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How Brief Motivational Interventions Impact Math Beliefs in Undergraduate University Students

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HOW BRIEF MOTIVATIONAL INTERVENTIONS IMPACT MATH BELIEFS IN UNDERGRADUATE UNIVERSITY STUDENTS

BY

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DISSERTATION

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Dedication

Bringing this manuscript and the preceding study to its completed state was an exercise in persistence, belief in myself, and a tremendous transformation in how I saw myself as a student, a researcher, and a learner. All that I was writing about manifested in my own life as monstrous doubts and mischievous thoughts that snuck into my subconscious mind whenever I stopped keeping diligent watch, which was more often than I would want to admit. Plunging myself in the midst of this challenge without much prescience of the hard road which I would journey down gave me little pause. So many before me had done it and many after me will do it – just another step along the path, nothing more. It would take me to the depths of who I thought I was and beyond to the person I became. Never had I explored my inner beliefs to such an extent. Never had I cared to do so as it is with most deep explorations – internal or external – there is a price to be paid.

As I am writing this rather lengthy dedication quite before my proposal is finished (even now my advisor awaits an email from me as she shakes her head and wonders if I shall ever finish) I cannot say at what point I was able to break free from my self-imposed constraints. I just knew it needed to be done. As I have submitted my last time extension request (and though I have been known to joke about taking the long path from Masters to PhD – 12 years – I am not prone to levity at this moment.) My resolve grows stronger even as I write this dedication: my resolve to bury the demons that call me back to mediocrity, my resolve to contribute meaningfully not only to the field of educational psychology, but to the teachers and the students playing and participating now on the learning field of life.

As it seems now, this field is being remade, recreated to accommodate a different game and the players don't know the new rules and have no coach, no marking on this field. There is only an umpire throwing penalty flags with no explanation as to why they were thrown in the first place. Now is the time for this student to commence, writing, research, planning and all. The players are ready for a coach and for the rules of the game to be explained so they can enjoy playing this game of learning once again. And so I dedicate this study to the children and teachers on the field and the ones in the stands awaiting their opportunity to play. May we play kindly with each other as we learn this new game.

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As is often customary, I will begin with thanking my advisor and chair, Dr. Terri Flowerday, but I do this not because I have to, but because I wish to place her in her right and proper place in the hierarchy of acquiring this dissertation. Without Dr. Flowerday being in my corner, I would not have finished. When I was ill, she kept up the encouragement for me to persevere; when I became the primary caretaker of my father as his health declined, she would listen to my stories and tell me not to quit. After numerous time extensions and a leave of absence due to health concerns, she did not write me off as another doctoral student who would not complete her dissertation. “Ayesha, you have to do this,” she would say. And so I did. A good student always listens to her teacher.

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HOW BRIEF MOTIVATIONAL INTERVENTIONS IMPACT

MATH BELIEFS IN UNDERGRADUATE UNIVERSITY STUDENTS

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Abstract

Despite best efforts, students in U.S. schools still underperform in mathematics compared to many other developed countries, and the achievement gap persists. Teachers play a most important role in student success, yet the knowledge about adult beliefs (and how they can be changed) concerning one's ability to learn math, the value one has for math, and one's understanding about how math anxiety derails learning still falls short in informing efforts to best train/support pre-service or in-service teachers. A group of undergraduate university students (N=123) participated in a fully online intervention measuring each of the components in the Expectancy-Value-Cost (EVC) motivational model (Barron & Hulleman, 2015; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000) as it related to their beliefs about mathematics, then completed a three-part intervention (based on Blackwell, Trzesniewski, & Dweck, 2007; Gaspard et al., 2015; and Ramirez & Beilock, 2011), followed by post-measurements of each of the components of EVC. Significant results were obtained for each component of EVC, implying short interventions can effect positive changes in beliefs for adults.

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Chapter 1: Introduction

Problem Statement

There is no such thing as a *math person*. Teachers and/or parents or other influential adults will either open the doors that lead to student learning or they will not. Having committed adults willing to support students to truly learn and understand mathematics will create opportunities for them both during their K-12 schooling, after they graduate high school, through scholarships to attend college (students with high math SAT and ACT scores, along with being a National Merit finalist, can be rewarded with over $40,000 in awards per year; PrepScholar, 2013). With a strong math background, students can choose careers that involve mathematics. The top ten careers that pay the most with a bachelor's degree all involve higher math (College Choice, 2017). Currently, many of these adults are in pre-service, elementary school education programs around the country, learning how to teach mathematics to children. If these individuals carry the belief that a student may not have the ability to learn a subject, they may in turn negatively influence their students, and the status quo of low performance will likely be maintained. Teacher expectations cannot be ignored as a source of variability in student performance (Rosenthal, 1994; Rosenthal, Baratz & Hall, 1974; Rosenthal & Jacobson, 1968), especially with at-risk students who belong to minority groups (Jussim & Harber, 2005). Low expectations that teachers hold about students can manifest in the classroom as teachers give students easier work, lower standards, or give feedback that accepts their weakness rather than supports them to do better. "Don't worry, you did your best" sounds kind, but it is demotivating to struggling students (Yeager et al., in press).

Due to factors, often beyond the students' control, the education they received did not open doors for them. Even if they had a desire to pursue a field in the sciences, if they had low math abilities, those careers would be out of reach for all but the most determined. Academic performance often separates between higher and lower performance by race and income. This gap in abilities along lines of race and income is called the *achievement gap*. That gap, even though it showed signs of narrowing in the 1980s, has stubbornly persisted and widened again despite our best efforts as an educational community (Lee, 2002). Low performing students often are saddled with many burdens outside the classroom, the outcome of which manifests as stress and anxiety due to the lack of the most basic of needs being met. In the classroom, these lower performing students are met with low expectancies of success from their teachers who have low expectations in their own ability to make a difference with low performing students (Ferguson, 2003).

Up to this point, the majority of focus for closing the achievement gap has been on what is termed *cognitive factors* (i.e., knowledge that is taught in schools) (Dweck, 2011). There are other factors that are not tested directly that fall under the term *noncognitive factors*, which include behaviors, attitudes, strategies and skills students need to utilize to experience success. These factors are *cognitive*, but the former term has imbedded itself in the literature (see Farrington et al., 2012). Underlying the best of cognitive practices, however, is still an undercurrent of low challenge for low performing students and a lack of belief that these students can achieve (Dweck, 2011; Steele, 1997). When *noncognitive factors* are taken into account, and pinpointed for improvement to incorporate into classrooms through specific interventions, the literature has shown promising results for motivating students to succeed (Brummelman & Walton, in press; Farrington, et al., 2012; Snipes, Fancsali, & Stoker, 2012). This often missing piece of the psychological learning equation is now being addressed through what Walton calls *wise* interventions (2014).

Wise interventions, typically of short duration, address specific underlying psychological aspects that, if changed, make meaningful differences in targeted behaviors (Walton, 2014). These interventions that are precise and easy to implement have been shown to narrow or even close the achievement gap in classrooms and schools by increasing grades for struggling students in the treatment group, even maintaining that increase over a period of years (Aronson, Fried & Good, 2002; Blackwell, Trzesniewski & Dweck, 2007; Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009; Hulleman & Harackiewicz, 2009; Park, Ramirez & Beilock, 2014; Walton & Cohen, 2011). “Students’ performance and psychological trajectory can be strongly influenced by timely actions, even when apparently small, that alter or reset the trajectory’s starting point” (Cohen et al., 2009, p. 324), and when these timely actions can change students’ mindsets about their learning, they can more readily march through those educational doors, even if they are opened only a crack (Yeager & Walton, 2011).

Even as research has supported how these wise interventions when used alone have had positive influence on student achievement as measured by course grades or overall grade point averages (GPA), there are gaps in the research about the effectiveness of how these interventions would affect performance in combination with each other. In previous research with the Expectancy Value (EV) framework (the element of cost originally was considered an aspect of value) a larger effect was gained with student motivation when the components of expectancy and value were considered together (Wigfield & Eccles, 2000). There appears to be some significance in considering the effects of each of the components of the Expectancy, Value, and Cost in combination. More recently, Durik and her colleagues tested whether or not an experimental manipulation using value would be moderated by expectancies of success on the part of the students, and the results supported a moderation effect of expectancy: when expectancy of success was low, the effect of the value manipulation was also low, the reverse was also true (Durik, Shechter, Noh, Rozek, & Harackiewicz, 2014).

Theoretical Foundation

This study focuses on improving the math beliefs of undergraduate university students by using a multi-component intervention in which each individual component has been demonstrated in past research to positively influence student performance. The Expectancy-Value framework (Wigfield & Eccles, 2000) with the component of *cost* as an independent element, i.e., Expectancy-Value-Cost or EVC (Barron & Hulleman, 2015) will be used as an organizing structure for the intervention.

Research Questions

Studying the effects of each element in the E-V-C framework in one combined intervention, as measured by increases in each component of the E-V-C framework of motivation, may reveal information about why some students respond to these interventions and some do not. The research questions this study addresses are the following: 1) - How does expectancy for math success, value for math and cost associated with math differ by demographics? And 2) - Does a brief intervention on how the brain learns, value of math, and math anxiety change student expectancy for math success, beliefs about value of math or math anxiety?

Chapter 2: Literature Review

This study employed a three-part intervention. Part one, aligned with the expectancy portion of the E-V-C framework, is Carol Dweck's Self-Theories (2000), used as an intervention, (Aronson, Fried & Good, 2002; Blackwell, Trzesniewski & Dweck, 2007; Lazowski & Hulleman, 2015) teaching how the brain learns and that intelligence is a malleable attribute rather than fixed. Part two, aligned with the value portion of the E-V-C framework, is a relevance intervention shown to increase student perception of value (Gaspard et al., 2015). Part three, aligned with the cost portion of the E-V-C framework, is an intervention shown to reduce math test anxiety (Park, Ramirez & Beilock, 2014; Ramirez & Beilock, 2011).

This study focuses on the role mathematics plays in students' academic trajectories by addressing undergraduate students' beliefs about their own ability both to learn and value math. Some researchers have found elementary school teachers have larger effects on math achievement than on achievement in other subjects (e.g., reading or Language Arts, Nye, Konstantopoulos, & Hedges, 2004). While both math and literacy are important, having mathematics knowledge along with literacy provides a student with additional benefits: expanded job choice. More jobs than ever require a higher understanding of mathematical principles, (National Science Board, 2006). Higher math skill equals higher chance of high school graduation (students with Algebra I course failure are four times more likely to drop out; Vogel, 2008) and higher job satisfaction and status with a college degree compared to those without (National Research Council, 2012). Half the students in community colleges cannot obtain math proficiency at the college level, preventing some students from graduating (Hulleman & Barron, 2014).

Test performance in mathematics is low and widely varied in primary and secondary schooling (The Nation's Report Card, 2013). Researchers found the trend of low math skills continuing at the college level, "The area of greatest skill deficiency has been identified as mathematics with the majority of entering students underprepared for college level work" (Dugan, 1999, p. 24). "Some 60 percent of the nation's 13 million community college students are unprepared for college-level courses and must enroll in at least one developmental course…[and] less than a quarter of students in developmental math courses earn a degree or credential within eight years" (Silva & White, 2012, p. 3).

Math performance differences between women and men are insignificant in the general population at the high school level, and women and men obtain bachelor's degrees in mathematics at the same rate, so the disproportionately low numbers of women compared to men in upper level math fields must be attributable to something other than a genetic disposition to math understanding, and one area that may have an influence is personal beliefs related to the ability to learn mathematics (Hyde, Fennema & Lamon, 1990). It is an individual's belief in her/his abilities that plays a large role in determining career choice, not just performance alone. In fact, beliefs held about abilities in math guide career choice, as demonstrated by students asking whether or not their future career would involve math. For those attracted to careers in education, statements about teaching at the elementary level concerned the fact that those prospective teachers would mention their career would not require a lot of math. In general, Pajares and Miller found females to have lower efficacy and higher anxiety in math than males, and further, that math performance and efficacy were highly correlated for both sexes (1994). Student beliefs about their abilities in math, their efficacy, were a stronger predictor of their performance than the other variables in the study, e.g., number of college math credits, perceived usefulness, math self-concept, and gender (Pajares & Miller 1994). The significance of beliefs about intelligence added to this field of research by Dweck and Leggett when they stated that students' intelligence beliefs are predictive of "whether individuals will be oriented toward developing their ability or toward documenting the adequacy of their ability" (1988, p. 263).

Expectancy

It is this strength of belief that guides actions that is a key component to an individual's motivation toward some desired outcome. The first component of E-V-C model is expectancy. This element of the model encompasses many motivational perspectives that focus on having a belief in one's ability to complete a task, including Carol Dweck's, implicit theory of intelligence (as stated in Barron & Hulleman, 2015). This theory focuses on mindsets or beliefs about the nature of one's intelligence (Dweck, 2000; Dweck et al., 1988; Hong, Chiu, Dweck, Lin, & Wan 1999). Dweck's work has shown if individuals have the belief that their intelligence is a fixed entity (entity theorists), genetically predisposed, where no amount of effort would meaningfully change their score on an I.Q. test, their behavior would lead them to outcomes and choices that were very different compared to those who identified with the malleable or growth mindset, in which individuals believe that their own efforts will make a difference in their learning or how smart they are. These individuals who hold a growth mindset are more persistent, are not failure averse, tend to tolerate long periods of confusion, and value learning over performance. In comparison, those individuals who believe their intelligence is fixed tend to be failure averse, withdraw from challenge so as to preserve the tenuous nature of their inherent “smartness,” and select goals that focus on their performance rather than on their learning, i.e., achieving a certain grade rather than achieving a higher level of understanding (Dweck, 2000; Walton, 2013).

Hong and colleagues found that even if students have a fixed mindset, when they are given a learning-oriented, mastery goal, regardless of their beliefs about their abilities, they will persevere in the face of difficulty (1999). A performance goal, however, will affect an individual based on their belief about their ability. High ability beliefs equaled high problem-solving strategies, but low ability beliefs led to helpless behavior when the task became too challenging and the focus was on proving ability through performance goals (Hong, et al., 1999). When classrooms are organized primarily around performance goals where students set goals to earn grades for their performances on tests or projects, those with low ability beliefs would exhibit helpless behavior (Hong, et al., 1999). Choosing to believe intelligence is malleable affects performance in a positive way, and those beliefs about ability, specifically intelligence, have been shown in multiple studies to be quite changeable themselves (Dweck, 2000; Dweck et al., 1988). “When students believe that their effort will lead to learning, they are more likely to experience high expectancy” (Hulleman, Barron, Kosovich, & Lazowski, 2014a, p. 259).

One study, conducted with 91, seventh grade math students in an inner city New York school, was carried out to see if teaching children about the incremental theory of intelligence could change their beliefs about their intelligence and how that would affect students’ achievement in math class. Both the control group and the experimental group received eight, 25 minute instructional sessions, with the experimental group and control group each receiving five of the same sessions and three unique sessions. The unique sessions for the experimental group focused on teaching the students about the incremental theory of intelligence, i.e., intelligence is something you grow with effort and everyone has the potential to grow their intelligence. The control group received useful information about memory strategies and goal setting. Even though the two groups only received 75 minutes of unique instruction, over a period of eight sessions during the semester, the results were dramatic for the experimental group, which received the incremental intelligence training. “Within a single semester, the incremental theory intervention appears to have succeeded in halting the decline in mathematics achievement” (Blackwell, Trzesniewski & Dweck, 2007, p. 258).

With this short exposure of a wise intervention, the declining trajectory for grades in the experimental group was also reversed, (as tracked from the spring of the previous academic year – time point #1, to the fall of that current year – time point #2, to the spring of the current year – time point #3). Blackwell and her colleagues demonstrated that targeting a key belief about one’s intelligence, even for a short period of time, can result in a dramatic change in achievement and motivation (2007).

Dramatic changes in performance and achievement can be created in adult populations as well when targeted belief interventions are used to change beliefs about intelligence, especially regarding the achievement gap between Whites and African Americans (Aronson, et al., 2002). Recent research points to a variable that may account for a fair amount of this achievement gap. This variable, called “stereotype threat,” is a belief that certain groups are stereotyped with having lower intellectual abilities than other populations, and in circumstances where these intellectual abilities are important, the negative stigma experienced by these groups manifests as anxiety and disconnection from the domain (Aronson et al., 1999; Aronson et al., 2002; Steele, 1997).

One confounding aspect of stereotype threat is that it affects those who identify with the domain the strongest, i.e., women who perform at higher levels in math or African-Americans who identify strongly with the academic domain. It is not doubts about ability that plague these high performing individuals; it is a worry about being stereotyped in a negative way concerning that domain. Even though the gap between men's and women's scores on standardized tests has narrowed and graduation rates for Black students have increased (Steele, 1997), anxiety arises because of the fear of validating the negative stereotyped belief – those beliefs held by others or even by themselves; however, these individuals do not even have to believe these stereotypes themselves in order to have stereotype threat affect performance. It is sufficient that they want to counteract these negative insinuations held by society (Aronson et al., 2002). If an individual performs poorly in a particular domain with which he/she has identified initially, the following step can be to disidentify with that domain. Statements like, "math is for boys" or "school is stupid" become more commonly heard from low-performing students in a stereotyped group. This phenomenon can be short-lived if these erroneous beliefs are corrected, but if students distance themselves from an academic domain at a young age, and continue this disengagement, a full disconnect from a particular subject, e.g., math, or even academics as a whole can result (Aronson et al., 2002).

The traits and behaviors of anxiety, low performance, and disconnecting from a subject that take place in students who are members of marginalized groups that have been stereotyped as having low performance (women, African-Americans, low S.E.S.

individuals) have been documented in the research for some time (Aronson, Lustina, Good, & Keough, 1999; Aronson, Fried, & Good, 2002; Reyes & Stanic, 1988; Spencer, Steele, & Quinn, 1998; Steele, 1997; Steele & Aronson, 1995). Earlier research spent time looking at hidden curricula or looking at social and media influences as a means to improve student achievement in marginalized groups (Reyes & Stanic, 1988). Unfortunately, most of the identified causes of low student achievement were either not able to be influenced in a meaningful way, or if some intervention could bring about positive change, it would be a long, slow journey before it could be implemented. Research methods such as observation in classrooms by social psychologists took time as they strove to determine the hidden, implicit curriculum that was operating in the environment. Meanwhile, the performance of students did not improve: high school sophomores in the United States have not performed significantly better over the years in the content areas of mathematics, reading and science (PISA, 2014).

One study by Aronson and his colleagues (2002) sought to investigate ways of reducing stereotype threat by teaching college students about Dweck's implicit theories of intelligence, via information on how the brain grows and learns with challenge and effort. Male and female, Caucasian and African American undergraduates were participants. There were three conditions: the experimental group where the students were taught about growth mindset and then assigned a pen pal of middle school age to whom they were to write, using the information they were learning about intelligence being malleable and affected by effort; a comparison group, which also had a pen pal, but their letters included the information that everyone has talents, and there are many different types of intelligences; and the control group, which filled out all the same pre and post measures (intelligence beliefs, academic enjoyment, degree of identification with academics, and measures of experience of stereotype threat) but had no pen pal. Scores from students' SAT test were on file to use as a covariate as were their transcripts.

The results from the study are extremely encouraging and point to an intervention that is a promising method to use with groups who experience stereotype threat as a part of their academic lives. In the experimental group (growth mindset condition), after only three sessions, more African American participants endorsed the growth mindset view of intelligence, which endured even at the follow-up session at the completion of the study. Also, compared to African American students in either of the other conditions, they reported more enjoyment of academics and higher grades (Aronson, et al., 2002).

More recently, interventions that teach the growth mindset to students have been implemented in high school math classes across the United States via two, 45-minute computer modules, resulted in positive outcomes: These interventions benefitted those students who were considered "at risk," those who had a 2.0 GPA or less and who had failed at least one of any core subject in the first semester. This group constituted one-third of the sample size (519 of 1594 students). The pass rate for core subject courses increased by 6.4% in the treatment group (no significant increase was observed in the control group). Even though these results may seem small, among the bottom third of all the students in the U.S., this could translate to over a million more completed courses (Paunesku, et al. 2015). As the research community learns more about Academic Mindsets, it is important that the information be scaled up carefully so the information is not diluted and the effects of the intervention lost (Yeager, Paunesku, Walton, & Dweck, 2013).

Value

The second aspect in the EVC framework is value. The importance of value in math education cannot be underestimated. There have been many curricular reforms in math education over the years aimed at increasing student understanding and resulting performance, but for students to be successful in mathematics, they must want to put forth the effort in learning it. In order to devote that effort and time, they must ascribe value to what they choose to do, otherwise they will not likely pursue it. Student decisions about whether or not to participate in some academic subject are mediated by value (Feather, 1982) and even if a student is sure they could achieve an acceptable level of competence in a given area of study, they may have no motivation to proceed without first having some value for the targeted learning subject to expend the effort required (Eccles & Wigfield, 2002; Luttrell et al., 2010).

Having value for mathematics correlates with achievement levels on standardized tests as well. Among the students taking the TIMSS 2011, Students Value Mathematics scale, those who scored as valuing mathematics achieved at a higher rate compared to those who only valued mathematics somewhat. Those students who scored at the lowest level of valuing mathematics had the lowest achievement of all (TIMSS, 2011, p. 329).

Researchers have long known about the importance of value, but getting students to value the subjects they were being taught was not so simple. Lately, intriguing studies using social-psychological interventions that are easy to implement, low or no cost, and of short duration have shown promise for increasing students' perceived value for academic subjects. Using a social-psychological intervention that targeted value for science content, participants who had a low expectation for completing their course successfully increased their science grades in comparison to the control group students (Hulleman et al., 2009), and in a similar study, the same intervention increased perceptions of value and course success for those students with low performance or expectations of successful class completion in the areas of math and psychology (Hulleman, Godes, Hendricks & Harackiewicz, 2010; Harackiewicz, Priniski, Canning, & Tibbetts, 2015, May). The intervention was simply having the students write a paragraph, intermittently throughout the semester, about how the course materials connected with their lives. Because much costlier, long term efforts have not resulted in lasting improvements, e.g., year-long teacher support or professional development programs, some have either found the results of these interventions difficult to believe or "magical" but they are neither. "Social-psychological interventions hold significant promise for promoting broad and lasting change in education, but they are not silver bullets. They are powerful tools rooted in theory…and reliant on the nature of the educational environment" (Yeager & Walton, 2011, p. 268).

Even as the relevance intervention to increase value, which took place in multiple times during the semester was successful, Hana Gaspard and her associates found that a one-time, 90 minute relevance intervention (with two short reinforcements) was successful in increasing value beliefs for mathematics in ninth grade students in Germany. Students were given examples of how mathematics would be useful for them in their future endeavors, then in one group, participants read six different quotations written by adults in their early twenties about how math was useful to them. The next task involved the students evaluating the quotations in the manner in which they applied to their own lives. The second group wrote an essay about how math was relevant to their lives. The reinforcement conditions were identical for both groups at the one week mark: summarizing what they did (either the quotations or essay condition). Then at two weeks, the reinforcements differed between the groups with the quotes group being asked to visit a website that talked about different aspects of math value and then report which one they agreed with most. Members of the essay group were asked to think of someone for whom math was useful and state why that was the case.

The quotations condition had more effect on utility, attainment, and interest (intrinsic) and the essay condition only had effects on utility value. In general, females in both the essay and the quotes conditions benefitted from the intervention more than males and reported lower beliefs than males before the study began. Changes in the sub-component of utility of math for daily life were maintained during an approximate 5-month timeline.

Cost

Cost makes up the last part of the E-V-C framework as some component that can be weighted as too high or too difficult to overcome in order to succeed in a particular area. Here the focus is on the psychological cost of math anxiety. Math anxiety has been found to correlate anywhere from a moderate to strong amount with both expectancy and value (Wigfield & Meece, 1988) – only a weak correlation was found between the cognitive dimension and expectancy and value. “These findings reveal that if math anxiety measures offer a proxy for assessing the negative psychological dimension of cost, we can infer that cost is clearly linked to expectancy” (Barron & Hulleman, 2015, p. 10).

One approach to increase math performance is focused on reducing math anxiety. Since math anxiety is negatively correlated with math performance and math attitude and positively correlated with math avoidance (the tendency to stay away from non-required math classes), it is a popular subject that many research studies have attempted to elucidate (Ashcraft, 2002; Beilock, 2008; Beilock, Gunderson, Ramirez, & Levine 2010; Hannula, Kaasila, Liljedahl & Rösken, 2007; Hembree, 1990; Ma, 1999; Rayner, Pitsolantis, & Osana, 2009). In Hembree's often cited meta-analysis (1990), 151 studies (122 at the postsecondary level) about mathematics anxiety were analyzed to better clarify the construct of math anxiety and to better identify treatments that were successful in the reduction of math anxiety.

Of the four categories of treatment for math anxiety (cognitive, classroom intervention, behavioral, and cognitive-behavioral) only the cognitive-behavioral and behavioral were effective at anxiety reduction, the tracking of which was based in part on increased math performance. Any whole class interventions such as calculator use, small group instruction, or self-paced instruction were not found to reduce math anxiety. Relaxation treatment alone (part of the behavioral intervention) was not found to be effective, but in combination with systematic desensitization, math anxiety was lowered. Finally, the cognitive-behavioral method sought to reduce worry and *emotionality:* "feelings of dread and nervous reactions" (Hembree, 1990, p. 42). This too showed a strong effect size for reduction in math anxiety. In this meta-analysis, all interventions that were successful were treatments done outside of the classroom environment (but cf. Gresham, 2007, whose study documented a reduction in anxiety for preservice teachers using manipulatives in the classroom – this intervention did not follow the preservice teachers into the classroom, however, to see if the reduction in anxiety transferred to practice). While Hembree documented some successful treatment of math anxiety and an increase in math performance, he gave no options about how to implement this in the classroom, especially since none of the interventions in the meta-analysis could be used easily at the classroom level (1990). Again, teachers are left with interventions that work to increase math performance and/or reduce math anxiety but are costly or difficult to implement in the classroom. Is it any wonder that math anxiety and unacceptable math performance continue to plague students and teachers alike?

While some research about math performance is based in alleviating math anxiety in K-12 students, other research looks to uncover the origins of math anxiety so educators can ameliorate it before it becomes a lasting problem. Researcher, Bekdemir (2010), in his study of preservice teachers' math anxiety, found that a large percentage of his research group (48%) recalled memories of their worst mathematics experience having begun with a negative incident with an instructor (either their instructor's behavior, their teaching approach or lack of knowledge of subject matter). One individual even recalled the teacher hitting the student's head on the blackboard when a problem was not solved correctly. As students moved through the educational system, they reported more negative experiences at later ages. Other researchers have found the source of math anxiety in individuals lies primarily with previous instructors as well, (Martinez & Martinez, 1996) especially in the elementary school years: 72% of reported cases of math anxiety origins referenced instructors (Uusimaki & Nason, 2004). Interestingly, elementary education majors, who are primarily female, have the highest math anxiety of any major (Hembree, 1990).

Alleviating math anxiety in preservice teachers then must be of the highest priority even more so since Beilock and her colleagues found math anxiety in female elementary teachers transfers particularly to girls, in whom subject stereotypes (e.g., math is easier for boys and reading is easier for girls) were strengthened at the end of the school year when math anxious teachers led the class (Beilock, 2008; Beilock, Gunderson, Ramirez, & Levine, 2010). Additionally, girls' performance in math only dipped in relation to boys when girls adopted a stereotypical attitude towards math as a subject for boys. Girls who believed math was a subject in which both boys and girls performed equally well outperformed the boys who held the same belief, and performed only slightly worse than boys who thought math was a subject where boys excelled. This study uncovered an interesting distinction about math anxious teachers: it's not just that math anxious teachers transfer their anxiety to their students; their anxiety transfers in a gender-biased way where girls pick up on negative stereotypes about math at a higher rate than boys. All the math teachers in this study were female so there were no results to compare with male teachers; although, teachers at the elementary level are primarily female - 91% throughout elementary school (National Education Association, 2001) so the absence of males, while unfortunate for lack of comparison, is almost representative of the teacher community at the elementary school level. With math anxiety being so prevalent in elementary school teachers, it follows that the students (in this case girls) would catch the implicit messages: math is hard; math is no fun; only some people can be good in math (Beilock, et al., 2010).

Research about math anxiety first appeared in the literature over 40 years ago (Ashcraft & Krause, 2007) and the interest in math anxiety has continued, possibly because of the far-reaching effects of this anxiety: low achievement, low motivation, avoidance, and low enjoyment of the subject. The understanding of why anxiety disrupts math performance is a relatively new area of research, and it appears that the working memory is a key player in this equation. From what researchers know so far, each individual has a limited amount of space in his or her working memory, and the research literature has supported the crucial connection between the working memory demand and the degree of difficulty of math problems. Specifically, it was found as the numbers in the problems grow larger and/or the number of steps required in order to solve a problem increase, the demand on the working memory increases as well (Ashcraft, et al., 2007). This limited space in the working memory has traditionally been thought of as seven items plus or minus two; this is now being revised to the working memory holding just four items, and even then individuals can only really attend successfully to one thing at a time! (Shell, et al. 2010). When anxiety is present, and an individual worries about proving a stereotype correct or performing accurately in a given time period, these worries take up room in the working memory, and the part of the working memory that could normally be used to solve a problem is now taken up with worry and other distracting thoughts and is not available. Some academic areas require more working memory allocation than others, and math computation and problem solving is one of them (Beilock, Kulp, Holt & Carr, 2004).

If math computation requires a larger amount of working memory, and anxiety takes up part of that memory, it would follow that anxiety would indeed disrupt math performance. And while some approaches to alleviating anxiety focus on something outside the anxiety realm like using manipulatives, other methods focus on the anxiety itself – using deep breathing for instance or systematic desensitization, which is focused on reducing the anxiety. One caveat to note, based on this information, is if a student is focusing on reducing anxiety *during* a math task, for example, their focus on reducing anxiety is using up valuable working memory space (Shell, et al., 2010). Therefore, it is important to focus working memory allocations on the task at hand (rather than focusing on reducing anxiety and work at a math task) so the limited space available can be optimally utilized for the target task.

As there have been effective interventions in the areas of expectancy (to increase beliefs about growth mindset) and in inducing perceptions of value, new research has uncovered another seemingly wise intervention that reduces the negative effects of anxiety on the working memory when students take math tests. In a recent study, students were asked to do an expressive writing task prior to a math and language test, writing for seven minutes, exploring their thoughts and feelings about the upcoming test. The expressive writing narrowed the gap in both response time and error rate between the low and high anxiety individuals from statistically significant (in the control group) to no statistical difference (in the experimental group) on math problems that demanded more working memory allocation - low working memory demand problems revealed no difference in high or low math anxious participants for either response time or error rate, in either the control or experimental group. The outcome of a test based on language rather than mathematics did not show differences between low and high math anxiety individuals (Park, Ramirez & Beilock, 2014). This wise intervention is another example of a short duration (seven minutes), no cost, noncurricular dependent activity that students can do to free space in their working memory so they have more of it available to solve problems.

Math anxiety appears to affect people with a higher working memory storage, presumably because they rely on their working memory more, and when anxiety begins to fill the available spaces, their earlier strategies that depend on greater working memory cease to be successful, resulting in poor performance. Gerardo Ramirez and his colleagues found those individuals with a higher working memory capacity had significantly higher math anxiety (Ramirez & Beilock, 2011; Ramirez, Gunderson, Levine, & Beilock, S.L., 2013). Math anxiety is not related to intelligence and about 50% of the population experiences some kind of anxiety related to math (Boaler, 2012).

If half the population has some kind of math anxiety, it would stand to reason that identifying it, explaining why it happens, and giving strategies to overcome this psychological cost would be an effective place to begin for a goal of increasing math performance. Finding other ways to increase the other components s of EVC, expectancy and value, could help increase motivation and performance, resulting in a higher course pass rate. The work of the Carnegie Foundation, which utilized interventions aligned with EVC along with study skill instruction increased course pass rates by over 50% for math classes at the community college level. (Silva & White, 2012)

Focusing attention on students as a way to increase math performance is the most logical place to start because of the six sources of variance that affect student achievement, (students, home, schools, principals, peers, and teachers) students account for 50% of that variance. But, teachers account for 30% of that variance, so they are another significant piece of the performance puzzle. The other four sources of student achievement, listed above, share the last 20% (Hattie, 2002). Logically, for an intervention to have the highest rate of effectiveness, the interventions that are incorporated into the classroom to improve student performance in math must be focused on both teachers and students. There is a high correlation between effective teachers and student achievement, (Darling-Hammond, 1999) and students who had been in classrooms with effective teachers for three years outperformed their peers who had been in classrooms with ineffective teachers for three years by an average of 50 percentile points (Sanders & Rivers, 1996).

Participants who are adults, some of whom may enter into teaching, is the population this study has targeted. Uusimaki & Nason found that pre-service primary school teachers' negative experience and anxiety about mathematics were often attributed to their own former teachers rather than to other factors like the actual math content or to social factors such as parents and peers (2004). In Koleza's study published in 2006, "A major finding was that preservice primary teachers have rather negative attitudes towards mathematics, and…through their instructional practice -- they influence negatively their students' attitudes too" (p. 2). A cycle begins in early elementary school with students who experience difficulty with mathematics. Many of these same individuals enter the classroom as teachers, often with some of the same attitudes or anxiety about the subject they first developed when they were students themselves. Unknowingly, they continue the cycle for more generations of students. This study, which was focused on undergraduate university students, was designed to check the efficacy of these interventions to see if there is some way to interrupt this cycle for adults which may then open the educational doors of opportunity for all students.

Chapter 3: Method

Research Design and Rationale

This research was designed as a multiple variable, one-group, pretest-posttest, three-part intervention study using survey instruments that assess beliefs about intelligence, expectancy for success in math, and value for and anxiety level in mathematics in order to answer the following research questions: RQ 1 - How does expectancy for math success, value for math and cost associated with math differ by demographics? And RQ 2 - Does a brief intervention on how the brain learns, value of math, and math anxiety change student expectancy for math success, beliefs about value of math or math anxiety?

Three wise interventions were used and had low costs associated with implementing them (short time period, brief training, and no financial cost). One intervention related to each component of the E-V-C framework. These interventions have been successfully utilized in isolation in previous studies, (to increase *expectancy* for learning via promoting belief in growth mindset: e.g. Blackwell, et al. 2007; to increase *value* for math via a relevance intervention: Gaspard et al., 2015; and to reduce *cost* via reducing math anxiety: Ramirez, et al., 2011).

Population

Participants in this study were undergraduate college students, taking courses in the educational psychology program at a southwestern university in the fall of 2017. Of the 165 participants who agreed to be in the research, 123 completed the study. Females were the majority of the participants at 78% (with four declining to state sex). For the race/ethnicity question, the majority of participants stated they were primarily of White heritage (36%), followed by Hispanic (29%). A category denoted as *mixed* contained 19% (more than one race/ethnicity category chosen); the category of *other* contained 11% (this category was made up of American Indian, Asian, Black, Middle East/North African, Native Hawaiian); the final category declined to state a race or ethnicity answer: 5%.

Grades reported were just over a *B* average, and the majority of participants were required to take four math classes to graduate. Most reported an average access to material capital growing up (62%) with slightly more reporting below average (23%) than above average (15%). Similarly, the majority reported an average access to human capital as well (referring to parents' or caretakers' skills abilities or credentials) at 64%. This time, slightly more reported above average (23%) than below average (13%). The means of father's and mother's education were similar; however, the majority (25%) reported the highest level of education attained by their father was a high school diploma, while the majority reported an undergraduate degree was the highest level attained by their mother (29%). However, more fathers had graduate degrees (16%) than mothers (13%). Finally, the majority of students when reflecting on their overall experiences in math classes stated it was a neutral experience (48%), with 37% reporting an overall positive experience and 15% reporting an overall negative experience.

Procedures for Recruitment, Participation, and Data Collection

Participating in this research was an optional component of the classes from which the subject pool was drawn (an alternative activity was offered for those who did not wish to participate in this study but who wanted to complete research by writing an essay). The data was collected in an online, survey format. Consent was granted by participants online before study commenced. All the measures were given as a pretest before the interventions, followed by interventions delivered in video format with the researcher's voice delivering the content, along with embedded videos in parts one and two from outside sources Follow-up questions and activities were completed as part of the survey. After the interventions, the posttest followed immediately. At the conclusion of the study, students were directed to a debrief form, which they printed and filled out and submitted to their instructor in order to receive class credit.

The survey opened for the students on September 15th and remained open until October 4th. Participants were notified the study was open via their instructors who notified them online or in person. Students were able to start the intervention and come back to it at a later time, but only one student used that option. Based on the time and date stamps on each response, students took between an hour and an hour and a half to complete the full intervention.

Of the 165 students that granted consent to be in the study, 75% (123) fully completed the study; 12% began the study by filling out the first half of the questions but did not finish the second half (their answers were not used); and another 12% only granted consent but did not fill out any of the questions. One response was dropped because the respondent had taken it twice. This became evident because of the unique response to one of the open-ended questions. The criteria used to determine which case to drop was done by looking at the time stamp. The dropped case was the one that took the respondent about 10 minutes (while the other response took approximately 90 minutes). Three pairs of responses were dropped because they were outliers. Criteria for outliers were any scores that had a *z* score greater than +/- 3.29.

Demographic information was collected at the close of the study. . The demographics collected were the following: Typical grade in a math class (participants could choose more than one grade. Grades were averaged on a traditional four-point scale); overall experience in math class (a three-point scale); number of math classes taken in high school; number of math classes taken in college; sex; questions to ascertain socio-economic status (see appendix for all items); and race.

Instrumentation (full measures in appendix)

Theories of Intelligence Scale for Adults, TISA (Dweck, 2000) was the scale used to measure an aspect of the component of *expectancy,* by determining the level of intelligence beliefs of the participants. Reliability for these items as originally tested was measured with Cronbach's alpha (α = .84, (Dweck, 2000). The scale used in this study was from 1 (strongly disagree) up to 5 (strongly agree). A five-point scale was used (rather than Dweck's six-point scale) so the Likert scale from three items from the *TISA* would match the other questions from the *MVI,* reducing chances of participant error, as the *TISA* questions were mixed throughout the other survey items. All three items in this scale were negatively worded and, as a result, were reverse scaled, so a high score would agree with having a growth mindset (e.g., "You have a certain amount of intelligence, and you can't really do much to change it,") would have low agreement from someone with a growth mindset. Two additional items were used to assess expectancy of future success in math, e.g., "Rate your confidence in your belief in your ability to complete your next math course with a grade of B or better;" and another item to assess likelihood of taking math classes not required in degree plan.

Mathematics Value Inventory (MVI), Luttrell et al. (2010) was given to measure how the participants value mathematics. Value is operationalized in this measure as a four facet domain in which each facet affects individuals' "engaging, persisting, and excelling in mathematics" (Luttrell, et al., 2010, p. 146). These four facets are the subscales of interest, general utility, attainment or need for high achievement and personal cost. Cost was not being considered part of the *value* component in this study, but rather three cost items were broken out from the subscale of cost into its own component to measure math anxiety as a type of psychological cost to be considered separately. In the *MVI*, *cost* as a subscale includes items that measure different types of cost including effort. The cost of effort was not the focus of this study, so those items were removed. Three items that assessed math anxiety exclusively were included to measure the psychological cost of math anxiety. In the original scale, the items measuring cost were reverse scored, so low anxiety would be a higher score. Here, with cost being considered separately, the items were not reverse scored, so those participants who indicated high agreement with the *cost* component would have a high score for cost/anxiety.

Without the section that measures cost, the modified MVI is a 21-item measure, 5-level Likert scale (with 1 – strongly disagree; 2 – disagree; 3 – neither agree nor disagree; 4 – agree; 5 – strongly agree). There are 7 items in each of the previously mentioned subscales with summed scores that can range from 5 – 35 in each category, with a maximum score across all subscales of 105. Higher scores equate with higher perceived math value, e.g., "Learning new topics in mathematics is interesting." The three areas of value (interest, general utility, and need for high achievement) are based on the work of Eccles and her colleagues in the Expectancy - Value model as applied to education (1983, 1984). Due to a technical error, one item was excluded from the subscale: need for high achievement. As a result, this subscale had a range of scores from 5 - 30, with a maximum score across all subscales of 100. As tested on college populations, the MVI has an overall reliability as measured by Cronbach's alpha of .95. A panel of outside experts determined the validity of each item and how it accurately captured the concept of each of the subscales (Luttrell, et al., 2010).

The Single-Item Math Anxiety Scale (SIMA) (Nunez-Pena, Guilera, & Suarez-Pellicioni, 2014). This measure was given as one measure to determine *cost* as level of overall math anxiety in the participants. This measure consists of a single item, measured with a ten level scale from 1 (not anxious) to 10 (very anxious). Construct validity for this measure was determined in past studies by administering another math anxiety measure to the same group of subjects, the sMARS (Alexander & Martray, 1989), which was highly correlated with the SIMA at .77 (Nunez-Pena, et al., 2014). In addition, the SIMA was negatively correlated with measures of math enjoyment, motivation, and self-confidence, all measures that have been shown in the literature to be negatively correlated with math anxiety (Hembree, 1990). Three additional items from the *MVI* were included to measure math anxiety, e.g., "Math exams scare me."

Procedures

The three interventions in this study have been shown in past studies (when used individually, apart from each other) to have a positive effect on academic performance, and/or decrease test anxiety for students in mathematics (see Blackwell et al. 2007;

Gaspard et al., 2015; & Ramirez et al., 2011; Stano, 2012). This research session was conducted in one online session, using the survey platform *Opinio* version 7.6.5. The session took participants on average anywhere from 60 – 90 minutes to complete as noted by the start and complete times logged on the responses. In that session, participants were exposed to interventions relating to each of the three concepts in the EVC framework as information about what motivates us to action. The *expectancy* component was simplified with one question: Can I do it? (Inspired by the question posed from Eccles and her colleagues "Can I do the task?" 1995); the *value* component was simplified with another question: "Do I care?" and the *cost* component was simplified with a third question: "Is it worth it?"

Pretest.

In this current study, participants first answered survey questions from the *TISA*, the *MVI*, and the *SIMA*, along with the two other questions for expectancy as a pretest, then began the intervention portion. The design for the three-part intervention was based on several influential studies in the field that utilized wise interventions that were brief yet had a long lasting effect on student learning as measured by grades or test performance. Each intervention also contained components of educational neuroscience: 1) information on how the students could better understand how their brains learned; 2) how their brain responds as they find relevance and value; and 3) what happens in the brain with the working memory when in an anxious state. The first intervention was aligned with the expectancy component of the E-V-C framework: increasing expectancy of ability to learn by explaining how the brain learns and that intelligence can be grown (intervention based on Aronson et al., 2002; Blackwell et al., 2007).

Intervention part one.

In part one of the intervention, participants were directed to watch a short video with the title "Can I do it?" about how the brain learns, in which the participants heard the researcher's voice explaining Dweck's growth/fixed mindset (2000) theory and how the brain learns. This video included a TEDxStanford talk from Jo Boaler (Boaler, 2016), author and professor of mathematics education at Stanford, which showed how the growth mindset was applied in a summer math program for middle school students. Please see the "Can I Do It?" video here: https://www.youtube.com/watch?v=6-23VkDYiKs&t=1s The videos were created using screen capture software called, "screen-cast-o-matic" which allows the user to record what is on the computer screen (in this case, a PowerPoint presentation to support the audio with visuals) and voice either from the computer or in the external environment. Next participants returned to the survey and answered questions about their favorite examples of brain plasticity they saw in the video and then gave an example from their personal life where they experienced brain plasticity. That completed the first part of the three-part intervention.

Intervention part two.

For part two of the intervention, the participants were then directed to watch a second video about value (the second facet in EVC) in mathematics entitled, "Do I Care?" https://www.youtube.com/watch?v=JCIiYh4i5Uk&t=2s . This second video incorporated ideas about the value mathematics has in our society (e.g., fields that utilize mathematics are the highest paying fields right out of college for undergraduates), see Gaspard et al., 2015 for further examples. Also as a part of this video, the theme continued of explaining how the brain works, this time in this context of value.

Information about the reticular activation system (RAS) was shared and how it acts like a filter for the conscious mind, for what is determined to be essential, unusual or dangerous (Bard, A.S. & Bard, M.G., 2002; Fincher, J., 1981).

Included in part two of the intervention video was a short clip that illustrated the function of the RAS by testing participants' awareness by counting how many times the white shirt team passes the basketball to other teammates (Do the test, 2008). Most people are watching so closely for the team passing the ball, they miss the moonwalking bear going through the middle of the game. The RAS will filter out what is not deemed important. They were asked to consider if they had thought mathematics were unimportant to them (as measured by the Utility portion of the *MVI*) it is likely they missed the evidence of how math could relate to their lives.

To finish the second intervention, participants returned again to the survey platform where they were asked to participate in a writing exercise where they read four different paragraphs other students had written about finding value in math and how they used math in their daily lives, then they chose a quote they agreed with most and stated why they agreed with it, see Gaspard, et al. (2015). After completing that task, they again clicked on a link that took them to the last video for part three: Cost.

Intervention part three.

Participants were directed to click on the link to watch a video on "cost" with the title "Is It Worth It?" https://www.youtube.com/watch?v=T6pIfOZCqOA&t=8s . This last part of the intervention focused on math anxiety. Participants were given information about math anxiety and how it can develop in children as young as six or seven years old (Wigfield & Meece, 1988). This anxiety is often linked to the administration of timed tests for math facts (Boaler, 2012). They were also exposed to information about the Hebb Principle: "What fires together, wires together", which may help people understand why anxiety develops in the first place after repeated failures on something like a math timed test. Further material was shared about working memory and how anxiety takes up valuable slots in our limited working memory, making it easier to make errors on problems requiring more working memory (Beilock et al., 2004).

This led to information about the technique of expressive writing (Ramirez, et al. 2011) as a way to decrease math anxiety before a test by freeing up working memory, thereby leaving more working memory room for solving problems. Working memory was defined as that part of the brain that accesses stored memories (like math facts or the procedure to solve a math problem) with information from the environment (like solving a problem before you on a page).

Continuing part three of the intervention, after the video about math anxiety (representing the cost facet), they returned to the survey and were given the opportunity to practice the expressive writing technique they had received information about in the video. The participants were invited to imagine they were preparing to take a difficult math test they needed to get a "B" on to pass their class. They were to imagine what their thoughts and emotions around the test they were preparing to take would be and explore them in writing. This exercise was to take seven minutes. This completed the third part of the intervention.

Intervention fidelity check.

As a way to gauge the intervention fidelity and receptiveness for the information, students were asked at the conclusion of the three-part intervention what they felt was most/least valuable about what they learned. They were also queried about whether or not they would use the expressive writing technique themselves, and/or if they would be willing to use any of the information they just learned to help themselves or others in the future. Information gleaned from these questions will be used to improve future interventions.

Post intervention.

To measure changes in beliefs, students were asked the same questions from the various measures (e.g., *MVI, TISA, SIMA)* which they had already been asked before they received the intervention about expectancy, value and cost as it related to mathematics. Participants were then given an opportunity to give advice to a fictional student who was struggling based on what they learned as a means of further reinforcing the content delivered (seeing is believing, Aronson et al., 2002). Finally, students were asked demographic questions about socio-economic status growing up (access to human and material capital, parents' education level); their typical grades in a math class; number of math classes taken and how many were required in both high school and college; sex; and race.

In this study, all three interventions were implemented in one protocol, rather than using them in isolation, as these interventions have been used in the previous studies mentioned.

Data Analysis Plan

Descriptive statistics were used to first explore the trends of the demographic factors to begin to answer the following research questions: 1) How does expectancy for math success, value for math and cost associated with math differ by demographics? 2)

Does a brief intervention about how the brain learns, the value of math, and math anxiety change student expectancy for math success, beliefs about value of math or math anxiety? For nominal factors, frequency and percentage distributions were examined, and for the continuous level variables, means and standard deviations were calculated. The conventional level for statistical significance was used: $\alpha = 0.05$.

Subscale scores were calculated for the pretest and posttest of the *MVI* with summations for each subscale: *Interest, Attainment, Cost & Utility* and averages (for *TISA*). Cronbach's alpha test of reliability was used to assess the internal consistency of each scale by providing the mean correlation between each pair of items and the number of items in a scale (Brace, Kemp, & Snelgar, 2006). Cronbach's alpha coefficients were interpreted using the following guidelines: $\alpha \geq .9$ Excellent, $\alpha \geq .8$ Good, $\alpha \geq .7$ Acceptable, $\alpha \geq .6$ Questionable, $\alpha \geq .5$ Poor, $\alpha < .5$ Unacceptable (George and Mallery, 2016). Pearson correlations were used as a preliminary analysis to examine the associations between all variables to determine the variables of interest. (Pagano, 2010). Outliers with *z scores* over +/- 3.29 were examined and considered for exclusion.

To address the first research question, a series of independent sample *t*-tests and analyses of variance (ANOVAs) were conducted to examine for differences in each of the variables by demographics. Information about the following variables was collected at the end of the study: sex, race/ethnicity (participants chose as many as applied), typical grade in a math class (participants could choose more than one; grades chosen were averaged on a traditional

four-point scale); number of math classes taken in high school; number of math classes taken in college; four questions to assess socio-economic status (access to human capital, access to material capital, father's education, mother's education). An independent sample *t*-test is appropriate for evaluating differences in a continuous dependent variable between two groups (Pagano, 2009). Using an ANOVA is appropriate when assessing differences in a continuous level variable between three or more groups (Tabachnick & Fidell, 2013).

To examine the second research question, prior to analysis, the assumptions of normality and homogeneity of variance were tested. Significance for either test would suggest that the assumption was not met. After checking the assumptions, the *t* test and *F* test were used to make the overall determination on whether significant differences existed by groups. If significance was found in the ANOVA with the *F* test, post-hoc analyses were conducted to determine exactly where the differences exist.

Chapter 4: Results

The purpose of this study was to determine if the math beliefs of undergraduate university students could be improved with a short-term, three-part intervention, based on the components of expectancy, value, and cost. These were the research questions: 1) How does expectancy for math success, value for math and cost associated with math differ by demographics? And 2) Does a brief intervention on how the brain learns, value of math, and math anxiety change student expectancy for math success, beliefs about value of math or math anxiety?"

Study Results

In the survey, demographic questions (Table 1) were asked to ascertain whether certain variables had any influence on math beliefs: grades (as measured by past grades, these were average grades earned in previous math classes that were self-reported from participants); overall experiences in past math classes; socio-economic status information was gathered by questions about access to material capital (in terms of income), human capital (parents' skills, abilities or credentials), and parents' education. Number of classes taken both in high school and college were collected as well.

Table 1.

Demographic Summary Statistics Table for Interval and Ratio Variables

Variable	*M*	*SD*	*n*	SE_M	Skewness	Kurtosis
Grades	3.02	0.74	122	0.07	-0.46	-0.51
Math HS	3.88	0.80	122	0.07	-1.54	3.92
Math Coll.	3.38	1.34	120	0.12	-0.24	-1.14

Material Capital	1.92	0.62	117	0.06	0.05	-0.39
Human Capital	2.09	0.59	116	0.05	-0.02	-0.17
Father's Ed	3.74	1.53	98	0.15	0.23	-1.47
Mother's Ed	3.72	1.55	109	0.15	-0.09	-1.25
Overall Class Experience	2.21	0.70	122	0.06	-0.31	-0.91

Note. Grades = traditional four-point scale, e.g., B = 3. Math HS = number of classes taken in high school; math college = number of math classes taken in college. Material and Human capital rated on a three-point scale with 2 being average. Mother's and Father's education was a five-point scale with five as "graduate degree" and one as "some high school". Overall experience in math classes were figured on a three-point scale with the score of two denoting a neutral experience.

Cronbach's reliability analyses were run for each test to determine the consistency of responses among the questions in each measure. All measures were either above .90 (Interest: $\alpha = .95$; *SIMA*: $\alpha = .95$; Future classes: $\alpha = .96$) or above .80 (*TIMA*: $\alpha = .89$; Cost: $\alpha = .87$; Attainment: $\alpha = .88$; Utility: $\alpha = .88$; Expectancy: $\alpha = .88$) indicating high reliability for all measures. After descriptive statistics were collected and reliability checked, a Pearson correlation analysis was conducted. (See tables 2 and 3)

Table 2

Pearson Pre Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Anx. SIMA	-																
2. Expectancy	-.47**	-															
3. Likelihood	-.28**	.28**	-														
4. Overall Exp	-.55**	.51*	.23*	-													
5. Grades	-.41**	.66**	.24**	.48**	-												
6. Interest	-.58**	.48**	.55**	.49**	.43**	-											
7. Utility	-.30**	.38**	.27**	.34**	.45**	.60**	-										
8. Attainment	-.24**	.45**	.43**	.31**	.51**	.46**	.41**	-									
9. Cost MVI	.81**	-.50**	-.33**	-.51**	-.45**	-.61**	-.30**	-.23*	-								
10. Intell. Bel.	-.13	.30**	.07	.16	.25**	.15	.40**	.04	-.22*	-							
11. Sex	-.14	.12	.25**	.07	.06	.24**	.12	.07	-.09	.03	-						
12. # College	-.13	.16	.28**	.11	.08	.26**	.18*	.36**	-.18*	.14	.14	-					
13. # HS	-.02	-.01	.03	.05	.01	-.04	-.08	-.01	.003	-.15	-.01	.003	-				
14. Mat.Cap.	-.02	.10	-.06	.02	.04	-.06	-.03	.01	-.06	-.08	-.15	-.22*	-.04	-			
15. Hum.Cap.	-.09	.11	-.01	.08	.15	.06	.06	.11	-.09	-.05	-.12	-.24*	.25**	.51**	-		
16. Fath.Ed	.03	.02	-.13	.05	.03	-.15	.03	-.06	-.01	-.08	-.08	-.21*	.09	.32**	.23*	-	
17. Moth.Ed.	.03	.19	-.03	.11	.24*	.09	.11	.12	-.06	-.01	-.003	-.16	.13	.37**	.27**	.41**	-

Note. Cohen's *d* was used as a metric to evaluate strength of relationship between variables: .10 - .29 = small; .30 - .49= moderate; > .50 = large (Cohen, 1988).
*p < .05 level **p < .01

Table 3

Pearson Post Correlation Matrix

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Anx. SIMA	-																
2. Expectancy	-.37**	-															
3. Likelihood	-.26**	.30**	-														
4. Overall Exp	-.47**	.46**	.24**	-													
5. Grades	-.35**	.60**	.22*	.48**	-												
6. Interest	-.49**	.49**	.58**	.51**	.36**	-											
7. Utility	-.25**	.39**	.17	.32**	.38**	.51**	-										
8. Attainment	-.08	.30**	.36**	.16	.35**	.33**	.29**	-									
9. Cost MVI	.69**	-.48**	-.28**	-.53**	-.32**	-.49**	-.29**	-.02	-								
10. Intell. Bel.	-.14	.33**	.09	.11	.24**	.10	.45**	.08	-.17*	-							
11. Sex	-.10	.14	.24*	.07	.06	.20*	.02	-.01	-.20*	.05	-						
12. # College	-.22*	.22*	.28**	.11	.08	.36**	.21*	.32**	-.14	.19*	.14	-					
13. # HS	-.07	-.03	.03	.05	.01	-.03	-.05	-.05	-.05	-.11	-.01	.003	-				
14. Mat.Cap.	-.01	-.04	-.04	.02	.04	-.09	-.04	.13	.07	-.13	-.15	-.22*	-.04	-			
15. Hum.Cap.	-.08	-.05	-.01	.08	.15	.01	.05	.13	-.02	-.07	-.12	-.24*	.25**	.51**	-		
16. Fath.Ed	.06	-.04	-.15	.05	.03	-.20*	.02	-.05	-.05	-.16	-.08	-.21*	.09	.32**	.23*	-	
17. Moth.Ed.	.03	.11	-.04	.11	.24*	.03	.11	.08	-.02	-.01	-.003	-.16	.13	.37**	.27**	.41**	-

Note. Cohen's *d* was used as a metric to evaluate strength of relationship between variables: .10 - .29 = small; .30 - .49= moderate; > .50 = large (Cohen, 1988).
*p < .05 level **p < .01

Results for research question one.

Analyses of variance were run to determine how sex, race, overall experiences in math classes, number of math classes taken in high school, number of math classes taken in college and Socioeconomic Status (as measured by human capital, material capital, fathers' and mothers' education) and grades affected scores about the expectancy, value and cost of mathematics. Starting with the component of expectancy (measured by beliefs about intelligence, expectancy for earning B or higher, and future likelihood to take math), some differences surfaced in the areas of sex and race.

For Future Likelihood to take Math, for the main effect of sex, the mean for Female (*M*=2.6, *SD* = 2.33) was significantly smaller than for Male (*M* = 3.95, *SD* = 3.37) $F(1, 110) = 5.00$, $p = .027$; $\eta_p^2 = .04$. (Tables 4 and 5)

Table 4

Analysis of Variance Table for Future Likelihood to Take Math by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	32.00	1	5.00	.027	0.04
Race_4Cat	30.00	3	1.56	.202	0.04
Residuals	703.59	110			

Table 5

Means, Standard Deviations for Future Likelihood to Take Math by Sex

Sex	*M*	*SD*
Female	2.6	2.33
Male	3.95	3.37

In the component of value, there were significant differences among the levels of sex for the sub-component of interest: the results of the ANOVA were significant, *F*(4,

110) = 3.17, *p* = .017, indicating there were significant differences in Interest Pre among the levels of Sex and Race. The main effect, Sex was significant at the 95% confidence level, *F*(1, 110) = 7.99, *p* = .006, η_p^2 = 0.07, indicating there were significant differences in Interest Pre by Sex levels. The mean of Interest Pre for Female (*M* = 21.62, *SD* = 6.57) was significantly smaller than for Male (*M* = 26.38, *SD* = 6.99). (Tables 6 and 7)

Table 6

Analysis of Variance Table for Interest Pre by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	350.67	1	7.99	.006	0.07
Race_4Cat	166.87	3	1.27	.289	0.03
Residuals	4828.30	110			

Table 7

Means, Standard Deviations for Interest Pre by Sex

Sex	*M*	*SD*
Female	21.62	6.57
Male	26.38	6.99

The post level of the sub-component of Interest was also examined. The main effect, Sex was significant once again at the 95% confidence level, *F*(1, 110) = 6.68, *p* = .011, η_p^2 = 0.06, indicating there were significant differences in Interest Post by Sex levels. (Tables 8 and 9) For the sub-components of Attainment and Utility, both pre and post, there were no significant differences amongst sex and race.

Table 8

Analysis of Variance Table for Interest Post by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	301.49	1	6.68	.011	0.06
Race_4Cat	237.28	3	1.75	.161	0.05
Residuals	4966.03	110			

Table 9

Means, Standard Deviations, and Sample Size for Interest Post by Sex

Sex	*M*	*SD*
Female	22.27	6.48
Male	26.62	8.06

For TISA, the main effect, race, was significant at the 95% confidence level, $F(3, 110) = 4.98$, $p = .003$, $\eta_p^2 = 0.12$, indicating there were significant differences in Intelligence Belief Pre by race levels. For the main effect of Race, the mean of Intelligence Belief Pre for Hispanic (*M* = 3.93, *SD* = 0.73) was significantly larger than for Other (*M* = 3.31, *SD* = 0.74). For the main effect of race, the mean of Intelligence Belief Pre for Mixed (*M* = 4.04, *SD* = 0.76) was significantly larger than for Other (*M* = 3.31, *SD* = 0.74). For the main effect of race, the mean of Intelligence Belief Pre for Other (*M* = 3.31, *SD* = 0.74) was significantly smaller than for White (*M* = 4.19, *SD* = 0.71). (Tables 10 and 11)

Table 10

Analysis of Variance Table for Intelligence Belief Pre by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	0.08	1	0.14	.710	0.00
Race_	8.04	3	4.98	.003	0.12
Residuals	59.25	110			

Table 11

Means, Standard Deviations, and Sample Size for Intelligence Belief Pre by Sex and Race

Sex	*Race*	*M*	*SD*	*n*
Female	Hispanic	3.98	0.78	29
Female	Mixed	3.97	0.77	20
Female	Other	3.28	0.76	12
Female	White	4.24	0.60	33
Male	Hispanic	3.72	0.39	6
Male	Mixed	4.56	0.51	3
Male	Other	3.67		1
Male	White	4.03	1.01	11

For the post scores of Intelligence Beliefs, the results of the ANOVA were significant as well *F*(4, 110) = 4.13, *p* = .004. The main effect, Race, was significant at the 95% confidence level, *F*(3, 110) = 5.44, *p* = .002, $\eta_p 2$ = 0.13. Mixed (*M* = 4.42, *SD* = 0.94) was significantly larger than for Other (*M* = 3.51, *SD* = 0.68). Other (*M* = 3.51, *SD* = 0.68) was significantly smaller than for White (*M* = 4.40, *SD* = 0.59). (Tables 12 and 13) No differences were found by sex or race for Expectancy for earning a B or higher.

Table 12

Analysis of Variance Table for Intelligence Belief Post by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	0.00	1	0.00	.983	0.00
Race	9.09	3	5.44	.002	0.13
Residuals	61.22	110			

Table 13

Means, Standard Deviations, and Sample Size for Intelligence Belief Post by Sex and Race

Sex	*Race*	*M*	*SD*	*n*
Female	Hispanic	4.15	0.83	29
Female	Mixed	4.33	0.99	20
Female	Other	3.50	0.70	12
Female	White	4.43	0.54	33
Male	Hispanic	4	0.63	6
Male	Mixed	5	0	3
Male	Other	3.67		1
Male	White	4.30	0.72	11

There were two instruments that measured the component of cost. The first one was the three items from the *MVI*, which only showed significance at the post measurement but not the pre. The main effect, Sex was significant at the 95% confidence level, $F(1, 110) = 7.08$, $p = .009$, $\eta_p 2 = 0.06$, indicating there were significant differences in Cost Post by Sex levels. Cost Post for Female ($M = 11.30$, $SD = 2.55$) was significantly larger than for Male ($M = 9.67$, $SD = 2.15$). (Tables 14 and 15)

Table 14

Analysis of Variance Table for Cost Post by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	44.73	1	7.08	.009	0.06
Race_	1.35	3	0.07	.975	0.00
Residuals	694.97	110			

Table 15

Means, Standard Deviations, and Sample Size for Cost Post by Sex

Sex	*M*	*SD*
Female	11.30	2.55
Male	9.67	2.15

For the *SIMA*, the main effect, Sex was significant at the 95% confidence level, $F(1, 110) = 4.03$, $p = .047$, $\eta_p^2 = 0.04$, indicating there were significant differences in *SIMA* by Sex levels. (Tables 16 and 17)

Table 16

Analysis of Variance Table for SIMA by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	26.41	1	4.03	.047	0.04
Race_	8.37	3	0.43	.735	0.01
Residuals	721.08	110			

Table 17

Means, Standard Deviations, and Sample Size for SIMA by Sex and Race

Sex	*Race_4Cat*	*M*	*SD*	*n*
Female	Hispanic	6.38	2.34	29
Female	Mixed	5.65	2.70	20
Female	Other	6.83	2.66	12
Female	White	6.67	2.51	33
Male	Hispanic	5	2.90	6
Male	Mixed	6.33	2.08	3
Male	Other	2		1
Male	White	5.27	2.80	11

The only other variable that was affected by demographics was grade for Race. The mean of Grade on the category of Other ($M = 2.54$, $SD = 1.01$) was significantly smaller than for White ($M = 3.24$, $SD = 0.68$). (Tables 18 and 19) There were no other significant effects from sex or race on any component.

Table 18

Analysis of Variance Table for Grades by Sex and Race

Term	*SS*	*df*	*F*	*p*	η_p^2
Sex	0.01	1	0.02	.896	0.00
Race	5.28	3	3.42	.020	0.09
Residuals	56.59	110			

Table 19

Means, Standard Deviations, and Sample Size for Grades by Sex and Race

Sex	*Race_4Cat*	*M*	*SD*	*n*
Female	Hispanic	2.95	0.74	29
Female	Mixed	2.95	0.60	20
Female	Other	2.46	1.01	12
Female	White	3.32	0.69	33
Male	Hispanic	2.92	0.49	6
Male	Mixed	3.50	0.50	3
Male	Other	3.50		1
Male	White	3	0.59	11

The assumption of normality was assessed by plotting the quantiles of the model residuals against the quantiles of a Q-Q scatterplot (DeCarlo, 1997). Levene's test for equality of variance was used to assess whether the homogeneity of variance assumption was met (Levene, 1960). The homogeneity of variance assumption requires the variance of the dependent variable be approximately equal in each group. The result of Levene's test was not significant in any statistical test, indicating that the assumption of homogeneity of variance was met.

Results for research question two.

To determine whether or not there were differences between the pre and post measures, paired *t*-tests were conducted. Table 19 contains all significant results.

Outcomes that were not significant include two sub-facets of value: interest and attainment; and the *SIMA*, one of the measures of math anxiety. Interest change pre/post was significant when looking only at females, however, albeit at low effect size: *d* = .10. (Table 4) Of the *t*-tests that showed significance, there was a representation from each component of the EVC theory that showed some measure of improvement: cost (as math anxiety), utility of math, expectancy of earning a B or higher in the next math class, and beliefs about intelligence. Utility showed the largest effect size.

Table 20

Paired Samples t-Test for the Difference between Significant Pre and Post Scores

	Pre		Post				
	M	*SD*	*M*	*SD*	*t*	*p*	*d*
Cost	11.39	2.59	10.93	2.66	2.87	.005	0.17
Utility	25.88	3.73	29.37	4.96	-13.42	<.001	0.80
Expectancy	6.48	2.37	7.11	2.10	-4.65	<.001	0.28
Intel. Belief	3.99	0.78	4.22	0.81	-5.09	<.001	0.29

Note. Degrees of Freedom for the *t*-statistic = 121. *d* = Cohen's *d.*

Table 21

Paired Samples t-Test for the Difference between Interest Pre and Post for Females Only

Interest Pre		Interest Post				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
21.67	6.55	22.32	6.44	-2.10	.038	0.10

Note. Degrees of Freedom for the *t*-statistic = 95. *d* represents Cohen's *d*.

In summary, to answer the first research question, “How does expectancy for math success, value for math and cost associated with math differ by demographics?” there were significant differences by demographics. Differences in sex appeared in the sub- component of Interest: females had lower interest than males for both the pre and post and increased in interest significantly (where males did not). Females also were significantly less likely to take math classes not required for their degree plan.

For the second research question, “Does a brief intervention on how the brain learns, value of math, and math anxiety change student expectancy for math success, beliefs about value of math or math anxiety?” there were significant results in each component being studied. For the change in Expectancy both the *TISA* and the question asking about participants' expectations of earning a B or higher in their next math class had significant increases. For the change in value, two sub- components of *MVI* had significant increases: Utility (for both male and female) and interest (for female only). Lastly, for Cost, the questions from the *MVI* portion that dealt with math anxiety had significant decreases.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this study was to determine if beliefs that undergraduate university students hold about mathematics could be changed with one combination, targeted intervention. These beliefs are in the area of what is understood about motivation in terms of EVC: Do we expect we can learn? Do we value what we are learning? And can we lower the cost of participating in the act of learning a certain subject enough that we can be convinced to allocate our time and our effort, and, as Shell and colleagues noted, our precious working memory? (2010).

Teachers have wondered how to motivate the apathetic or unenthusiastic student that has so much untapped potential. Sometimes showing how relevant a subject is (finding value) can make a difference towards increasing motivation and success. Sometimes instructing a student about how their brain learns with effort and challenge, and letting them know that their intelligence is not fixed and that failure actually helps their brains to grow and make new connections will encourage them to continue on despite the failure they have experienced, increasing their expectancy for success and learning. Lowering the costs of participating by finding out what psychological costs like math anxiety (or other costs like the perception of a disproportionate amount of time or effort required to achieve success) that are being experienced by the student that prevents them from learning can make a difference. When utilizing all three components of the EVC framework like the Carnegie institute did with their program *Starting Strong*, the developmental math program in the community college saw a three-time increase in the student success rate in their classes that was not short-lived. Student achievement has maintained and the program has spread to more programs over the past years (Clyburn, 2014).

Making sure the teachers are trained not only about math pedagogy but how to motivate their students to learn it is of highest importance. Can beliefs about math be raised in terms of value and ability to learn? Can the costs be lowered, especially those costs that individuals may think they have no control over, like anxiety? If teachers walk into the classroom with the belief that all children can learn math, and that they can teach math effectively (or can learn to do so), and that they value math as a subject, would that make a difference?

This study just made a small inroad into what might be possible to change adults' beliefs about mathematics in a short period of time. The significance of learning mathematics and having a working knowledge of how math is used in our lives is important. If teachers see the utility of math in their own lives, where they once found little, perhaps they can communicate that more effectively to their students. If teachers can experience less anxiety themselves around mathematics and understand how their own anxiety may have begun in the first place, this understanding may assist them in helping their students with the same issues.

When students feel empowered, when blockages are removed from them being able to learn, and when they know that what they are learning has value, they will jump in with both feet, and all will be amazed at what they create.

Summary and Interpretation of the Findings

Because females were the majority of the participants at 78%, the male population was less represented. For the ANOVAs that were run looking at differences by race and sex, the results must be interpreted carefully. For example, the “Other” category for race only had one male, which is not representative of males in that category. The two variables that did differentiate by race were Grades and Beliefs about intelligence. Most components s did not differ significantly by race. The category of Grades did differ by race, but it was the category of Other, which was problematic, and so must be interpreted with care. The other area that differed by race and ethnicity was Intelligence Beliefs.

The mean score on the *TISA* for the category of Hispanic, Mixed, and White categories was significantly larger than for Other. It is noted that the Native American students were the majority of the category of Other. Future studies, which have a higher percentage of Native Americans, would be useful to see if this trend repeats in a larger population. There is research about how a Fixed Mindset is fostered, e.g., by praising intelligence or ability and neglecting to honor hard work and effort (Dweck, Walton, & Cohen, 2011), but little or no information exists about any one culture doing this differently from another and whether or not those cultures tend towards one Academic Mindset or another.

Sex differences surfaced as well in the areas of interest, future likelihood to take math classes, and the differences between the change scores for the three-item *Cost* measuring anxiety. The differences in the variable of interest did not become evident in the paired *t*-test until the females were considered as a group apart from the males. First, females across all races had a lower interest score than males. The intervention has a positive, albeit small, effect on the females, but the males did not increase, possibly because the male scores were already at the higher end. Any increase of interest is welcome, since high interest correlates with course taking and career choice (Morgan, Isaac, & Sansone, 2001).

The next category that females scored below males was in the future likelihood to take math classes not required for their degree plan. This question was a 1-10 scale with "1" being not likely and "10" highly likely. Both males and females scored on the low end of the spectrum with females at $M=2.6$, compared to males at $M = 3.95$. These data differences corroborate the interest research correlating with course taking (Reese & Dietrich, 2014). This category did not increase with this intervention, perhaps because when students are weighing the course taking with the time they have available, that may overshadow their inherent interest in the subject.

The final category that showed an influence by sex is the Cost variable of math anxiety. Previous research has shown females to be more math anxious than males (Beilock et al., 2010; Gleason, 2008; Harper & Daane, 1998; Hembree, 1990;), but in this study, the only significant differences were in how much the females' scores dropped (to a less anxious score) compared to the males' scores. Other measures of anxiety did not show a difference between males and females when looking at averages. Females did select "highly anxious" more than males, however, on the *SIMA* (17 females versus 2 males).

More research is needed to identify whether or not females react differently to ways to ameliorate math anxiety and how difficult it is to lower. Considering the intervention used in this study, expressive writing, it mimics the way some researchers have pointed out that females handle stress: *tend and befriend*, compared to males, *fight or flight* (Taylor et al., 2000). Female's cortisol levels decrease when they are able to talk about what was stressful to them. It may be that expressive writing could be a good way to decrease stress that may work even more so with females. This would be another area for future research.

The number of math classes taken in high school did not correlate at all with any of the motivational variables in this study. Even though Luttrell (2010) reported significantly lower levels of cost and higher levels of interest and utility value when students took more classes, this study did not reflect that. The majority of the students in this study had taken four classes in high school. Some students, who had graduated at an earlier time when requirements for number of math classes were less, had taken fewer classes, but their scores on motivational variables did not differ from their counterparts who took the maximum. Number of math classes taken in college did correlate with more motivational variables, however. It could be because those classes were more recently taken, and the positive effects from taking them were still influencing them in a positive way.

Other elements included the low effect overall for socioeconomic status. Parent's education did not seem to play a large roll in beliefs about math or ability to learn or math anxiety or grades as tested here. It could be that the three-point scale that was used in the questions was not discriminating enough to tease apart the differences in participants' experiences. Since the majority of participants chose the answer of "average" it may be more informative to have a scale that had an even number of answers, forcing a response towards the positive or towards the negative. This same pattern was seen with the reporting of overall classroom experience (a three-point scale), with the majority of participants selecting "neutral". A four-point scale may discriminate more here. This concept of past math class experience could use further research in tandem with math belief research. If more can be found about the spectrum of the contributors to negative beliefs about math, there may be more interventions that could be designed that would be effective in ameliorating anxiety or increasing value.

This "Overall" variable was negatively correlated with math anxiety as measured by the cost items in the *MVI* (-.519) and *SIMA* (-.551). Some researchers, like Jo Boaler from Stanford (2012), have researched the roots of math anxiety and have traced them back to timed tests as one possible culprit. Young children, as early as first grade, can develop math anxiety. With that knowledge, more needs to be done to lessen that cost of participating in the learning of mathematics. The *MIV* Cost items and *SIMA* measure negatively correlates significantly with every single component of this EVC model except for Intelligence Beliefs. Understanding about how the brain learns and that one's intelligence can be grown can be applied to any subject, not just math. Although, a challenging subject like math is the perfect place to experience the growth in the complexity of the neural circuits from trying and failing, then not giving up until you get it.

Understanding that your efforts will not be in vain, and that continuing to try new ways to learn and understand will pay off is the premise behind the understanding of the Growth Mindset (Dweck, 2000). When teachers understand their students will learn with proper practice and support, they have the motivation to continue helping them until they learn (Jussim et al. 2005). This study did significantly increase participants' beliefs towards a Growth Mindset, with a Cohen's d=.29 (small effect size). This corresponds to a 20% non-overlap with the pre-test scores. Previous studies (e.g., Blackwell et al. 2007) have had larger effect sizes, but the designs of the studies were over a longer period and some (Aronson et al., 2002) had other elements in the intervention that helped anchor the information, like coming back at a later time to write advice to a student. This study included that aspect as well, but writing advice came at the point the information had been fully delivered rather than being used at a later time, so the idea of a Mindset "tune up" or reinforcement midway during the study was not achieved.

Expectancy for success increases as the belief about your current abilities increase and the belief you can learn it in the future if you don't know it now increases. The participants were given information about how the brain learns, that there is no such thing as a math person, and that math can be learned (that it is not a skill some have and others do not). Expectancy to earn a grade of a B or higher did change significantly from the pre to the post score, but the effect size again, was small (d=.28). Even with a small effect size, when Expectancy is raised, how are the other variables affected that correlate with Expectancy? The highest correlation with Expectancy is Grades (r=.663). When a student believes he or she can learn, the grades reflect that belief. Interestingly, Overall experience in math class correlated with expectancy at r=.551. Teachers in the classroom hold the key.

The final variable that was significantly changed was utility at r =.80, a high effect size. This was the variable that changed the most. Previous researchers have related utility value to both performance and interest (Durik et al., 2006; Mac Iver, Stipek, & Daniels, 1991). An interesting question to follow up on this research is, "Will increasing utility value increase interest and course completion?" Answering this question would require a longer study to track what the effects from the intervention would be as they manifest in the environment. More intervention studies are needed to further define these complex ideas and apply what is known, creating useful applications for teachers and students alike.

Limitations of the Study

In this situation of having a limited time period to collect data and a limited number of participants, it was not practical to have a control group since there was not the time to give both groups the treatment. I felt it was not ethical to have a control group that never received the intervention since these practices have increased performance and motivation in previous students, when given either one at a time or in different combinations with other interventions. Even though there was not a control group, the short time between pretest and posttest actually reduced threats to validity from maturation or history since most of the students took the entire study in one sitting (only one did not).

The group of students was a convenience sample since the research was drawn from groups of students that were all taking one of two different classes in the educational psychology program. Of the original 165 students that gave their consent to participate, 12% did not complete any portion of the study. Another 19% did not finish some portion of the study, either the posttest questions or the free text responses that were part of the survey. Additionally, of the three videos that were part of the intervention, they were not equally viewed. The first video, “Can I do it?” had 172 views, the second video, “Do I Care?” had 115 views, and the final video, “Is It Worth It?” had 125 views. In each case, there were views of the videos not attributed to the participants due to testing prior to launching of the study (approximate three to five views). Thus, the viewing of a portion of the intervention protocol was inconsistent. If the students had all seen the videos and participated, there may have been different results. Because all the videos were shown to all participants, and the post questions were given at the end after all three portions of the intervention had taken place, there is not a way to determine which intervention may have had an impact on which outcome. Furthermore, the students that finished the study were likely the ones who exhibited more motivation and perseverance in general.

Lastly, the participants were enrolled in educational psychology classes. Since class choice tends to attract a particular type of person, these results should not be generalized to the larger adult population. The results of this study should only give us ideas about where to go next with our research, not make generalizations about college students until a sufficient number of studies have replicated similar results.

Recommendations for Further Research

The source of the current study's limitations can be rectified and considered for inclusion for future studies. One remedy to include in future studies is increasing the time span for the intervention and follow-up. Even though this short-term study did produce results in each component of EVC, with extended time and reinforcement of ideas over the period of a semester (rather than in one sitting) those results may have increased in number or effect size if the time period was lengthened, and if the lessons could have been reinforced over a period of a semester, rather than all delivered in one sitting. Also, while it is useful to know that people's self-reported beliefs have changed, it would speak more to the effectiveness of this intervention protocol to track other outcomes at the collegiate level that are less subjective such as grades (both in challenging classes like mathematics and as a cumulative grade point average) and tracking registration for math classes not required for their degree plan (taken as an elective).

Additionally, extending the study by following preservice teachers who received this information into the classroom and supporting them in teaching these concepts to their students, and further, monitoring their own beliefs as they are challenged with students who are reluctant learners would be helpful in determining how their beliefs are changed and where they may need bolstering. Further interventions can then be designed that will bring individuals to the next level of understanding.

Another way to bring more understanding to this concept would be to include a control group. This would be helpful to more accurately compare the results, especially if there is a longer time period in between reinforcements. It is important to include all participants in the intervention by having one group as the experimental group first, then trading the groups later, allowing the initial control group to then receive the intervention as a waiting control design (see Gaspard, et al., 2015). With this design, everyone could benefit from the information.

Conclusions

Continuing to study and understand beliefs about learning, particularly beliefs about learning challenging subjects like math, is crucial to understanding the current situation of low performance in mathematics and how to improve mathematics learning and understanding for everyone. As teacher beliefs about learning mathematics (both for themselves and their students) more accurately reflect what is known about learning, it is hoped these teachers will be more likely to share those beliefs with their students, empowering them to learn challenging subjects like math and science. This will change the landscape of our current educational milieu by opening the door to a wider range of employment opportunities and successful careers in the STEM fields to students for whom little to no opportunities may have existed. Let the doors to learning open wide and the path be made clear for all students to march through.

Appendix

Instruments:

Single-Item Math Anxiety Scale - SIMA (Nunez-Pena, Guilera, & Suarez-Pellicioni, 2014) given pre and post: Scoring 1 (not anxious) up to 10 (very anxious)

“On a scale from 1 to 10, how math anxious are you?”

Theories of Intelligence Scale for adults – TISA (Dweck, 2000) given pre and post, reverse scored: Scoring: 1 = strongly disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree; 5 = Strongly Agree

A higher score indicates agreement with the growth mindset theory of intelligence. 3-Item scale

1. You have a certain amount of intelligence, and you can’t really do much to change it. (9)

2. Your intelligence is something about you that you can’t change very much. (16)

3. You can learn new things, but you can’t really change your basic intelligence. (29)

Math Value Inventory - MVI (Luttrell, 2004), given pre and post; sections 1 – 3 relating to the sub-components s within this scale: interest, attainment, and utility. () Cost was considered separately.

Scoring: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree; 4 = Agree;

5 = Strongly Agree

Items noted as (r) are reverse scored. Numbers that follow in parentheses are original item numbers in the overall scale.

I. Interest

I find many topics in mathematics to be interesting. (14)

Solving math problems is interesting for me. (26)

Mathematics fascinates me. (30)

I am interested in doing math problems. (21)

It is fun to do math. (18)

Learning new topics in mathematics is interesting. (3)

I find math intellectually stimulating. (11)

II. General Utility

There are almost no benefits from knowing mathematics. (4r)

I see no point in being able to do math. (20 r)

Having a solid background in mathematics is worthless. (15 r)

I have little to gain by learning how to do math. (7 r)

After I graduate, an understanding of math will be useless to me. (12 r)

I do not need math in my everyday life. (24 r)

Understanding math has many benefits for me. (22)

III. Need for High Achievement/Attainment

Earning high grades in math is important to me. (19)

It is important to me to get top grades in my math classes. (10)

If I do not receive an “A” on a math exam, I am disappointed. (5)

Only a course grade of “A” in math is acceptable to me (This item was dropped due to a technical glitch.)

I must do well in my math classes. (31)

I would be upset to be just an "average student" in math. (13)

Doing well in math courses is important to me. (17)

IV. Cost (Only the items relating to math anxiety were included - reverse scored in the original, but not reversed in the context of this study - so a high score on the construct would indicate high anxiety.)

I worry about getting low grades in my math courses. (8)

Trying to do math causes me a lot of anxiety. (23)

Math exams scare me. (28)

Expectancy of passing course grade (given pre and post):

Rate your confidence in your belief in your ability to complete your next math course with a grade of B or better…Confidence ratings for passing course grade. Responses on a 10-point continuum (1 = no confidence…10 = complete confidence).

Likelihood of taking future math classes not required for degree plan (given pre and post):

How likely are you to take a future math class that is not required for your degree plan? Responses on a 10-point continuum.

(1 = not likely… 10 = completely likely)

Letter to struggling student: (Based on *Saying is believing* (Aronson, et al., 2002) (post)

"What kind of advice would you give this student?"

Marcus is 14-years old and in the 7th grade. He was held back to repeat his 7th grade year because he failed math, science and English. This year his English grades are passing, but he is still failing both math and science and says he is sure he won't pass his 7th grade year again. His math teacher has often heard him say the course work is too hard and he can't learn it, that he's just not a math person. What advice would you offer him and how would you work with him if you were his teacher?

Demographics: (National Reporting System Tips) given at post session only

Looking back at the math classes you have taken in the past, how would you rate your experiences overall in these classes?

Overall positive experience, Overall neutral experience, Overall negative experience

In general, what is your typical grade in a math class? You can choose more than one category if you feel your grades are evenly split between two options.

A, B, C, D, F

How many math courses did you take in high school?

1, 2, 3, 4, 5+

How many math courses have you taken in college so far?

1, 2, 3, 4, 5+

What sex are you registered as on your original birth certificate?

(male, female)

Socio-economic status (adapted from Oakes, p. 18)

1. How would you rate your access to material capital growing up? Think of material capital in terms of income, wealth, trust funds, etc.

Above average, average, below average

2. How would you rate your access to human capital growing up? Think of human capital in terms of your parent(s) or primary caretakers' skills, abilities and/or credentials.

Above average, average, below average

3. What is the highest level of education attained by your father?

Some high school, High school diploma/GED, Some college, Certification in trade, Undergraduate degree, Graduate degree, Do not know

4. What is the highest level of education attained by your mother?

Some high school, High school diploma/GED, Some college, Certification in trade, Undergraduate degree, Graduate degree, Do not know

Format for race/ethnicity

Which categories describe you? You can select as many as apply.

❑ American Indian or Alaska Native. (A person having origins in any of the original peoples of North and South America, including Central America, and who maintains a tribal affiliation or community attachment.)

❑ Asian. (A person having origins in any of the peoples of the Far East, Southeast Asia, or the Indian Subcontinent, including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam, etc.)

❑ Black or African American (A person having origins in any of the peoples belonging to Black racial groups of Africa, Jamaica, Haiti, etc.)

❑ Hispanic/Latino (A person having origins in any of the peoples of Mexico, Puerto Rico, Cuba, etc.)

❑ Middle East, North Africa (A person having origins in any of the peoples of Egypt, Lebanon, Iran, Israel, Saudi Arabia, etc.)

❑ Native Hawaiian or other Pacific Islander (A person having origins in any of the original peoples of Hawaii, Samoa, Guam, Fiji, etc.)

❑ White (A person having origins in any of the peoples of Germany, Ireland, England, Spain etc.)

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