth mindset. A growth mindset is conveyed “by teaching students about the new science of brain plasticity and the new view of talent and giftedness as dynamic attributes that can be developed” (Dweck, 2008a, p. 9). Also, it is critical to portray “challenges, efforts, and mistakes as highly valued” (Dweck, 2008a, p. 12). Finally, it is necessary that praise and feedback focus on the process rather than on the intelligence, talents, or final product. Incorporating messaging to female or minority students that “past underachievement has its roots in environmental rather than genetic factors and can be overcome by enhanced support from their educational environment and by personal commitment to learning” can address stereotype threat (Dweck, 2008a, p. 15).

Aronson et al. (2002) succeeded in changing college students’ theories of intelligence through a growth mindset intervention. Their intervention consisted of teaching students the science behind the brain’s malleability, having them create a mental image of the brain developing neural connections when effort is put forth in the face of academic challenges, and writing a letter to a struggling student using what they learned from the intervention. Students were asked to generate and promote a message to a younger student on how the brain can grow. This activity is a powerful social means of persuasion. The intervention group had an average increase in their grade point average of .23.

Good et al. (2003) studied the effect of implicit theories on academic resilience on seventh graders. The purpose of this study was to determine if an intervention program could

address stereotype-based educational performance for students during the transitional period to junior high school. In particular, the study hoped to address the socioeconomic disparities in education for minority students and underperformance of females in math and science. The majority of the students who participated in the study were underrepresented and low income. Twice, students met with college student mentors for 90 minutes each and received weekly emails from them explaining the concepts of incremental theory by explaining how the brain is malleable and normalizing academic challenges. Those in the intervention group had higher math and verbal scores on their statewide achievement test.

Overall, students in the experimental group performed better than students in the control group. However, female students in the experimental group had significantly higher standardized test scores in math than females in the control group. In fact, the experimental group did not show a significant difference between genders on the math test, whereas male students performed significantly higher on the math test in the control group. Therefore, this study provided promising results on a mindset intervention and overcoming gender stereotype threat.

Blackwell et al. (2007) implemented a longitudinal study researching the relationship between implicit theories of intelligence of seventh graders and academic achievement in math. This is a transitional time for students academically and personally. Junior high is often the first experience with competition, social comparison, and self-assessment of ability. These changes and pressures lead to disengagement from the academic environment and declining grades in some students. Other students, however, are resilient in the face of these changes. Blackwell, Trzesniewski, and Dweck (2007) studied the psychological mechanisms that enabled some students to overcome academic challenges and transition. The motivational component identified as enabling this result is the belief the implicit theory that intelligence is malleable versus the

theory that intelligence is fixed. Students' theories of their intelligence influence how they respond to an academic challenge.

Blackwell et al. (2007) identified three limitations of previous academic mindset studies:

1. They did not examine the role of theories of intelligence in long-term achievement trajectories.
2. They did not examine mediators of the impact of theories of intelligence on a change in grades.
3. They did not probe for motivational changes in the classroom. (p. 248)

In their studies, Blackwell et al. (2007) used longitudinal data from a field study of students in junior high school and administered an intervention to determine the relationship between intelligence theory and achievement and examine the mediators of this relation. The study addressed all three limitations in prior research by examining the long-term impact of intelligence theories on academic trajectories, testing a full mediational model, testing the impact of teaching an incremental theory of intelligence on declining achievement, and assessing the impact of the intervention on student behavior.

In their first study, Blackwell et al. (2007) measured the implicit theories of four groups of junior high students and assessed their educational outcomes in the seventh and eighth grades. They found that students' theory of intelligence is a significant predictor of achievement in mathematics. Students who believed that intelligence was malleable developed learning goals and outperformed students with an entity theory of intelligence. In their second study, Blackwell et al. (2007) administered an intervention to teach students the incremental theory of intelligence and studied the effects on motivation and achievement compared to a control group. For this study, they found that students who initially assessed as having an entity theory of intelligence

saw the most significant increase in their grade trajectory post-intervention. This finding indicates that even a brief intervention can have a meaningful effect on motivation and achievement.

Cohen, Garcia, Purdie-Vaughns, Apfel, and Bruzustoski (2009) also found that psychological factors have an impact on intellectual achievement and a short intervention can have a long-lasting impact. In particular, they studied the effect of a psychological intervention on negatively stereotyped minority students in an attempt to disrupt a recursive cycle where poor academic performance causes a psychological threat, which then has a negative impact on academic performance. Students who face a stereotype threat are more vulnerable to believing that academic failure confirms a stereotype regarding their abilities. They are more likely to have a fixed mindset regarding their abilities due to these stereotypes.

Cohen et al. (2009) observed students from the beginning of seventh grade through the end of eighth grade and found that the initial intervention led to higher grade point averages over those two years for students in the experimental group who also faced stereotype threat than those in the control group. Additionally, they found that the intervention had an impact on math placement. Students who faced stereotype threat and were in the experimental group saw greater representation in advanced placement in math.

Paunesku et al. (2012) adapted Blackwell et al.'s (2007) study with community college students in developmental math. This intervention specifically taught students about the malleability of adults' brains to address the perception that math ability is stagnant after greater periods of learning as children. This study combined teaching the factors of an incremental theory of intelligence with evidence that of an individual's potential to improve their ability in math, particularly adult students, including those who may not have been successful in math in

the past.

Paunesku et al. (2015) created and administered a growth mindset intervention to approximately 1,500 high school students via online delivery in an attempt to scale up academic mindset interventions. This intervention was designed to help students persist through academic difficulty and was designed to benefit poorly performing students. This study found favorable results; the intervention raised semester grade point averages for participating students in academic courses and increased the success rate in core courses.

Up until this point, growth mindset interventions required that researchers be present at schools to tailor the content of the intervention for the particular population, provide in-depth training to participating teachers, and control the execution and delivery of the intervention. Requiring a third party to be physically present during an intervention decreased the affordability and accessibility of being able to provide the content. Paunesku et al. (2015) were the first to test whether a growth mindset intervention could be administered on a larger scale and maintain the results of improved academic achievement.

To provide a standardized intervention that could be used widely, Paunesku et al. (2015) developed brief, computer-based modules using the tested psychological process for growth mindset interventions. Computer-based modules allow for delivery of the content without the need for researcher presence or teacher training. This delivery method creates open access to students at multiple sites and reduces logistical difficulty and related costs. This intervention consists of two 45-minute sessions administered two weeks apart in school computer labs. The students read an article describing neuroplasticity and the brain's ability to develop as a result of effort and scientific evidence of students' potential to increase intelligence through study and practice. The article stresses that challenges in school do not indicate limited intelligence or

potential but provides an opportunity to learn. The online intervention also includes two writing exercises. Students summarize the scientific evidence in the article, read a case study about a hypothetical student who is facing an academic challenge, and write advice they would give that student using what they learned in the article.

Yeager et al. (2016a) developed a methodology to design and redesign interventions with the purpose of scaling them up. They tested this methodology using a fixed and growth mindset intervention with students transitioning to high school. Previously, positive, but not rigorously tested, results occurred with school-administered psychological interventions. Online interventions allowed for a larger scale of administration, but no testing occurred on an entire student body or student subgroup. Yeager et al. (2016a) set out to study a population of students who were facing similar academic and psychological challenges for which an intervention might help them navigate.

The methodology was a randomized, experimental form with approximately 3,000 high school students as participants. The students included in the experimental group that received a growth mindset intervention had improved ninth-grade core-course grade point averages and reduced D and F grades. The intervention taught scientific facts about neuroplasticity, used writing assignments to help students internalize and synthesize the concepts, and aimed to increase persistence and encourage students to embrace challenges. This study gave insight into a process to scale up psychological interventions and expressly provided insight on how to develop an effective growth mindset intervention.

The study by Yeager et al. (2016a) employed an experimental design to test whether insights gained from the intervention lead to actual improvements. This methodology utilized A/B testing, through low-cost, short-term, random assignment experiments to revise and test the

intervention content. By revising and testing the intervention, it can be adapted for a specific population and maximize effectiveness. Growth mindset was chosen as the focus of the study as it correlates with success during education transitions, and there is a defined psychological process that explains how growth mindset relates to student success. They have since broadened this project to become the largest randomized study of mindset interventions (Mindset Scholars Network, n.d.). Ultimately, 20,000 ninth graders throughout the country will participate and result in outcomes that can be generalizable to ninth graders enrolled in high school in the United States.

PERTS (n.d.) researchers also administered a study at two community colleges with 886 participating students. This study included two 45-minute interventions administered within two-a-half weeks of each other. Random assignment designated students to a control group or one of three interventions; a growth-mindset intervention, a sense-of-purpose, or a combined intervention. The sense-of-purpose intervention leads students to define how their education helps them reach their life and career goals. The design of the growth-mindset intervention was based on the Paunesku et al. (2015) study. Students read an article on the connection between neuroplasticity and an individual's potential to become more intelligent through applied effort. Students then completed writing activities reinforcing the concepts learned in the article. Students who participated in the growth-mindset intervention were more likely to complete their math course satisfactorily.

Conclusion

This literature review provided an overview of the concepts that are relevant to this research study. Math performance in the United States is not competitive with other countries (OECD, 2016). Community colleges provide an opportunity for academically unprepared

students to develop math skills, but students struggle to complete their developmental math sequences and move into credit-level courses needed for their credentials (Bailey et al., 2010). Multiple factors create barriers to success in developmental coursework including psychological causes such as stereotype threat (Steele, 1997), noncognitive elements (Bandura, 1977), implicit theories of intelligence (Dweck & Leggett, 1988), as well as unmet student development conditions.

A significant body of research exists on implicit theories of intelligence and the science of neuroplasticity. This research informed numerous academic mindset interventions with positive results on student academic outcomes. However, few studies researched the effect of academic or growth mindset interventions on students enrolled in developmental math courses at a community college.

CHAPTER 3: METHODOLOGY

Introduction

Addressing barriers to success for students who place and enroll in developmental math is a long-term struggle for community colleges. Students who test into developmental math are historically less likely to complete their programs of study (Cohen et al., 2014). Growth mindset interventions are one approach to addressing the barriers that students who are academically at risk face (Dweck, 2008b; Yeager et al., 2016b).

The purpose of this study is to determine the impact of a growth-mindset intervention on changing mindset, successful completion (grade of C or better) of a developmental math course, and progression to the next level math course at a large, suburban, open-access community college in the Midwest. The study utilizes quantitative measures, began during the fall 2017 semester, and concluded during the spring 2018 semester. This study is an experimental design as class sections were randomly assigned (Creswell, 2012) to an experimental group which included a growth-mindset intervention and a control group. A pre- and post-intervention mindset assessment, a growth-mindset intervention, data collection of successful completion of MTH 065, and participant enrollment in the student's next level math course in the spring 2018 semester encompass the methods used in this study.

The quantitative data collected for this study includes results from growth-mindset assessments taken the first week in September and last week in November. Additional quantitative measures include Fall 2017 grades in MTH 065 and enrollment in the next level of math for the Spring 2018 semester. The collection of student race and gender data was also used

to study the effect of a growth-mindset intervention on stereotype threat commonly experienced by female and historically underrepresented students (Steele, 1997).

The research questions for this study are:

1. What is the impact of the intervention in changing mindset?
2. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students who participated in the growth mindset intervention and those who did not?
3. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students with a growth mindset and students with a fixed mindset?
4. What is the difference in successful completion of MTH 065 between the experimental group and the control group? (A grade of C or better indicates successful completion.)
5. What is the difference in successful completion of MTH 065 between students with a growth mindset, students with a fixed mindset, and those unsure of mindset? (A grade of C or better indicates successful completion.)
6. What is the difference in successful completion of MTH 065 of students who face a stereotype threat (female and historically underrepresented students) between the experimental group and control group? (A grade of C or better indicates successful completion.)

The research design and the use of random selection to determine which group is the control and which is the experimental group resulted in the experimental design for this study. The experiment follows the pretest-posttest control group design which controls for internal validity (Campbell & Stanley, 1963). This design allows for statistically significant results to be generalized to a larger population, in this case, developmental math students.

Participants

This research study focuses on the impact of growth mindset on developmental math students enrolled in MTH 065 (Algebraic Modeling) at a large suburban community college in the Midwest. Students enrolled in developmental math were chosen because of the research

indicating that students struggle to complete developmental math sequences then progress and complete college-level math (Bahr, 2008). Students' perception of placement into developmental math being an indicator of lack of ability in math is a barrier in itself (Hall & Ponton, 2005). A growth-mindset lesson plan is an appropriate intervention for this student population as research shows influencing a change from a fixed to a growth mindset has a positive impact on math performance by teaching the concept that any student is capable of improving math ability by putting forth effort (Dweck, 2008a; Paunesku et al., 2015).

The community college in this study uses multiple measures to place students into appropriate levels of math coursework. Students can place directly into college-level math by showing an ACT math subscore of 22 or higher, an SAT math subscore of 530 or higher, transfer college-level math course with a grade of C or higher, or by passing an aligned high school math course (Harper College, 2018). Students who meet any of these measures have demonstrated they are academically prepared to take college-level math coursework and do not need to take remedial or developmental coursework.

Students who do not place into college-level math through these measures take the ALEKS[®] math placement assessment. ALEKS[®] is a web-based and untimed assessment.

The ALEKS[®] assessment policy at the community college in this study requires students to begin by taking a non-proctored practice test through their student portal. The practice test gives students an estimate of the score they can expect when they take the test for actual placement and exposure to the test format. After students take the practice test, they have the option to study within personalized ALEKS[®] Prep & Learning[®] modules which identify topics that individual students would benefit from improving upon (Harper College, n.d.a.).

Students then take the ALEKS[®] math placement assessment on campus in a proctored

environment. If they do not place into college-level math by scoring a 46 or higher, they have the option to retest three additional times. In between each retest, students are required to spend a prescribed number of hours within the ALEKS® Prep & Learning® modules (Harper College, n.d.a.). Before the second proctored attempt, they are required to spend three hours in the Prep & Learning modules; before the third attempt they are required to spend an additional five hours; and before the fourth attempt, they need eight additional hours (Harper College, n.d.a.).

Students who place at the lowest level of math through ALEKS® begin their math sequence with Basic Mathematics (MTH 055). Once they have completed MTH 055, they move into Algebraic Modeling (MTH 065), the course of focus in this study. Students can also place directly into MTH 065 by scoring between 14 and 29 in ALEKS® (Harper College, n.d.a.).

Algebraic Modeling (MTH 065) is the second to lowest developmental math course in the developmental math sequence at this community college. The course description states that MTH 065 “develops conceptual understanding of number systems, algebraic expressions, equations, inequalities and graphs of equations. Develops algebra skills with an emphasis on data modeling throughout the course” (Harper College, n.d.a., para. 1).

Once students have successfully completed MTH 065 with a grade of C or better, they have the option to progress into a developmental option that is designed for students who plan to pursue science, technology, engineering or math fields or take one of two options of credit-level math that have a one credit-hour developmental course co-requisite. Intermediate Algebra (MTH 080) is the developmental math course option that prepares students for College Algebra (MTH 103), the beginning of the math sequence for science, technology, engineering, or math majors (Harper College, n.d.b.). The co-requisite option of either Quantitative Literacy (MTH 101) and Supplemental Math/Quantitative Literacy (MTH 081) or Elementary Statistics (MTH 065) and

Supplemental Math/Elementary Statistics (MTH 085) allow students to take college-level math before fully completing their developmental math sequence (Harper College, n.d.b.).

This study includes six sections of MTH 065 during the Fall 2017 semester. A total of 13 sections were offered in the fall but in order to control for teaching style, this study only included six sections where three instructors taught two sections each of MTH 065. Each instructor taught one section in the control group and one section in the experimental group. A coin flip assigned one of the sections taught by each of the three instructors to the control group versus the other section to the experimental group.

Each MTH 065 section was capped at 20 students; however, enrollment is fluid as students add/drop into sections through the start of the semester. Participation in the study occurred as a result of attending class the day of the initial visit by the researcher, completion of the informed consent and attendance the day of the researcher's return for the post-test. Four of the sections met during the day, four days a week and two of the sections met at night, two nights a week. The two sections taught during the evening were taught by the same instructor; one section was included in the control group and one section was included in the experimental group to control for teaching style.

The researcher visited all six sections to collect consent forms from a total of 87 students. The experimental group initially consisted of 38 students and the control group had 49 students. The day of the researcher's return in November 2017, 24 students from experimental group and 30 students from the control group were present. The students in the experimental group participated in the pre-test, growth mindset intervention, then post-test and the control group just participated in the pre- and post-tests during the same weeks as the experimental group (see Table 4).

Table 4: Research Participant Numbers with Submitted Consent Forms

GROUP	NUMBER OF PARTICIPANTS	PERCENT OF SAMPLE
Control	30	55.56
Experimental	24	44.44

Students enrolled in MTH 065 are the sample population because growth-mindset interventions have been found to be effective for students facing a challenge (Good et al., 2003). Due to the at-risk nature of students in developmental math and those facing stereotype threat, students enrolled in MTH 065 at this community college are a population that research suggests would respond to a growth mindset assessment with academic improvement (Dweck, 2008a, Good et al., 2003; Steele, 1997; Yeager et al., 2016b).

Although there is a lack of growth mindset studies in community colleges and developmental education, there is growing evidence of a positive relationship between students' mindsets and their math achievement (Dweck, 2008a). This particular level of math is ideal for this study for multiple reasons: there are more sections than other developmental math levels in Fall 2017, other initiatives at the community college in this study are driving students toward placement out of the lowest level of developmental math (MTH 055); and three instructors teach multiple sections. Including three instructors who teach multiple sections allows for a section in the experimental and control group to be taught by the same instructor to control for teaching style.

Assumptions

The researcher made multiple necessary assumptions as part of this study. An assumption is a belief that is accepted as true without proof but supported by reasoning (Polit & Beck, 2010). One assumption is the belief that students took this study seriously and thoughtfully and

truthfully completed the pre-and post-tests. An additional assumption is that students engaged in the growth-mindset lesson and contemplated the topics included. Finally, an assumption exists that student populations are similar between the control and experimental groups, and each group shares similar barriers to college success. Having one section taught by the same instructor in both the experimental and control group as well as one evening section in the experimental and control group attempted to control for differences in student population.

Student Survey Instruments and Research Measures

The pre-intervention assessment was designed and developed by Mindset Works[®]; a company focused on growth mindset training that was co-founded by Carol Dweck (Mindset Works, n. d.). The Mindset Works[®] assessment provides information on students' mindset toward intelligence; whether they believe that intelligence is a fixed amount, the ability for growth exists, or belief falls on the continuum between fixed and growth mindset. The eight-question assessment is drawn from research-validated measures and uses a six-point Likert-type scale that ranges from *Disagree A Lot* to *Agree A Lot* (Mindset Works, n.d.). The assessment uses reverse coding, in which *Disagree A Lot* equals 0 on the Likert-scale for half of the questions and six for the other half. The assessment takes approximately five minutes to complete.

A Cronbach's alpha measure determines the internal consistency reliability of the scales (Muijs, 2011). Cronbach's alpha ranges between 0 and 1, with scores closest to 1 indicating higher internal consistency reliability (Muijs, 2011). The assessment averages ratings for each of three topics included. The three categories assessed include: theory of intelligence, learning goals versus performance goals, and effort beliefs.

The two questions that assessed theory of intelligence are as follows:

- You can learn new things, but you can't really change your basic intelligence (reverse-coded).
- No matter who you are, you can change your intelligence a lot.

These two questions assessing theory of intelligence are based on Dweck's (1999) research on whether a student possesses an implicit theory of intelligence in which they believe that intelligence can develop or entity in which they believe that intelligence is a stagnant or fixed quality. The questions have a reliability of 0.78 (Cronbach's alpha) in two samples, one with 373 students and one with 99 students (Mindset Works, n.d.).

The two questions that assessed learning goals are as follows:

- I like school work best when it makes me think hard.
- I like school work that I'll learn from even if I make a lot of mistakes.

The two questions that assessed performance-approach goals are as follows:

- I like my work best when I can do it really well without too much trouble (reverse-coded).
- I like my work best when I can do it perfectly without any mistakes (reverse-coded).

These two questions on performance-approach goals relate to students' learning goal orientation; whether students have a performance versus a learning goal orientation (Dweck & Leggett, 1988; Mueller & Dweck, 1998). Performance goals represent those "in which the documentation of high ability levels through successful performance becomes their primary motivational aim" (Mueller & Dweck, 1998, p. 33). In contrast, learning goals are those that emphasize effort and lead to "focus on the development of their skills through the mastery of new material" (Mueller & Dweck, 1998, p. 34). The questions were developed using Midgley et al.'s (1998) scales assessing students' goal orientations and have a reliability of 0.73 (Cronbach's

alpha) in a sample consisting of 373 students and the other consisting of 99 students (Mindset Works, n.d.).

The two questions that assessed effort beliefs are as follows:

- When something is hard, it just makes me want to work more on it, not less
- To tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart.

These questions on effort beliefs stem from Blackwell (2002) and Blackwell et al.'s (2007) research on whether students believe that effort leads to positive outcomes or that effort is a negative indicator of ability. The reliability of this set of questions is a Cronbach's alpha of 0.79 for the sample group of 373 students and 0.60 for the sample group of 99 students.

Three different results can be achieved using the Mindset Works[®] survey. Students who display a growth mindset receive the following feedback from the survey if taken online:

You understand that you can increase your intelligence by learning, and you aren't afraid of a challenge. You believe that the best way to learn is to work hard, and you are willing to make mistakes while you do it. This is what we call the "growth mindset."

Even though you have a good foundation, there are probably some areas where you could benefit from learning how to cultivate your growth mindset thinking and practices. Maybe you could use techniques to be more comfortable with negative feedback or explore the possibility of growth in areas that you have neglected. You might gain from strategies to boost learning and productivity. Or you might like to learn how to help others develop growth mindset thinking. You probably still have lots of ways to grow! People who believe that they can increase their intelligence through effort and challenge actually get smarter and do better in school, work, and life over time. They know that mental exercise makes their brains grow smarter—the same way that exercise makes an athlete stronger and faster. And they are always learning new ways to work smart and build their brains. (MindsetWorks, n.d.)

Students who display a fixed mindset receive the following feedback:

Right now, you lean toward thinking that your intelligence doesn't change much. You prefer not to make mistakes if you can help it and you probably don't really like to put in

a lot of effort on things that don't come easily to you. You may think that learning should be fast and when you find something difficult you may feel like giving up.

You tend to be disappointed in yourself when you don't do well at something quickly and feel embarrassed by failure. This may be holding you back from achieving all that you could if you put forth your best effort in all areas. For example, maybe there is one or more subjects that you think you are "just not good at" and try to avoid. Or you may do well but feel a lot of stress when you make mistakes.

Chances are that you probably have a lot more potential than you are using! People who believe that they can increase their intelligence through effort and challenge actually get smarter and do better in school, work, and life over time. They know that mental exercise makes their brains grow smarter—the same way that exercise makes an athlete stronger and faster. And they are always learning new ways to work smart and build their brains (Mindset Works, n.d.).

Students who display both fixed and growth mindset tendencies receive the following feedback:

Right now, you are unsure about whether you can develop your intelligence. You probably care about performing well and you do want to learn, but you may not want to have to work too hard for it. You may feel a bit discouraged when you perform poorly at something.

This could be holding you back from doing your best, if it deters you from taking on challenges or causes you to experience anxiety when you aren't sure that you will do well at something. Maybe there are things that you think you are "just not good at." You may be coasting when you could be excelling.

You probably have more potential than you are using! People who believe that they can increase their intelligence through effort and challenge actually get smarter and do better in school, work, and life over time. They know that mental exercise makes their brains grow smarter—the same way that exercise makes an athlete stronger and faster. And they are always learning new ways to work smart and build their brains (Mindset Works, n.d.).

Research on effective growth mindset interventions informed the development and evaluation of the intervention created for this study. The researcher adapted the growth mindset intervention from a lesson plan created through a partnership between Khan Academy and PERTS (see Appendix A). The intervention educates students on neuroplasticity, the concept that

intelligence can be developed and encourages students to pursue challenging work (Khan Academy & PERTS, 2015). The intervention also includes activities to apply the topics addressed.

For the experimental group, the researcher administered the 45-minute intervention (Appendix B) during the same class period as the pre-assessment at the beginning of the Fall 2017 semester. The researcher then administered the post-intervention assessment at approximately the two-thirds point of the Fall 2017 semester. The post-intervention growth mindset assessment is a re-ordered version of the pre-intervention assessment. The assessments take participants approximately five minutes to complete. The control group participated in the initial assessment at the beginning of the Fall 2017 semester and the second assessment at the two-thirds point of the semester.

Growth-Mindset Intervention

Valid implicit theory and growth mindset interventions are those that include neuroscientific information about the brain's ability to create new pathways and grow new neural connections, the concept known as neuroplasticity (Yeager & Dweck, 2012). A Sentis (2012) brain animation video that describes how the brain can and does change throughout life due to malleability addresses neuroplasticity in the intervention. The video discusses how billions of pathways exist that trigger when individuals act, think, or feel. Pathways frequently used strengthen which makes it easier for the brain to use that pathway. When new pathways are used, new connections form and old ones weaken. The video indicates that all people have the ability to learn and change by "rewiring the brain" (Sentis, 2012, 1:54). The topic of neuroplasticity is substantiated in Edward Briceno's TedX Talk (2012) on mindset when he also describes the malleability of the brain. Discussion questions apply this concept, asking the students to define

neuroplasticity in their own words and discussing how the brain changes and grows.

Additionally, growth mindset interventions must inform students that people's characteristics and abilities have the potential to change and grow (Blackwell et al., 2007; Yeager et al., 2013; & Yeager & Dweck, 2012). The intervention used in this study addresses the concept that intelligence grows through Briceno's TedX Talk (2012) video on the relationship between mindset and success. Briceno explains that growth mindset presents in those that believe that qualities and intelligence grow with effort versus those that have a fixed mindset and believe that abilities are ingrained. These beliefs manifest in different behaviors; those with a growth mindset see an increase in grades over time whereas those with a fixed mindset saw no improvement.

By addressing the questions "Can my intelligence grow?" and "What is the purpose of learning?" growth mindset beliefs and purpose of learning goals are identified and can help students increase their resilience, respond to academic challenges, and influence a positive cycle that will increase success (Garcia & Cohen, 2012; Paunesku et al., 2015; Yeager & Walton, 2011). Edward Briceno's TEDx Talk on mindset discusses the difference between learning and performance goals through the explanation that those with a fixed mindset focus on information about their performance such as grades whereas those with a growth mindset are most concerned about information about how they can improve their performance. Views on effort also display a propensity toward a fixed or growth mindset. Students with a fixed mindset worry about being judged and see effort as evidence that they are incapable of achieving difficult tasks. Students with a growth mindset, however, see setbacks and effort as part of growth and embrace challenges as it is an opportunity to learn. Discussion questions on this topic asked the students what those with a fixed mindset focus on the most and how each mindset views effort and

obstacles.

Two additional applications were used to guide students through the internalization of growth mindset concepts. The first application had students pair up to share a time when they could tell that they got smarter. The researcher set the stage by sharing the following:

I struggled with geometry in high school until I started meeting with my teacher before school. The teacher was able to explain the concepts in a different way and once I was caught up, I made sure to prioritize geometry to make sure I spent enough time studying and doing practice problems. I also made sure to ask for help anytime I needed it. I noticed that although I was still putting in a lot of effort, I was able to learn new concepts in geometry more quickly than I was at the beginning of the year.

This application reinforces the concept that the brain is malleable and effort results in improved abilities and intelligence (Dweck, 2008b; Yeager & Walton, 2011).

The second application asked students to take a few minutes to think about a time when they overcame a struggle to learn something and reflect on the times when you failed at first but through perseverance, your brain created new neural connections and you eventually became better at the task at hand. Students were asked to write a letter to a future student of this class about this struggle. The letter should tell the student their story and give them advice on what they should do next time they encounter an obstacle when learning something new. This application again reinforced growth mindset concepts, neuroplasticity, and learning goals (Yeager & Walton, 2011).

Procedures

In April 2017, the researcher connected with a representative from Mindset Works® to request permission to use their Growth Mindset assessment and get information about the validity of the assessment. A representative from Mindset Works® responded and granted permission to use resources from Mindset Works®, including the assessment.

The researcher tailored the lesson plan created by PERTS and Khan Academy by tailoring the activity, so students would apply the concepts learned in the videos and discussion questions to their mindset toward math. The PERTS and Khan Academy (2015) lesson plan is broken down into three parts. Part one includes showing videos explaining neuroplasticity and growth-mindset concepts and incorporating discussion questions. In the study, the Sentis (2012) video describes neuroplasticity and Edwardo Briceno's (2012) TedX Talk substantiates neuroplasticity and describes growth mindset concepts. Part two has students engage in a personal discussion about a time they overcame a struggle in learning. In the study, the prompt given to students for the personal discussion was to think about and share a time when you could tell that you were getting smarter. Part three of the lesson plan has students write a letter to a future student about a struggle related to learning. In the study, students were specifically asked to write a letter to a future student of MTH 065 and give them advice using growth-mindset concepts to overcome their concerns or anxiety about taking a math course.

Before recruiting participants and implementing the procedures of the study, the research proposal was submitted to the Institutional Review Boards for Ferris State University and Harper College (see Appendices C and D). Approval was received from Ferris State University and Harper College (see Appendices E and F).

In May 2017, the researcher contacted the Dean of Mathematics and Science to request permission to reach out to instructors of MTH 065 to determine their interest in participating in the study. The researcher shared the intervention (see Appendix B) as well as the expectations and time commitment of the study. The Dean of Mathematics and Science granted approval to contact MTH 065 instructors for recruitment purposes. The researcher contacted four instructors who taught at least two sections of MTH 065 to request participation in the study. These

instructors taught two sections in the Fall 2017 semester which allowed for one section to be randomly selected to be part of the experimental group and one section to be selected to be part of the control group. The instructors received the plan for the intervention, the time commitment, and expectations. Three of the four instructors agreed to allow the study to take place in two of their sections for a total of six sections and 88 student participants.

The first part of the intervention included gathering consent forms (see Appendix D), the Mindset Works[®] pre-assessment, and administering the lesson plan for the experimental group and gathering consent forms and the Mindset Works[®] pre-assessment for the control group. The random selection of sections being a part of the experimental group or control group occurred using a coin flip. The first part of the intervention was administered the first week in September for each section included in the study.

In the sections that were part of the experimental group, prior to having the students sign the consent form, the researcher introduced herself, informed the students that the study was researching students' mindsets toward math, would take approximately 45 minutes of their time in class that day and five minutes further along in the semester, would require no out-of-class commitment, would have no impact on their grade, and participation was voluntary. In the sections that were part of the control group, the researcher introduced herself, informed the students that the study consisted of a survey that would have no impact on their course grade, would take approximately five minutes to complete that day and another five minutes later on in the semester, would require no out-of-class commitment, and participation was voluntary.

In September 2017, students in the experimental group who agreed to participate in the study took the pre-intervention Mindset Works[®] assessment which provided quantitative data on the students' mindset orientation. Then they participated in the lesson plan which consisted of

watching the two videos, answering discussion questions, and participating in two application activities. Students in the control group who agreed to participate in the study took the Mindset Works® assessment but did not participate in the growth-mindset intervention. In November 2017, the researcher administered the re-ordered Mindset Works® assessment to both the control and experimental groups. Again, the researcher let the participants know that the assessment would take only five minutes, would only be considered part of the study if the informed consent was on file, student information would remain anonymous, and there would be no impact to grades as a result of this study.

The data mining of successful completion of MTH 065 and enrollment status in the next level of math after MTH 065 occurred at the ten-day census mark during the Spring 2018 semester and was considered to be a snapshot of enrollment. This date is when the majority of registration has stabilized as the last date to add or drop courses starting at the beginning of spring 2018 semester was January 22, 2018 and the ten-day census occurred on January 29, 2018. Additionally, the gender and race of the students participating in the study were captured to determine the impact of the intervention on stereotype threat. Successful completion of MTH 065 is considered a grade of A, B, or C because a C or better is required to meet the prerequisite to move into one of three options considered to be the next level of math at Harper College.

Data Collection

The data collected in this study is quantitative and collected beginning September 2017 through January 2018 (see Table 5). The researcher only collected data for students who signed and turned in an informed consent. Students who did not sign and turn in an informed consent did not participate in the assessments or the growth mindset intervention and left the classroom.

Table 5: Data Collection Timeline

DATE	DATA COLLECTED
September 2017	Number of participants, Participants names and student identification number, Mindset Works® assessment results
November 2017	Mindset Works® re-ordered assessment results
January 2018	Participants' academic performance in MTH 065, progression into next level of math, race and gender information

Once all data collection occurred, references to participants were no longer identifiable. Coding was used to protect student anonymity and to ensure that participants are no longer identifiable. Data on paper was transported in a locked briefcase and electronic data on a password-protected external drive.

Data Analysis

Statistical analysis occurred to address each research question and test each hypothesis. Descriptive statistics are displayed through tables and graphs depicting the number of participants in the experimental and control groups, results of the pre-intervention and post-intervention assessments, number of students who progressed or did not progress into the next level of math and number of students who successfully or unsuccessfully completed MTH 065.

The data displayed in these tables and graphs was used to test the research question on the impact of the growth mindset intervention on influencing performance in developmental math. Data analyzed includes the number of students who completed MTH 065 with a grade of C or better as well as students who progressed from MTH 065 to the next level math course at the 10th-day census point of the spring 2018. Mindset is tested and identified in both the control and experiment group and the results displaying successful completion of MTH 065 and progression into the next level of math were collected for both groups to study whether student's original mindset impacted progression or if the intervention and change in mindset had an impact. Data

on successful completion of MTH 065, progression into the next level math course and its relationship to growth mindset was also analyzed by gender and race to determine if the growth mindset intervention is effective against stereotype threat.

The independent variable in this study is the growth mindset intervention and the dependent variables are mindset, successful completion of MTH 065, and progression into the next level math course. Individual student completion of MTH 065 and progression into the next level math course after MTH 065 will result in data that will support or not support the null hypothesis. The hypothesis predicts that a mindset intervention that is effective in developing a growth mindset in students who placed into developmental math will increase the percentage of students who complete MTH 065 and progress into the next course in their math sequence. The null hypothesis states that the mindset intervention has no statistically significant impact on successful completion of MTH 065 and progression from MTH 065 to the next level of math.

Inferential statistics consist of Chi Square tests to determine whether the findings indicate a relationship that is statistically significant. The Chi Square tests determine if the results from the control groups and experimental groups are significantly different from each other. Specifically, it tests whether the students in the experimental groups were more likely to successfully complete MTH 065 and progress from MTH 065 to the next level course than those in the control group. Also, the Chi Square test determined if data collected displays a statistically significant correlation between students assessing as having growth mindset indicated by the post-test and successful completion of MTH 065 and progression into the next level of math. Finally, correlation between the intervention and a change in mindset determined the effectiveness of the intervention itself in changing mindset. Data on students who may face stereotype threat due to gender or race was also analyzed to compare the impact of the growth-

mindset intervention on student successful completion of MTH 065 and progression into the next level of math. If there is no significance in the difference in successful completion of MTH 065 or progression into the next level math course between students who received the growth-mindset intervention and those who did not, then the null hypothesis would be supported.

Limitations and Delimitations

Limitations are factors that affect the generalizability of a study's findings that are outside of the researcher's control (PhD Student, n.d.). Delimitations are factors that occur based on decisions the researcher makes in the design of the study. Limitations and delimitations exist in studies due to constraints such as access, time, funding, and external factors.

Delimitations and limitations affected the number of participants included in this study. The researcher chose to include participants from one Midwestern community college in the study with the intention of collecting data that would be generalizable to other community college students. The number of participants was small due to the lack of instructors who taught multiple sections of MTH 065. One additional instructor taught multiple sections but chose not to participate, limiting the size of the sample population. In one section, the students were given the option by their instructor to leave class if they chose not to participate in the study. This option resulted in a significant number of students choosing not to participate so they could leave class early. In a class of twenty students, only seven remained to participate.

Additionally, many students were present for the first assessment but were absent the day of the second assessment. In the experimental group, 14 students who were present for the pre-test and growth mindset administration were absent. In the control group, 19 students were absent the day of the researcher's return to administer the post-test. The absences lead to the small sample size of 54 total students. Due to the small sample size, the ability of the study to

produce statistically significant results is lessened.

The researcher administered the pre- and post-intervention assessments and delivered the growth mindset intervention. Although the researcher took care to consistently introduce the assessments for both the experimental and control group, it is a possibility that researcher bias impacted the outcomes. Additionally, the researcher had no prior relationship with the students, and the study potentially disrupted the usual routine of the course, affecting the study.

Classes were offered at different times of day, potentially impacting the student demographics in sections. Four sections met during the day, whereas two sections met at night. However, the daytime courses were broken up into two control groups and two experimental groups, and the evening sections included one control group and one experimental group. The same two instructors taught the daytime courses, and the third instructor taught both evening courses.

The data collected may also be impacted by limitations and delimitations. It is possible that students did not enroll in the next course in their math sequence because of factors unrelated to mindset. They may have met the math requirement for their degree program or because of other circumstances such as the next course that they needed was not at a time or in a format that worked for their schedule. Additionally, students who waited to register close to the start of the spring semester may have found that the sections they needed were full at that point.

Conclusion

Students who are academically unprepared to begin at college-level math in community colleges take longer to graduate and graduate at lower rates than students who directly enroll in college-level coursework (Cohen et al., 2014). Numerous studies provide insight into the multiple approaches to address the barriers that students enrolling in developing math, including

growth-mindset interventions. This study specifically researches the impact of a growth-mindset intervention on performance in developmental math.

This study is an experimental design. The experimental group experienced a pre- and post-intervention assessment on mindset, and a growth-mindset intervention. The control group experienced the pre-and post-intervention assessment. The data collected includes the results from the pre- and post-intervention assessments, grades in MTH 065, progression in the next level math course, and gender and race demographic information. The data were analyzed to answer research questions regarding the impact of a growth-mindset intervention on successful completion of a developmental math course and progression into the next level of math. The results of this study may influence the adoption of growth-mindset strategies within developmental math coursework.

CHAPTER 4: RESULTS AND FINDINGS

Introduction

The purpose of this study was to determine the relationship between mindset and performance in developmental math and the impact of a short growth mindset intervention on influencing a change in mindset. This study intended to determine the difference in outcomes between the control group that received no intervention and the experimental group which participated in a short growth-mindset lesson plan. Additionally, the study intends to determine the affect a growth mindset, being unsure of mindset or having a fixed mindset has on performance in developmental math. The data collected in this study is quantitative and provides an indication of whether or not the growth mindset intervention is an effective tool in changing students' mindsets and, in turn, has an impact on successful completion of MTH 065 and progression into the next level of math.

The research questions for this study are as follows:

1. What is the impact of the intervention in changing mindset?
2. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students in the experimental group and the control group?
3. At the ten-day census mark for the spring 2018 semester, what is the difference in progression into the next level math course between students with a growth mindset, students with a fixed mindset, and those who are unsure of their mindset?
4. What is the difference in successful completion of MTH 065 between the experimental group and the control group? (A grade of C or better indicates successful completion.)
5. What is the difference in successful completion of MTH 065 between students with a

growth mindset and students with a fixed mindset? (A grade of C or better indicates successful completion.)

6. What is the difference in successful completion of MTH 065 of students who face a stereotype threat (female and minority students) between the experimental group and control group.

The study included a sample of 54 participants enrolled in MTH 065 in the fall semester at a large, suburban community college. Of the 54 participants, 30 students participated fully in three sections of MTH 065 that comprised the control group, and 24 students fully participated in the study as part of the experimental group. The control group participated in a pre-test and post-test assessment developed by Mindset Work[®] that assessed mindset as fixed, unsure of mindset, or growth. The experimental group participated in the pre-test, a growth mindset intervention, and the post-test.

Sample by Gender and Ethnicity

Gender is considered to be a significant factor in this study as female students are historically susceptible to stereotype threat in math and science (Steele, 1997, 2003). The experimental group includes sample N of 24 of which 12 are female and 12 are male students. The control group includes sample N of 30 of which 15 are female and 15 are male.

Ethnicity is believed to be a significant factor in the study as stereotype threat affects historically underrepresented groups (Steele, 1997, 2003). The ethnicity distribution in the control group is 70% White, 26.67% Hispanic/Latino, 3.33% Black/African American, and 0% Asian. See Figure 1.

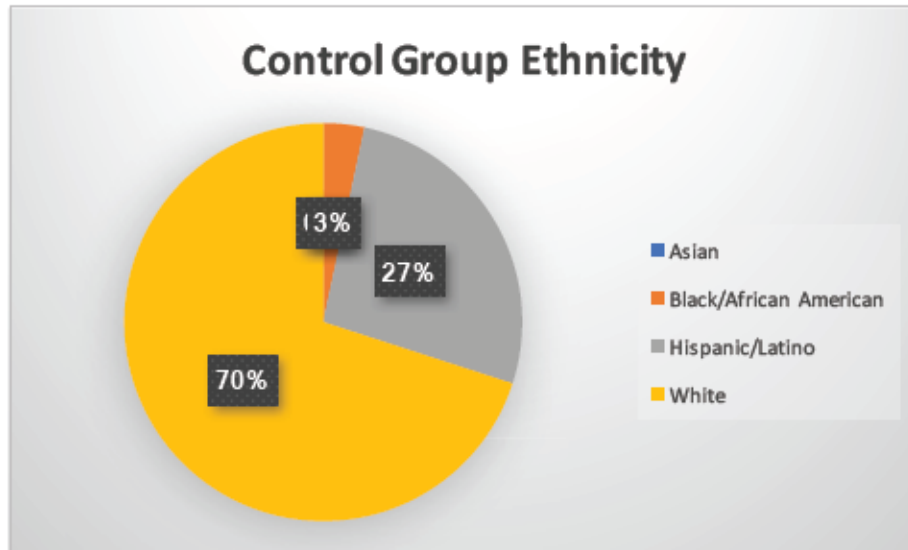


Figure 1. Control group ethnicity.

The ethnicity distribution for the experimental group is 37.5% White, 50% Hispanic/Latino, 8.33% Black/African American, and 4.17% Asian. See Figure 2.

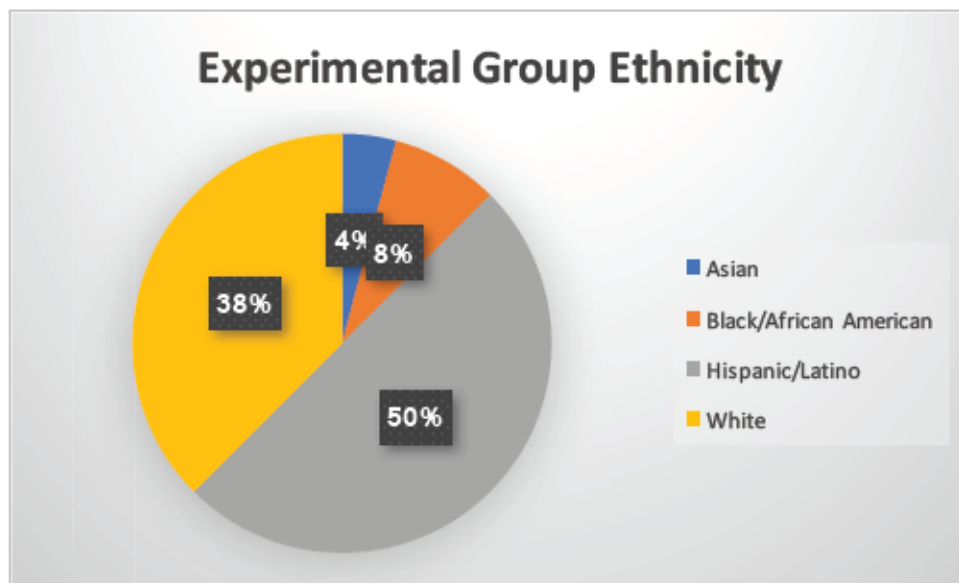


Figure 2. Experimental group ethnicity.

Sample Attrition

The first point of contact with the sample population occurred at the beginning of the fall 2017 semester in September. The sample for the experimental group consisted of 38 students

who participated in the pre-test Mindset Works® assessment and growth mindset intervention. The researcher returned to the classroom in November 2017 to administer the post-test. On the date of the post-test administration, fourteen students who were present for the pre-test and growth mindset administration were absent, resulting in 24 students participating in the entire study. In the control group, 49 students participated in the pre-test and 19 students were absent the day of the researcher’s return to administer the post-test, resulting in 30 students participating fully in both the pre-test and post-test.

The percentage of students absent in the experimental group and control group on the day of the researcher’s return was comparable with 36.8% absent in the experimental group and 38.8% absent in the control group. A similar breakdown of mindset as assessed by the pre-test for students present for the second part of the study and those absent was observed. See Table 7.

Table 7: Mindset by Attendance at Post-Test

	GROWTH MINDSET	UNSURE OF MINDSET	FIXED MINDSET	TOTAL
Experimental Group - Absent	5	8	1	14
Control Group - Absent	5	13	1	19
Total - Absent	10	21	2	33
Experimental Group - Present	11	13	0	24
Control Group - Present	3	24	3	30
Total - Present	14	37	3	54

Overall, the percentage breakdown of students with a growth mindset, unsure of mindset, or fixed mindset showed similarities between students present in class the day of the second component of the study and those absent. The percentage of students with a growth mindset is slightly higher among students absent the day of the post-test and the percentage of students unsure of mindset is slightly higher in the group that was present. The percentage of students

with fixed mindset is the same among students absent and those present for the post-test. See Figures 3 and 4.

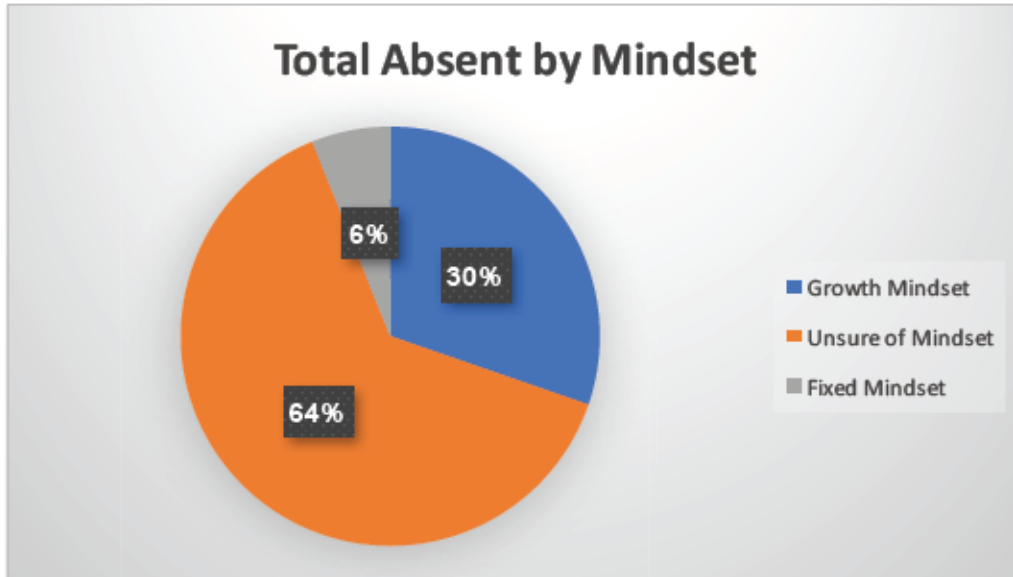


Figure 3. Pre-test mindset breakdown for students absent at time of post-test

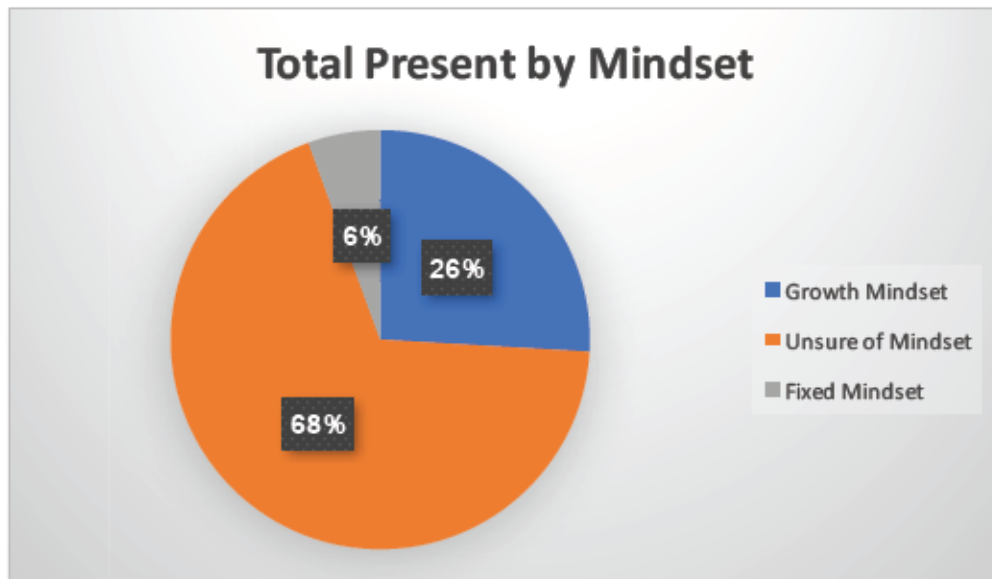


Figure 4. Pre-test mindset breakdown for students present at time of post-test

Students who were absent the day of the post-test did not successfully complete MTH 065 or progress into a higher-level math the following semester at the same rate as students who

were present on the day of the post-test. A greater number of students present for the second data collection activity in both the experimental and control groups successfully completed MTH 065 compared to those that were absent during the researcher’s return in November of 2017. See

Table 8.

Table 8: Completion of MTH 065 by attendance at post-test

	SUCCESSFUL COMPLETION OF MTH 065	NO SUCCESSFUL COMPLETION OF MTH 065	TOTAL
Experimental Group - Absent	8	6	14
Experimental Group - Present	21	3	24
Control Group - Absent	11	8	19
Control Group - Present	25	5	30

Of the students present at the time of the researcher’s return to administer the post-test, 85.19% successfully completed MTH 065 with a grade of C or better whereas 57.58% of students absent the day of the post-test successfully completed MTH 065. See Figure 5.

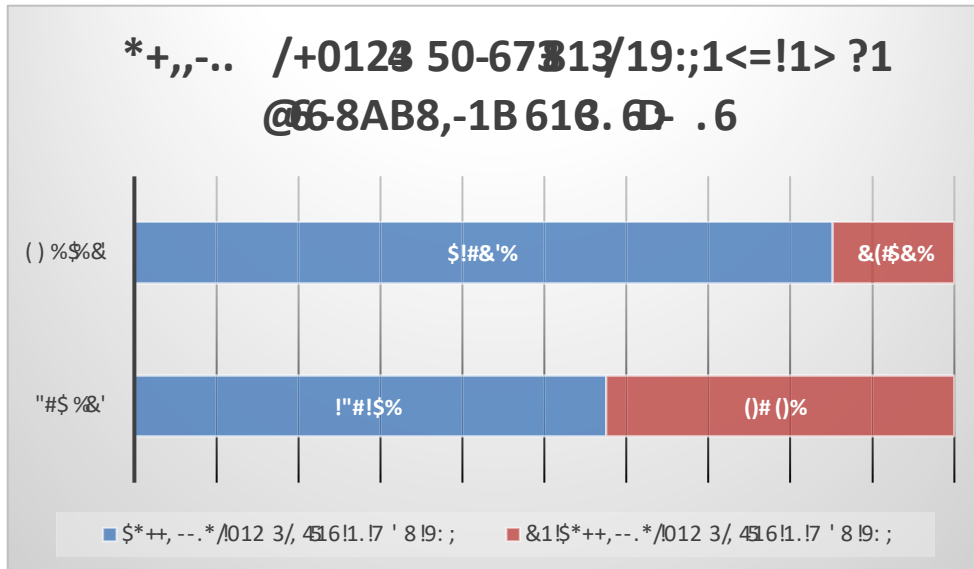


Figure 5. Successful completion of MTH 065 by attendance at post-test

Similarly, students present at the time of the post-test progressed into the next level math the following semester at a higher rate than students who were absent. See Table 9.

Table 9: Progression into next level math by attendance

	PROGRESSION	NO PROGRESSION	TOTAL
Experimental Group - Absent	5	9	14
Experimental Group - Present	17	7	24
Control Group - Absent	8	11	19
Control Group - Present	17	13	30

Students present for the post-test progressed into the next level math course at a higher rate than those no present. Of the students present at the time of the post-test, 62.96% progressed into the next level of math the following semester. Of the students absent the day of the researcher's return, 39.39% progressed into the next level of math. See Figure 6.

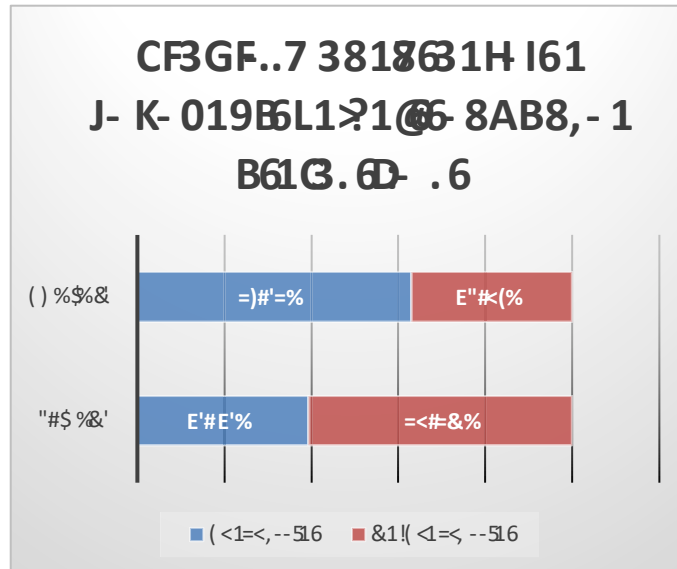


Figure 6. Progression into next level math by attendance at post-test

Sample attrition occurred through student absence for the post-test portion of the study. This affected the sample size by decreasing the experimental group from 38 to 24 students and the control group from 49 to 30 students. The breakdown of mindset as assessed by the pre-test showed similar results between absent and present students. However, students present at the time of the post-test demonstrated higher rates of successful completion of MTH 065 and progression into the next level of math.

Sample by Instructor

In order to control for teaching style which may influence a particular mindset toward math, the selection of MTH 065 sections allowed for one section taught by the same instructor to be included in the experimental group and one section in the control group. The purpose of this selection process was to have students taught by the same instructors in both the experimental and control group to balance the results. The sample sizes varied slightly from section to section, particularly in the experimental section taught by instruct 3. In this section, multiple students left

prior to completing the informed consent as they were told that they could leave class early if they did not participate, therefore incentivizing the option of not participating in the study. See Table 10.

Table 10: Sample Size by Instructor

INSTRUCTOR	GROUP	PRE-TEST SAMPLE SIZE	POST TEST SAMPLE SIZE
Instructor 1	Experimental Group	15	10
	Control Group	20	13
Instructor 2	Experimental Group	15	9
	Control Group	14	8
Instructor 3	Experimental Group	8	5
	Control Group	15	9

The pre-test and post-test results show a similar distribution of mindset by instructor. The pre-test results show fixed mindset as the lowest occurrence, growth mindset as the second lowest occurrence, and unsure of mindset as the highest occurrence. The percentages of students displaying each mindset result is similar in groupings of each instructor. See Figure 7.

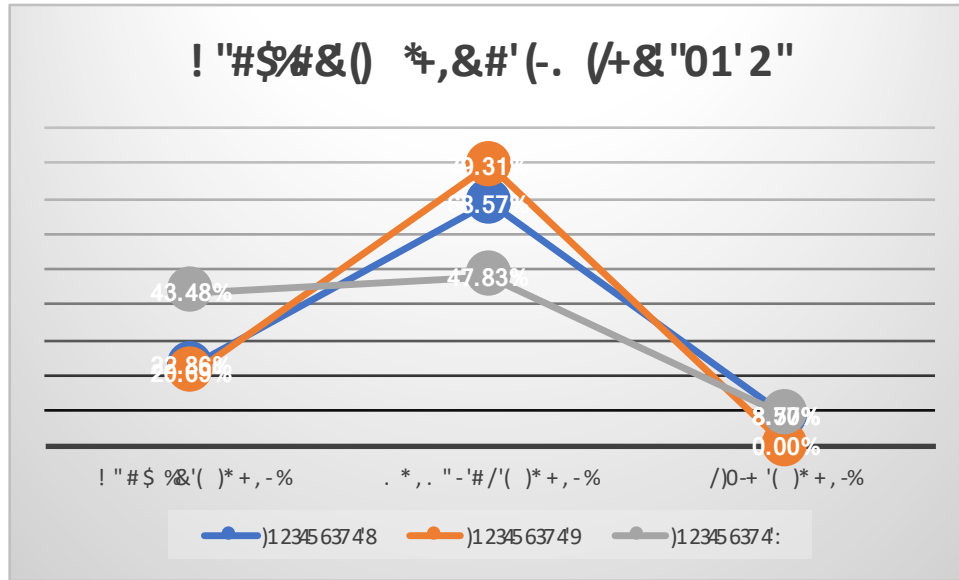


Figure 7. Pre-test mindset by instructor.

Likewise, the post-test results show a similar distribution of mindset by instructor. The percentages of students displaying each mindset as assessed by the post-test are nearly identical in each instructor grouping. See Figure 8.

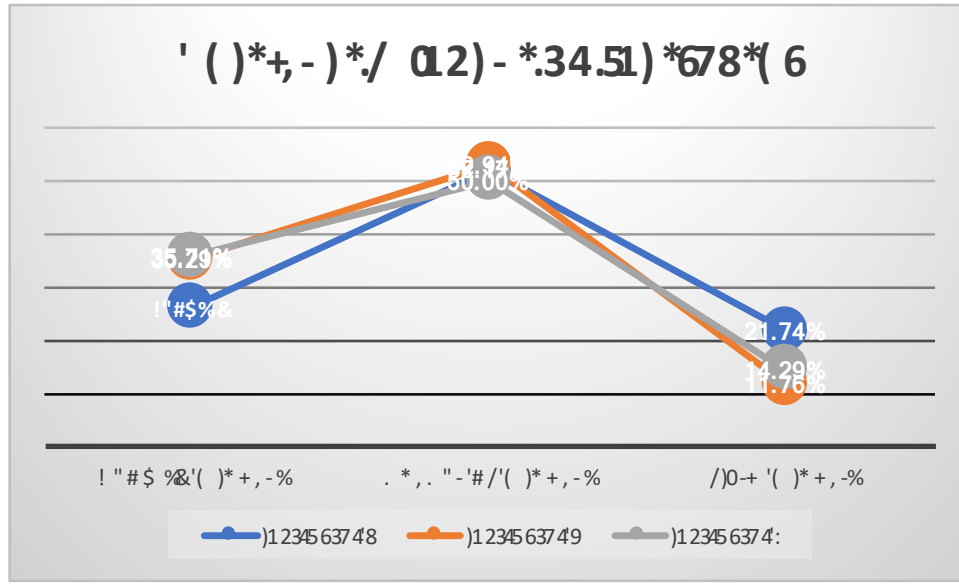


Figure 8. Post-test mindset by instructor

Summary of Results

Overall, the results for this study are not statistically significant, largely due to population size. The small size of the study is due to the need to use sections of MTH 065 in which an instructor teaches at least two sections, one that participates in the control group and one that participates in the experimental group, to ensure that students in both the experimental and control groups have similar MTH 065 classroom experiences that may affect mindset. The population size for research questions that require the inclusion of post-test results is smaller due to lack of attendance on the day of post-test administration.

The growth-mindset intervention did not significantly influence a change toward a growth mindset. The growth-mindset intervention also did not impact progression to the next level of math as similar percentages of students from both the control and experimental groups successfully completed MTH 065 with a C or better and enrolled in the next level of math. However, although not statistically significant, students with a growth mindset as determined by the post-test Mindset Works assessment progressed to the next level of math at a greater

percentage than those with a fixed mindset and at a slightly higher percentage than those unsure of their mindset. Additionally, the percentage of students in the experimental group who successfully completed MTH 065 with a C or better is slightly higher than students in the control group. Students with a growth mindset as determined by the post-test had the highest percentage of successful completion of MTH 065; students unsure of mindset had the second highest percentage; and students with a fixed mindset had the lowest percentage of successful completion, although the data was not statistically significant. Finally, there was no statistical difference in successful completion of MTH 065 by students susceptible to stereotype threat due to ethnicity or gender in the control group versus the experimental group.

Research Question 1: Findings and Results

Research question #1 asks: What is the impact of the intervention in changing mindset? The Mindset Works mindset assessment evaluated students' mindsets in both the control and experimental groups at the beginning of the semester and at the 10-12-week point. The experimental group took the assessment prior to the intervention and again at post-intervention. The control group took the pre-test at the beginning of the semester and again at the 10-12 week point of the semester but did not participate in an intervention. The assessment results indicate either growth mindset, fixed mindset, or unsure of mindset.

The independent variable for this research question is the growth-mindset intervention administered to the experimental group. The dependent variable is mindset as assessed using the Mindset Works pre-test taken prior to the intervention and the post-test taken after the intervention. The null hypothesis for this research question states that the experimental condition, the 45-minute growth-mindset intervention does not influence a change toward a growth mindset. The alternative hypothesis states that the growth-mindset intervention does impact a

change in mindset. See Table 11 for changes in mindset.

Table 11: Change in Mindset Pre-Test and Post-Test

	NO CHANGE	IMPROVED MINDSET	DECLINE IN MINDSET
Experimental Group	16	3	5
Control Group	23	3	4

The total number of students in the experimental group who participated in the pre-test, intervention, and post-test is 24. Of the 24 students in the experimental group, 16 students' mindsets remained the same prior to the growth mindset intervention and after. Three of the students saw an improved mindset indicated by a change from fixed mindset to unsure of mindset, unsure of mindset to growth mindset or fixed mindset to growth mindset. Five students saw a decline in mindset from growth mindset to unsure of mindset, unsure of mindset to fixed mindset, or growth mindset to fixed mindset. The total number of students in the control group who participated in the pre-test and post-test is 30. Three students in the control group saw an improved mindset and four students saw a decline in mindset.

Table 12: Chi Square Test for Research Question #1 – Experimental Group

Chi Square	0.709615385
Alpha	0.05
p value	0.70130083

The researcher performed a Chi Square test to determine if the experimental condition, the growth-mindset intervention, had a statistically significant impact on changing student's mindset. The Chi Square test suits this research question as it tests categorical data, in this case change in mindset (Hoy & Adams, 2016). Chi Square determines the likelihood that the relation between two variables arises from chance (Hoy & Adams, 2016).

For this research question, the dependent variable is students' mindset, and the

independent variable is the growth-mindset intervention. The p-value is greater than 0.05, which means there is no significant difference between the control group and the experimental group. Therefore, the growth mindset intervention did not significantly change students' mindset in this study. The null hypothesis is accepted stating that the growth-mindset intervention has no relationship on changing student mindsets, and the alternative hypothesis stating that the growth mindset intervention influences a change in mindset is rejected.

Research Question 2: Findings and Results

Research question #2 asks what the difference is in progression into the next level math course between students in the experimental group and the control group at the ten-day census mark for the Spring 2018 semester. Progression in the next level of math indicates that the student received credit for Algebraic Modeling (MTH 065) and enrolled in the next level of math which includes MTH 080 or co-requisite options that include credit level math.

The independent variable is the growth-mindset intervention received by the experimental group, and the dependent variable is progression or enrollment in the next level course in a math sequence. The N=30 for the control group with 13 students showing no enrollment in the next level math course and 17 with enrollment in a next level math course. The N=24 for the experimental group with 17 students showing progression into the next level math course and 7 showing no progression in math. Therefore, 56.7% of students in the control group progressed to the next level of math compared to 70.8% of students in the experimental group who progressed to the next level of math. See Figure 9.

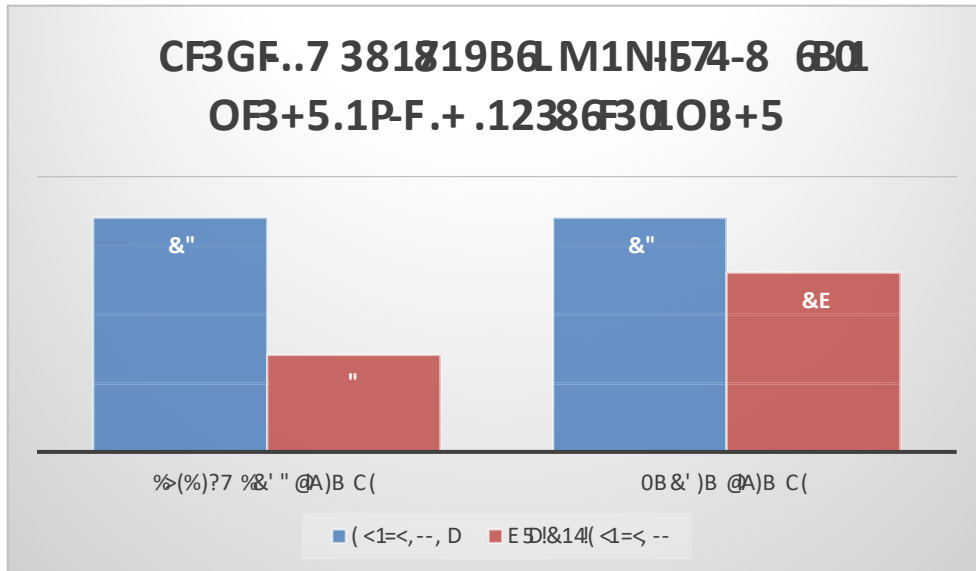


Figure 9. Progression in math: experimental group versus control group.

The researcher analyzed the data for this research question using a Chi Square test to determine if the results are statistically significant through a p -value of less than 0.05. The null hypothesis for this research question states that the growth mindset intervention administered to the experimental group does not influence progression from MTH 065 to the next level math course. The alternative hypothesis states that the growth mindset intervention does have an impact on progression to the next level math course. See Table 13.

Table 13: Chi Square Test for Research Question #2

Chi Square	1.1475
Alpha	0.05
p value	0.284073

A Chi Square test is the appropriate data analysis method for this research question, considering the categorical value of the independent and dependent variables. The p -value is significantly greater than 0.05 resulting in the null hypothesis that there is no relationship between the growth- mindset intervention and progression into the next level of math being

accepted. Therefore, the alternative hypothesis stating that a relationship exists between the growth mindset intervention and progression into the next level of math is rejected.

Research Question 3: Findings and Results

Research question #3 asks, at the ten-day census mark for the Spring 2018 semester, what is the difference in progression into the next level math course between students with a growth mindset, students with a fixed mindset and students who are unsure of their mindset. The data used to analyze this research question originate from the mindset results from the post-test. The N=54 with the largest percentage of progression into the next level of math occurring in students with a growth mindset and lowest percentage occurring in students with a fixed mindset. See Table 14 and Figures 10, 11, and 12.

Table 14: Progression in Math by Mindset

	FIXED MINDSET	UNSURE ON MINDSET	GROWTH MINDSET
Progression	4	18	12
No Progression	5	10	5
Total	9	28	17

More students unsure on mindset or with a growth mindset progressed into the next level of math whereas more students with a fixed mindset did not progress.

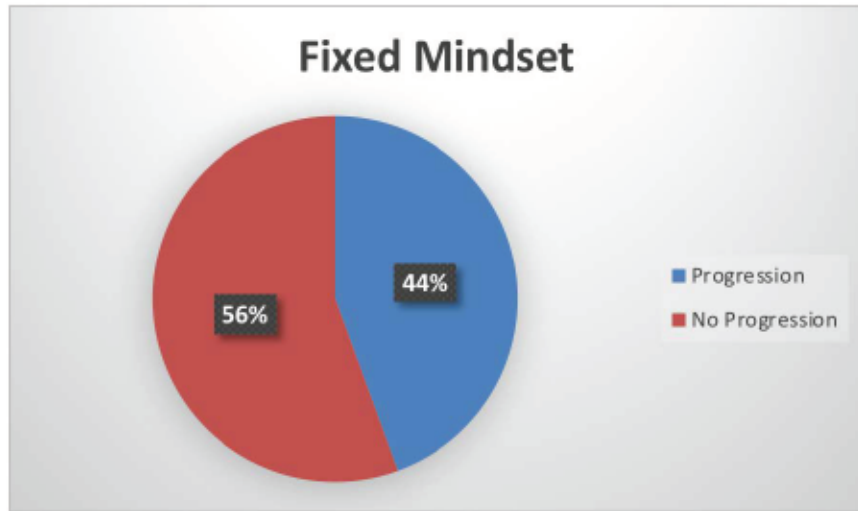


Figure 10. Percentage of progression in math by students with a fixed mindset.

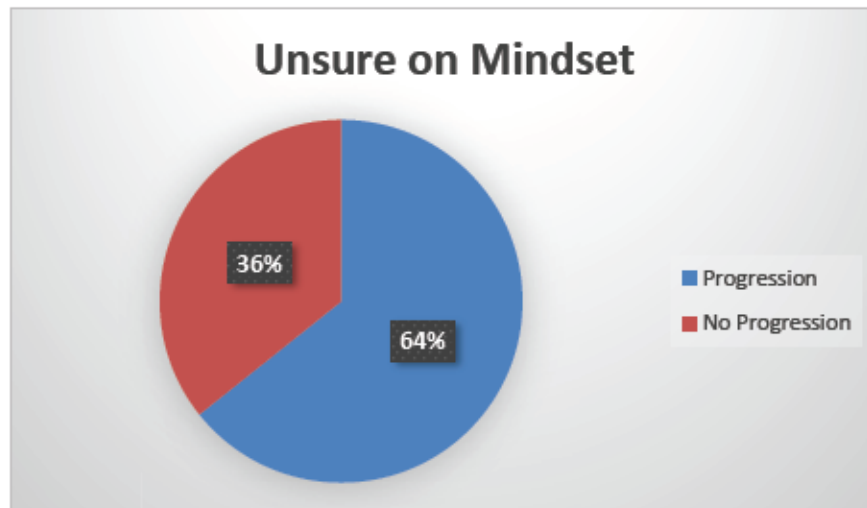


Figure 11. Percentage of progression in math by students unsure of their mindset.

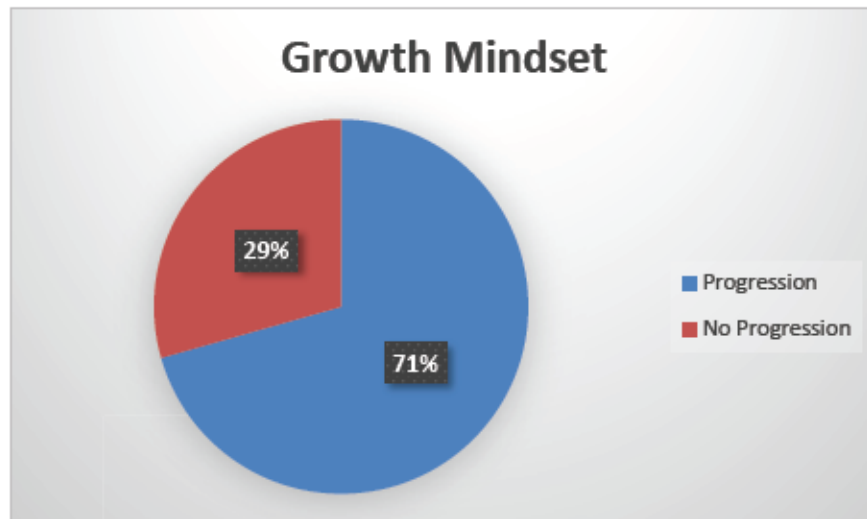


Figure 12. Percentage of progression in math by students with a growth mindset.

The independent variable for this research question is mindset, and the dependent variable is progression into the next level of math. The researcher analyzed the data for this research question using Chi Square tests to determine if the data comparing the difference in progression between students with a fixed mindset and unsure of mindset, students with a fixed and growth mindset, and growth mindset and unsure of mindset is statistically significant. The data is considered statistically significant if the p -value is less than 0.05. The null hypothesis states that mindset does not relate to progression from MTH 065 to the next level of math. The alternative hypothesis states that mindset does relate to progression in math with students with a growth mindset seeing the highest rate of progression, students unsure of mindset progressing at the second highest rate and students with a fixed mindset progressing at the lowest rate.

The Chi Square test for analyzing the data comparing progression of students with a fixed mindset and students unsure of mindset is not statistically significant as indicated by the p -value greater than 0.05. Therefore, the null hypothesis stating that mindset has no impact on progression into the next level of math is accepted and the alternative hypothesis stating that

students with a fixed mindset will progress at a lower rate than students unsure of their mindset is rejected. See Table 15.

Table 15: Chi Square Test for Dataset Including Fixed Mindset and Unsure of Mindset

Chi Square	1.1123
Alpha	0.05
p value	.29158

The Chi Square test for analyzing the data comparing progression of students with a fixed mindset and students with a growth mindset is not statistically significant as indicated by the p -value greater than 0.05. Therefore, the null hypothesis stating that mindset has no impact on progression into the next level of math is accepted, and the alternative hypothesis stating that students with a fixed mindset will progress at a lower rate than students with a growth mindset is rejected. See Table 16.

Table 16: Chi Square Test for Dataset Including Fixed Mindset and Growth Mindset

Chi Square	1.6993
Alpha	0.05
p value	.192373

The Chi Square test for analyzing the data comparing progression of students unsure of their mindset and students with a growth mindset is not statistically significant as indicated by the p -value greater than 0.05. Therefore, the null hypothesis stating that mindset has no impact on progression into the next level of math is accepted, and the alternative hypothesis stating that students unsure of their mindset will progress at a lower rate than students with a growth mindset is rejected. See Table 17.

Table 17: Chi Square Test for Dataset Including Students Unsure of Mindset and Growth Mindset

Chi Square	0.1891
Alpha	0.05
p value	.663687

Research Question 4: Findings and Results

The goal of research question #4 is to determine the difference in successful completion of MTH 065 between the experimental group and the control group. A grade of C or better indicates successful completion. This question sought to determine whether or not the intervention or treatment condition of the experimental group influenced the completion rate for students in MTH 065. The N=54 for this research question. In the control group, 25 students successfully completed MTH 065 and 5 students did not. In the experimental group, 21 students successfully completed MTH 065 and 3 did not. The percentage of students in the experimental group who successfully completed MTH 065 is slightly higher than that of the control group at 87.5% compared to 83.3%. See Figure 13.

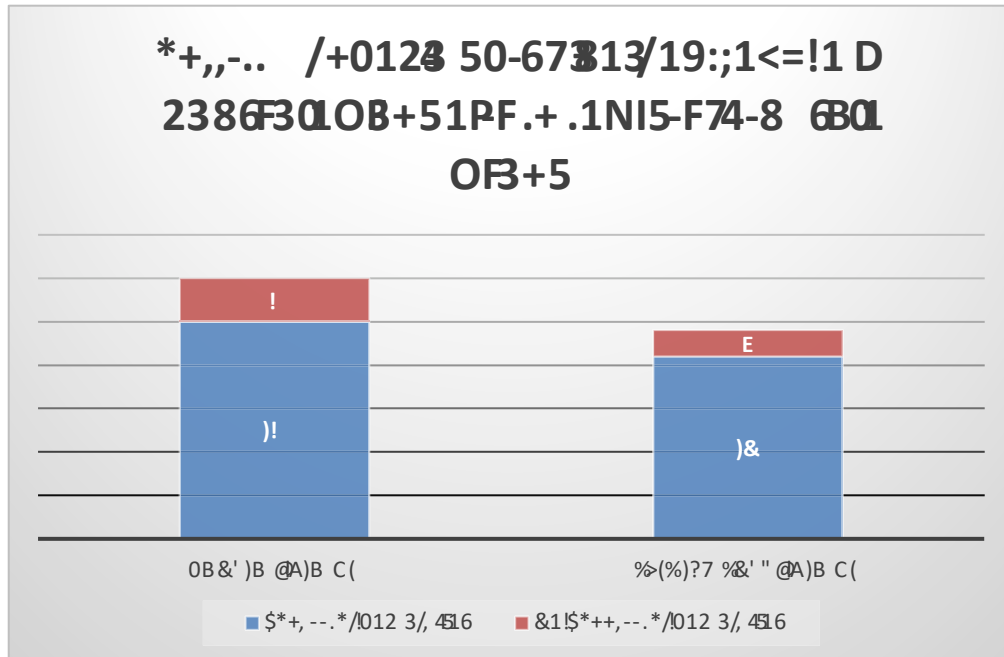


Figure 13. Successful completion of MTH 065: control group versus experimental group.

The researcher used a Chi Square test to determine if the data showing that students in the experimental group successfully complete MTH 065 with a C or better at a higher rate than students in the control group is statistically significant. The independent variable for this research question is the experimental condition, or growth mindset intervention. The dependent variable for this research question is successful completion of MTH 065. The null hypothesis states that there is no difference in successful completion of MTH 065 for the experimental or control group. The alternative hypothesis states that students in the experimental group successfully complete MTH 065 at a higher rate than students in the control group. See Table 18.

Table 18: Chi Square Test for Research Question # 4

Chi Square	0.1834
Alpha	0.05
p value	.668447

The Chi Square test indicates a p -value greater than 0.05 which indicates that the data for this research question is not statistically significant. Therefore, the null hypothesis stating that there is no difference in successful completion of math for the experimental or control group is accepted, and the alternative hypothesis stating that students in the experimental group is more likely to successfully complete MTH 065 than students in the control group is rejected.

Research Question 5: Findings and Results

Research question #5 studies the difference in successful completion of MTH 065 between students with a growth mindset, unsure on mindset, and students with a fixed mindset. A grade of C or better indicates successful completion. Mindset for this research question was determined through the post-test Mindset Works assessment which determined whether students have a growth mindset, fixed mindset, or are unsure of their mindset.

The population of students with a growth mindset had $N=17$ with 16 students who successfully completed MTH 065 with a C or better. The percentage of students who successfully completed MTH 065 is the highest of the three mindsets at 94%. The population of students unsure of their mindset had $N=28$ with 24 students who successfully completed MTH 065 and a percentage of 85.7%. The population of students with a fixed mindset had $N=9$ and the lowest percentage of students successfully completing MTH 065 at 66.6% or 6 out of 9. See Figure 14.

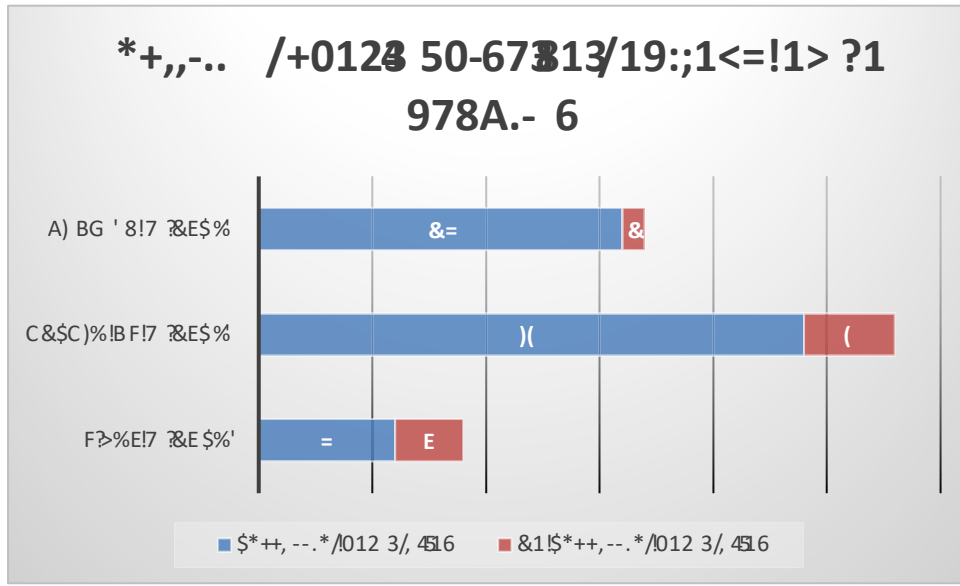


Figure 14. Successful completion of MTH 065 by mindset.

The researcher used a Chi Square test to determine if the data indicating the students with a growth mindset successfully complete MTH 065 at the highest rate is statistically significant through a p -value of less than 0.05. The independent variable for this research question is mindset, and the dependent variable is successful completion of MTH 065. The null hypothesis states that there is no difference in successful completion of MTH 065 by mindset, and the alternative hypothesis indicates that students with a growth mindset successfully complete MTH 065 at a higher rate than students unsure of their mindset or with a fixed mindset and students unsure of their mindset successfully complete MTH 065 at a higher rate than those with a fixed mindset.

The Chi Square test comparing the difference in successful completion of MTH 065 by students with a fixed mindset and those unsure of their mindset indicates that the data is not statistically significant as a p -value greater than 0.05 exists. Therefore, the null hypothesis that no relationship exists between mindset and successful completion of MTH 065 is accepted, and

the alternative hypothesis that students unsure of their mindset successfully complete MTH 065 at a higher rate than students with a fixed mindset is rejected. See Table 19.

Table 19: Chi Square Test for Dataset Comparing Students with a Fixed Mindset and Unsure of Mindset

Chi Square	1.6109
Alpha	0.05
p value	.204368

The Chi Square test comparing the difference in successful completion of MTH 065 by students with a fixed mindset and those with a growth mindset indicates that the data is not statistically significant as a p -value greater than 0.05 exists. Therefore, the null hypothesis that no relationship exists between mindset and successful completion of MTH 065 is accepted and the alternative hypothesis that students with a growth mindset successfully complete MTH 065 at a higher rate than students with a fixed mindset is rejected. See Table 20.

Table 20: Chi Square Test of Dataset Comparing Students with a Fixed Mindset and Growth Mindset

Chi Square	3.4064
Alpha	0.05
p value	.064943

The Chi Square test comparing the difference in successful completion of MTH 065 by students unsure of their mindset and those with a growth mindset indicates that the data is not statistically significant as a p -value greater than 0.05 exists. Therefore, the null hypothesis that no relationship exists between mindset and successful completion of MTH 065 is accepted and the alternative hypothesis that students with a growth mindset successfully complete MTH 065 at a higher rate than students unsure of their mindset is rejected. See Table 21.

Table 21: Chi Square Test of Dataset Comparing Students Unsure of Their Mindset with Growth Mindset

Chi Square	0.7563
Alpha	0.05
p value	.384488

Research Question 6: Findings and Results

Research question #6 asks about the difference in successful completion of MTH 065 of students who face a stereotype threat (historically underrepresented and female students) between the experimental group and control group. The N=14 for students in the experimental group susceptible to stereotype threat due to identification as belonging to historically underrepresented group (Hispanic/Latino or Black/African American). Of the 14 students susceptible to stereotype threat, 12 students successfully completed MTH 065 with a grade of C or better. The N=9 for students in the control group susceptible to stereotype threat. Of the students susceptible to stereotype threat, 7 successfully completed MTH 065. See Table 22.

Table 22: Successful Completion of MTH 065 by Stereotype Threat

		SUCCESSFUL COMPLETION	NO SUCCESSFUL COMPLETION
Experimental Group	Stereotype Threat	12	2
	No Stereotype Threat	9	1
Control Group	Stereotype Threat	7	2
	No Stereotype Threat	18	3

A Chi Square test determines whether a statistically significant difference in successful completion of MTH 065 occurred between students susceptible to stereotype threat due to ethnicity in the control versus the experimental group. The independent variable is participation

in the growth mindset intervention in the experimental group versus no participation for students in the control group and the dependent variable is successful completion of MTH 065. The null hypothesis for this research question states that there is no difference in successful completion of MTH 065 between the control and the experimental group. The alternative hypothesis states that there is a difference in successful completion of MTH 065 between the control group and the experimental group.

The Chi Square Test shows that there is no statistical significance in the difference in successful completion of MTH 065 for students susceptible to stereotype threat due to ethnicity in the control group versus the experimental group as the p-value is greater than 0.05. Therefore, the null hypothesis is accepted, and the alternative hypothesis is rejected. See Table 23.

Table 23: Chi Square Test for Students with Stereotype Threat Due to Ethnicity Successful Completion of MTH 065

Chi Square	0.2402
Alpha	0.05
p value	.624073

Next, the difference in successful completion of MTH 065 for females who are susceptible to stereotype threat in math (Steele, 2003) in the experimental group who received the growth-mindset intervention was compared to female students in the control group. A Chi Square test determines if there is a statistically significant difference in successful completion of female students in the experimental group versus the control group. The independent variable is participation in the experimental group which received the growth mindset intervention and participation in the control group which did not. The null hypothesis states that there is no difference in successful completion of MTH 065 between female students in the experimental group and those in the control group. The alternative hypothesis states that there is a statistically

significant difference between the experimental group and the control group.

The N=12 for female students who participated in the experimental group of this study. Of the 12 female students who participated in the growth mindset intervention, 11 or 91.7% successfully completed MTH 065. The N=15 for female students included in the control group. Of the 15 students, 12 or 80% successfully completed MTH 065. See Figure 15.

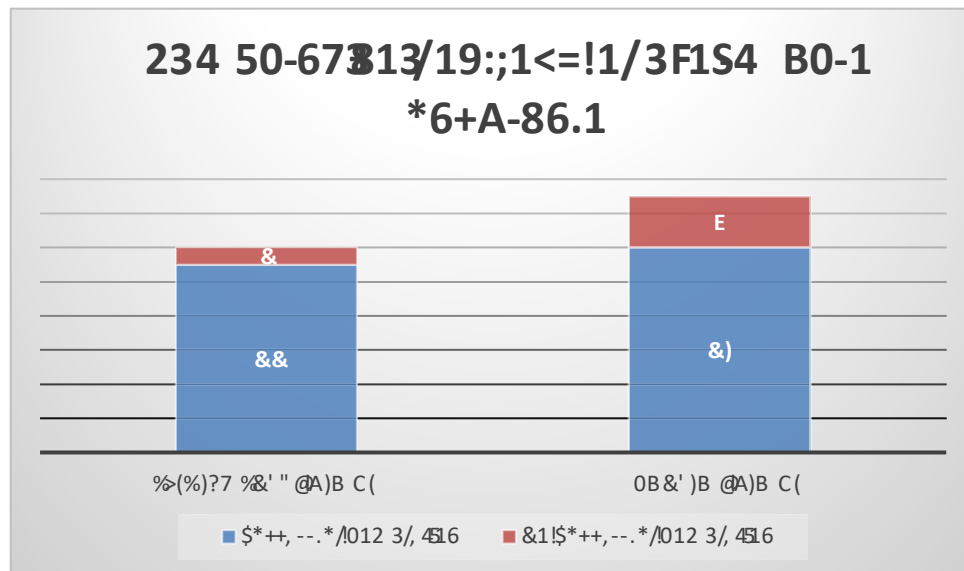


Figure 15. Successful completion of MTH 065 for female students susceptible to stereotype threat control versus experimental group comparison.

A Chi Square test determined whether the difference in successful completion of MTH 065 by female students in the experimental group versus the control group is statistically significant. The independent variable is participation in the experimental group versus the control group, and the dependent variable is successful completion of MTH 065. The null hypothesis states that there is no difference in successful completion by female students in the experimental group compared to the control group. The alternative hypothesis indicates that there is a statistically significant difference in successful completion between the experimental and control groups.

As the p -value is above 0.05, the Chi Square test indicates that a statistically significant difference does not exist between successful completion of MTH 065 in the experimental group compared to the control group. Therefore, the null hypothesis is accepted, and the alternative hypothesis is rejected. See Table 24.

Table 24: Chi Square Test for Successful Completion of MTH 065 by Female Students in the Experimental Group Compared to the Control Group

Chi Square	0.719
Alpha	0.05
p value	.396465

Conclusion

The purpose of this study was to determine the impact of growth mindset on performance and successful completion of MTH 065 and to test the effectiveness of a short growth mindset intervention on influencing a change in mindset toward a growth mindset. None of the data collected resulted in relationships determined to be statistically significant. The comparison of pre-test and post-test assessment results did not show a statistically significant difference in mindset change between the experimental and control groups. Additionally, no difference in progression from MTH 065 to the next level math occurred between the experimental and control group. However, students with a growth mindset successfully completed MTH 065 and progressed to the next level of math at a slightly higher rate than those who were unsure of their mindset or assessed at a fixed mindset, although it was determined to not be statistically significant. Similarly, students in the experimental group successfully completed MTH 065 at a slightly higher rate than those in the control group, but again, not at a statistically significant rate. Finally, there was no difference in successful completion of MTH 065 for students susceptible to

stereotype threat in the experimental group compared to the control group for historically underrepresented populations or female students.

CHAPTER 5: CONCLUSIONS AND IMPLICATIONS

Introduction

Community colleges are open-access educational institutions. As such, they face the challenge of educating students at different academic levels. Chapters 1 and 2 provide detailed information on the struggling success and completion rates of community college students. Students who begin college with math and English placement below college level face developmental coursework that potentially adds multiple semesters to their time in college. In particular, students placing into developmental math see low graduation rates of 28% after 8.5 years (Attewell et al., Levey, 2006). Stereotype threat is an added barrier for developmental math students whose race or gender is perceived to have limited abilities in math (Steele, 1997; Steele et al., 1995).

Research shows that mindset interventions designed to influence a change from a fixed mindset, or the belief that abilities are stagnant, to growth mindset, which is the belief that individuals can improve any abilities are effective at setting off a recursive cycle that results in improved academic performance (Dweck, 2008b). Studies show that short, infrequent interventions change mindsets from fixed to growth and are recursive when students experience successes which, in turn, motivates repeated behaviors that align with improved academic performance (Paunesku et al., 2012).

This quantitative research study has the purpose of determining the impact of a mindset intervention on performance in developmental math. The research questions include identifying the relationship between growth mindset and successful completion of MTH 065 and progression

into the next level math course. In addition, the relationship between the growth-mindset intervention and its impact on changing mindset from fixed or unsure to growth mindset and the related success in MTH 065 and progression into the next level math was identified. Finally, the study investigated the impact of the growth mindset intervention on students who experience stereotype threat in math. Data provided in Chapter 4 displays the relationship, or lack of relationship, between the independent and dependent variables for each research question. Overall, the results indicate a weak, not statistically significant correlation between mindset and performance in math.

Contribution to Research

Research described in Chapter 2 indicates a relationship between growth mindset and academic performance (Blackwell et al., 2007; Cohen et al., 2009). Prior studies show that research-informed psychological interventions are effective at influencing a change in mindset toward academic studies from fixed to growth (Cohen et al., 2009). This type of intervention develops a student's belief that they can improve abilities through effort and hard work and encourages an interest in learning. Recent studies indicate that these interventions are scalable, potentially cost-effective, and successful at influencing a cycle of improvement in academic potential (Yeager et al., 2016a). These factors indicate that growth mindset interventions have the potential to help community colleges face challenges such as serving students of all academic levels and addressing low completion rates with limited resources. An extremely weak, not statistically significant relationship exists between the growth- mindset intervention administered in this study and overall academic performance in developmental math.

Discussion of Study Attrition

At the time of the first data collection phase of the study, which included the pre-test and administration of the growth mindset intervention in the experimental group and the pre-test in the control group, the sample consisted of a total of 87 students who completed the informed consent. At that point in September 2017, the experimental group consisted of 38 students and the control group consisted of 49 students. At the time of the researcher's return to administer the post-test in November 2017, a total of 33 participants with informed consent were absent the day of the post-test and, therefore, eliminated from the study. The attrition affected the sample size to an extent that the ability of the data to produce statistically significant results was diminished.

Regular attendance in college courses is related to student success (Credé & Kieszczynka, 2010). The students absent on the day of the researcher's return may share characteristics that impact their likelihood of success or lack of success in college coursework. Conversely, the students present on the day of the researcher's return may also exhibit characteristics that affect their likelihood of success and persistence in college coursework. If attendance on the day of the researcher's return to the class represented a pattern of absence or attendance, the data may be affected.

Discussion of Sample by Instructor

The distribution of mindset by instructor as assessed by the pre-test is similar with each group showing fixed mindset as the lowest occurrence, growth mindset as the next lowest occurrence, and unsure of mindset as the highest occurrence. The samples enrolled in the classes of instructors 1 and 2 demonstrated nearly identical distributions for mindset as assessed by the pre-test. The sample enrolled in the class of instructor 3 had a higher rate of growth mindset. This is due to the majority of students in the experimental group leaving prior to signing the

informed consent when told by the instructor that they if they did not want to participate in the study they were free to leave the class. The distribution of mindset by instructor through data from the post-test shows a similar breakdown of students with a growth mindset, unsure of mindset, and with a fixed mindset for each instructor.

Interpretations of the Findings

The purpose of the first research question was to determine the impact of the growth-mindset intervention designed for this study on changing mindsets from fixed toward a growth mindset. The Mindset Works assessment used in this study evaluated whether a student has a fixed mindset, growth mindset, or is unsure of mindset. The experimental group did not see a positive change in mindset between the pre-test and the post-test. This indicates that the growth-mindset intervention was not effective in changing mindset from fixed toward growth.

The intervention was adapted from one designed by a Stanford research group and Khan Academy. However, its design was meant for younger students in middle school or grade school. The lack of relationship between the growth-mindset intervention and a change in mindset indicates that the intervention should be further vetted and refined. Previous research indicating the success of growth mindset interventions on improving academic performance indicates that this would be a worthwhile effort.

Research question two attempts to study the difference in progression from MTH 065 to the next level of math between students who participated in the growth-mindset intervention and students who did not. Progression into the next level of math indicates that a student successfully completed their math course with a grade of C or better and committed to continue on in math toward credit-level math. The control group saw a slightly greater percentage of students' progress into the next level of math than the experimental group. This indicates that the growth-

mindset intervention had no effect on progression from MTH 065 to the next level math.

The results imply that the intervention did not have a positive influence on academic performance in developmental math. Again, further development of an effective intervention that changes a student's mindset from fixed to growth and develops the belief that effort improves ability in subject areas such as math should be explored. An effective growth-mindset intervention motivates a student to work hard toward learning material when they see improvement in ability.

Research question three studied the relationship between students with a growth mindset and progression into the next level of math to that of students with a fixed mindset or unsure of their mindset. Although not statistically significant, students with a growth mindset progressed into the next level of math at the greatest percentage, students unsure of mindset progressed at the second highest rate, and students with a fixed mindset progressed at the lowest rate. The growth-mindset intervention was not effective at changing mindset in the overall population of students in MTH 065, but students with a growth mindset, as indicated by the post-test, continued on into the next level math at a higher percentage than students unsure of their mindset or with a fixed mindset. This result suggests that the students with a growth mindset put effort forth in their math course because they saw an improvement in their math abilities. Continued research with a larger population of students could validate that there is a statistically significant relationship between growth mindset and progression in developmental math and, in turn, validate the need to continue to refine a growth-mindset intervention that is effective in influencing a change toward a growth mindset.

Research question four studied the relationship of successful completion of MTH 065 between the experimental group and control group. The results showed a slightly higher but not

statistically significant percentage of students in the experimental group completed MTH 065 with a C or higher than the control group. A repeat of this study with a larger population of students would determine whether the growth-mindset intervention experienced by the experimental group has a statistically significant impact on changing mindset in a way that leads to behaviors that result in a higher rate of successful completion of developmental math.

Research question five explored the relationship between students with a growth mindset, unsure of their mindset, or fixed mindset and successful completion of MTH 065. Similar to the results seen regarding progression into higher level math by mindset, students with a growth mindset successfully completed MTH 065 at a higher percentage than students unsure of their mindset or with a fixed mindset. Although there was no statistically significant change in mindset as a result of the intervention, the results suggest that mindset is an indicator of success in developmental math. An additional study repeating the methodology used in this research with a larger participant population would determine if there is a statistically significant relationship between mindset and successful completion of MTH 065. If a statistically significant relationship exists, further effort to create an effective growth-mindset intervention would be beneficial.

The purpose of the final research question was to determine the effectiveness of a growth mindset intervention in helping students overcome stereotype threat due to race or gender and successfully complete MTH 065 with a grade of C or better. The impact of the intervention on stereotype threat due to race was studied separately from stereotype threat due to gender. The results for the impact on successful completion of MTH 065 for students who face stereotype threat due to identity within historically underrepresented population was not statistically significant, although there was a slightly higher rate of completion in the experimental group than in the control group. This may be due to the small population size in the study; further

research with a larger participant group would determine whether there is a statistically significant relationship.

However, the results for the population of students who face stereotype threat due to gender regarding their successful completion of MTH 065 were statistically significant. Students facing stereotype threat due to gender, female students, successfully completed MTH 065 with a grade of C or higher at a statistically significant higher rate in the experimental group than in the control group. This indicates that female students were more receptive to the growth-mindset intervention than results from other research questions suggested the overall class was. The results imply that the design of this growth-mindset intervention was effective in triggering changes in behavior that resulted in higher success rates in female students.

Female students face the perception that math and science are male-dominated subjects in which females naturally struggle more than men (Steele, 1997). An intervention that indicates neuroscientific evidence that all students, male or female, can improve their abilities in any subject, including math and science, is effective at counteracting the effects of stereotype threat. The results from the data for this research question indicate that a one-time growth-mindset module that shows how brain pathways develop and encourages a focus on learning rather than performance goals affects performance in developmental math in a positive way.

Further Research

This study researched the impact of a one-time mindset intervention on performance in developmental math at a large, suburban community college. Further research on different approaches to influencing a growth mindset and broadening the population of participants is recommended. For example, this study did not research the impact of the teacher's mindset in conjunction with the intervention on influencing a change in mindset. This recommendation

includes studying the effect of a growth mindset intervention in addition to training teachers to reinforce growth mindset through praising effort and substantiating that academic improvement stems from hard work and focus rather than natural talent. An additional recommendation includes gathering qualitative data to fine-tune the intervention to determine which components of the intervention are most effective at influencing a positive mindset change toward growth.

Research shows that short-term interventions influence a change in mindset from fixed to growth. A gap exists in studying the effects of events that may trigger a change in mindset from growth or unsure to fixed, such as the act of placing into developmental math. A study that researches the impact on mindset due to placing into developmental math would inform effective timing for a growth-mindset intervention. If the act of placing into developmental math influences a change in mindset from growth or unsure to fixed, further research on the impact of a growth-mindset intervention prior to math placement testing is beneficial. This recommendation includes studying the effect of this growth-mindset intervention pre-placement testing on placement test scores and resulting performance in math coursework.

Conducting further research on the impact of a mindset intervention on female students in other academic subjects where stereotype threat exists, such as science courses, is also recommended. The difference in impact for female students in subjects typically susceptible to stereotype threat such as math and science compared to other subjects may provide evidence that mindset interventions are especially effective for this population. Additionally, comparing the effects of a mindset intervention on female students versus male students, isolating race, can determine if a mindset intervention is effective for students who experience multiple forms of stereotype threat such as female students of historically underrepresented race.

This study included a small population at one community college. The size of the

population was restricted due to the researcher's access to students enrolled in MTH 065 sections in which the same instructor taught at least two sections. It is recommended to perform similar studies with a larger population of students to generalize the results. Performing the study with a larger population at the same community college can determine if statistically significant results occur to generalize the findings to all developmental math students at the college. Performing the study at multiple community colleges representing a variety of settings and population demographics determines if the findings are generalizable to developmental math students at all community colleges.

This study used an intervention adapted by the researcher from a lesson plan designed for younger students. Additional research using a standardized, evidence-based mindset intervention, such as that developed by PERTS, the Stanford research group which is currently being tested with a larger population of community college and university students is recommended. Further refining can be done to ensure the intervention is specifically effective at changing mindset toward developmental math performance and ability.

Studying the impact of a growth mindset intervention on setting off a recursive cycle that leads to higher completion rates of developmental math sequences is an additional recommendation for future research. Chen (2016) found that only 49% of students complete their developmental course sequence and move to credit level math, which is nearly always required to complete a credential.

Finally, it is recommended to study the drop off of students who chose not to participate in the study. Further qualitative research on the reasons students did not want to participate would be valuable in identifying concerns or fears of participating in a research study. Collecting this data could inform the presentation of future research studies to students in a way that

addresses concerns and encourages participation.

Conclusion

This study researched the relationship between mindset and performance in developmental math. Six research questions sought to better understand the difference in performance between students with a growth mindset, fixed mindset, or unsure of mindset and the impact of a mindset intervention in influencing a shift toward a growth mindset. Partially due to the small sample size, the results for all but one of the research questions were not statistically significant.

Although the results for the majority of the research questions were not statistically significant, prior research on growth mindset indicates that it is a worthwhile area to continue to study. Recommendations for future research on this topic include expanding the population size and further developing the growth mindset intervention so it is effective for community college developmental math students. The growth mindset intervention did result in higher rates of successful completion of developmental math for female students who likely experience stereotype threat due to the perception that male students are typically stronger in math and science. As it is a short-term, cost-effective intervention, community colleges should consider the addition of growth mindset treatment in their developmental math curriculum.

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APPENDIX A: GROWTH MINDSET INTERVENTION LESSON PLAN
DRAFT

The following lesson plan was adapted from Khan Academy and PERTS' (Stanford University's research group on academic mindset's) partnership on growth mindset.

1. **Pre-intervention Survey:** Research-validated survey to determine breakdown between fixed mindset and growth mindset.
<http://blog.mindsetworks.com/what-s-my-mindset>
2. **Growth Mindset/Neuroplasticity Videos and Discussion:**
<https://www.youtube.com/watch?v=ELpfYCZa87g>
Introduces neuroplasticity.

Ask: What is neuroplasticity?

<https://www.youtube.com/watch?v=pN34FNbOKXc>
Discusses growth mindset, learning goals, and reinforces neuroplasticity.

Stop at 1:57

Briefly discuss Josh's story and the quote

• "The moment we believe that success is determined by an ingrained level of ability, we will be brittle in the face of adversity." - Josh Waitzkin

Stop at 5:36

Discuss differences in Growth and Fixed Mindsets

Ask: What do people with fixed mindsets focus the most on? How do both mindsets view effort?

Ask: How do both mindsets view obstacles?

Watch remaining video, then ask students:

Ask: How does their brain change?

Ask: How does it grow?

3. Application:

- a. Get in pairs. Think about and share a time when you could tell that you were getting smarter. *For me, I struggled with geometry in high school until I started meeting with my teacher before school. The teacher was able to explain the concepts in a different way and once I was caught up, I made sure to prioritize geometry to make sure I spent enough time studying and doing practice problems. I also made sure to ask for help anytime I needed it. I noticed that although I was still putting in a lot of effort, I was able to learn new concepts in geometry more quickly than I was at the beginning of the year.*

- b. Take a few minutes to think about that time when you overcame a struggle to learn something. It could be anything - from learning algebra to writing an introduction for a difficult essay (it could also be the example you shared with your classmate). Reflect on the times when you failed at first but through perseverance your brain created new neural connections and you eventually became better at the task at hand.
 - c. Write a letter to a future student of your class about this struggle. In at least five sentences, tell this student your story and give them advice on what they should do next time they encounter an obstacle when learning something new.
- 4. Post-intervention Survey:** 8 weeks post lesson plan, reverse coded Mindset Works survey.
<http://blog.mindsetworks.com/what-s-my-mindset>

APPENDIX B: MINDSET ASSESSMENT PROFILE ITEMS

STUDENT MINDSET SURVEYS - MOTIVATION SCALES

Note: All of the following scales are rated from 1 (Disagree Strongly) to 6 (Agree Strongly) on a Likert scale, and then reverse-coded where appropriate. Then, ratings for a particular construct are averaged together. A high score on the scale reflects agreement with the construct.

Items that are highlighted form the questions of the Mindset Assessment Profile.
Scale alphas, Means and SD based on all the subscale items listed under each scale.

1. Theory of Intelligence (Growth mindset; Dweck, 1999)

Scale: Sample 1 (N= 373): $\alpha = .78$; mean = 4.45, std. deviation = .965
Sample 2 (N=99): $\alpha = .78$; mean = 4.47, std. deviation = .976

Items:

Your intelligence is something you can't change very much. (reverse-coded)
You have a certain amount of intelligence, and you really can't do much to change it. (reverse-coded)
You can learn new things, but you can't really change your basic intelligence. (reverse-coded)
No matter who you are, you can change your intelligence a lot.
You can always greatly change how intelligent you are.
No matter how much intelligence you have, you can always change it a good amount.

2. Learning Goals (* Midgley et al, 1998, 2000 PALS)

Scale: Sample 1 (N= 373): $\alpha = .73$; mean = 4.41, std. deviation = 1.09
Sample 2 (N=99): $\alpha = .77$; mean = 4.38, std. deviation = 1.20

Items:

An important reason why I do my school work is because I like to learn new things. *
I like school work best when it makes me think hard. *
I like school work that I'll learn from even if I make a lot of mistakes.

2. Performance-Approach Goals (Mueller & Dweck, 1998)

Scale: Sample 1 (N= 373): $\alpha = .87$; mean = 4.00, std. deviation = 1.64
Sample 2 (N=99): $\alpha = .67$; mean = 2.21, std. deviation = .996

I like my work best when I can do it really well without too much trouble. (reversed-scored for MAP)
I like my work best when I can do it perfectly without any mistakes. (reversed-scored for MAP)
The main thing I want when I do my school work is to show how good I am at it.

3. Effort Beliefs (Blackwell, 2002; Blackwell et al., 2007)

Scale: Sample 1 (N= 373): $\alpha = .79$; mean = 4.66, std. deviation = .89
Sample 2 (N=99): $\alpha = .60$; mean = 4.62, std. deviation = .79

(Effort Beliefs) Positive Items:

When something is hard, it just makes me want to work more on it, not less.

If you don't work hard and put in a lot of effort, you probably won't do well.

The harder you work at something, the better you will be at it.

If an assignment is hard, it means I'll probably learn a lot doing it.

If my homework is really easy, it makes me feel like it's a waste of time doing it.

Negative Items (reverse-scored):

To tell the truth, when I work hard at my schoolwork, it makes me feel like I'm not very smart.

It doesn't matter how hard you work--if you're not smart, you won't do well.

If you're not good at a subject, working hard won't make you good at it.

If a subject is hard for me, it means I probably won't be able to do really well at it.

If you're not doing well at something, it's better to try something easier.

You only know you're good at something when it comes easily to you.

The best way to tell if you're good at something is to see how quickly you catch on to it.

In school my main goal is to do things as easily as possible so I don't have to work very hard.

I try to spend as little time on my school work as I can.

APPENDIX C: IRB APPROVALS

Institutional Review Board for Human Subjects in Research

Office of Research & Sponsored Programs, 1010 Campus Drive FLITE 412F· Big Rapids, MI 49307

Date: July 25, 2017

To: Dr. Sandra Balkema and Megan Dallianis
From: Dr. Gregory Wellman, IRB Chair
Re: IRB Application #170701 (*STUDY TITLE*)

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, "*STUDY TITLE*" (#170701) and determined that it meets Federal Regulations Expedited-category Z. This approval has an expiration of one year from the date of this letter. **As such, you may collect data according to the procedures outlined in your application until July 25, 2018.** Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#170701), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

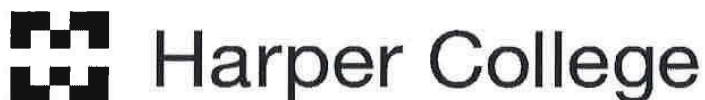
Understand that informed consent is a process beginning with a description of the study and participant rights with assurance of participant understanding, followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document and investigators maintain consent records for a minimum of three years.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,



Ferris State University Institutional Review Board
Office of Research and Sponsored Programs



Harper College

Go Forward®

Protocol # FY18_001

NOTICE OF APPROVAL - EXPEDITED REVIEW

DATE: August 8, 2017

TO: Megan Dallianis

From: Katherine Coy, Institutional Research Director and Institutional Review Board Chair 

Re: **The Impact of a Growth Mindset Intervention on Progression in Developmental Math.**

Approval Date: August 8, 2017

Thank you for applying for approval through the Harper College IRB. I have reviewed the materials you submitted for Harper's process as well as the approval received through the Ferris State University (FSU) Institutional Review Board. Based on this review, I have determined that your research qualifies for expedited review in accordance with the criteria published by the OHRP, 45 CFR 46.110 and FDA 21 CFR 56.110.

- Research poses no more than minimal risk to subjects, as assessed by the reviewer; AND
- Research for which each of the procedures falls within one of the DHHS Expedited review categories 1-7 and the Food and Drug Administration (FDA)
 - Specifically Category 7: Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As outlined in our Expedited Review protocol; I am able to grant Harper College IRB approval without a review by our full IRB panel for the study identified above. This study is approved from July 25, 2017 to July 25, 2018. For each additional year of study approval, you will need to submit a Study Continuation Request along with the FSU letter of continued approval.

AMENDMENTS: Investigators are required to report via email to OIR@HarperCollege.edu ANY changes to the research study (such as design, procedures, study information sheet/consent form, or subject population, including size). The new procedure may not be initiated until IRB approval has been given.

AUDIT OR INSPECTION REPORTS: Investigators are required to provide to the IRB a copy of any audit or inspection reports or findings issued to them by regulatory agencies, cooperative research groups, contract research organizations, the sponsor, or the funding agency.

COMPLETION: It is your responsibility to let the IRB know when this study is complete by sending an email to OIR@HarperCollege.edu. In addition, please provide the Harper College IRB with a copy of any presentations or papers that result from this study. Finally, it is your responsibility to let the IRB office know of address changes and project date changes.

We suggest you keep this letter with your copy of the approved protocol. Please refer to the exact project title and protocol number in any future correspondence with our office. All correspondence must be typed.

APPENDIX D: FERRIS UNIVERSITY INFORMED CONSENT

Dear _____,

I am a student in the Doctorate in Community College Leadership program at Ferris State University and am working on a dissertation project designed to study the impact of a growth mindset intervention on progression in developmental math.

To inform this project, I am administering surveys on growth mindset and retrieving data on student progression in math from the fall 2017 to spring 2018 semester.

Your participation in this study is voluntary which is explained along with other details in the informed consent form. When the study completed, I will use pseudonyms for participants to protect the anonymity of all participants.

If you have any questions, please give me a call at 847-925-6316 or send an email to mdallian@harpercollege.edu.

Thank you for your consideration,
Megan Dallianis

INFORMED CONSENT FORM

Project Title: The Impact of a Growth Mindset Intervention on Progression in Math.

Principal Investigator: Sandra Balkema

Email: SandraBalkema@ferris.edu

Phone: 231-591-5631

Student Investigator: Megan Dallianis

Email: mdallian@harpercollege.edu

Phone: 847-925-6316

STUDY PURPOSE

You are invited to participate in a research study about the impact of a growth mindset intervention on progression in developmental math. In particular, the researchers are looking at progression from Algebraic Modeling (MTH 065) to the next level math course from fall 2017 to spring 2018.

PARTICIPATION

Taking part in this study is completely voluntary.

You are eligible to participate in this study because you are enrolled in Algebraic Modeling (MTH 065) during the fall 2017 semester. If you agree to be part of this study, you will be asked a series of questions related to growth mindset and participate in a 50-minute lesson plan during your regular MTH 065 class time.

POTENTIAL RISKS/DISCOMFORTS

There are no known risks associated with this study.

ANTICIPATED BENEFITS

This research is designed to examine the impact of a mindset intervention's influence on change from a fixed to a growth mindset. A growth mindset has been identified as a positive influence on students' motivation and attitudes toward challenges.

CONFIDENTIALITY

Signing this form is required in order for you to take part in the study and gives the researchers your permission to obtain, use and share information about you for this study. The results of this study could be published

in an article but would not include any information that would identify you. There are some reasons why people other than the researchers may need to see the information you provided as part of the study. This includes organizations responsible for making sure the research is conducted safely and properly, including Ferris State University.

In order to keep your information safe, the researchers will protect your anonymity and maintain your confidentiality. The data you provide will be stored in a locked file. The researchers will retain the data for 3 years after which time the researchers will dispose of your data by standard state of the art methods for secure disposal. The data will not be made available to other researchers for other studies following the completion of this research study.

CONTACT INFORMATION

The main researcher conducting this study is Megan Dallianis, a doctoral student at Ferris State University. If you have any questions you may email her at mdallian@harpercollege.edu or call 847-925-6316.

If you have any questions or concerns about your rights as a subject in this study, please contact: Ferris State University Institutional Review Board (IRB) for Human Participants, 220 Ferris Drive, PHR 308, Big Rapids, MI 49307, (231) 591-2553, IRB@ferris.edu.

SIGNATURES

Research Subject: I understand the information printed on this form. I understand that if I have more questions or concerns about the study or my participation as a research subject, I may contact the people listed above in the “Contact Information” section. I understand that I may make a copy of this form. I understand that if my ability to consent for myself changes, either I or my legal representative may be asked to re-consent prior to my continued participation.

Signature of Subject: _____ **Date of Signature:** _____

Printed Name: _____

Contact Information: email - _____ **phone -** _____

Principal Investigator (or Designee): I have given this research subject (or his/her legally authorized representative, if applicable) information about this study that I believe is accurate and complete. The subject has indicated that he or she understands the nature of the study and the risks and benefits of participating.

Printed Name: _____ **Title:** _____

Signature: _____ **Date of Signature:** _____