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Cover Page Footnote
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Abstract

More and more students enter college in need of math remediation. Students in remedial math courses tend to report low self-efficacy, which negatively affects academic performance. To help low-achieving students succeed, researchers such as Dweck (2006) find that fostering a growth mindset increases self-efficacy and academic performance. The purpose of the present study was to explore the effects of a growth mindset intervention on the self-efficacy and performance of students in remedial math. It was hypothesized that students who participated in the growth mindset intervention would report higher levels of self-efficacy and test scores than the students who did not. Descriptively the results were in the anticipated direction, however results of an independent samples *t*-test were non-significant for self-efficacy and academic performance. These findings suggest preliminary evidence for the effectiveness of the growth mindset intervention and warrant further investigation.

Keywords: growth mindset, self-efficacy, achievement, performance, remedial math, remediation, higher education

Finding the Right Equation for Success: An Exploratory Study on the Effects of a Growth Mindset Intervention on College Students in Remedial Math

Much education today is monumentally ineffective. All too often we are giving young people cut flowers when we should be teaching them to grow their own plants –John W. Gardner, 1973

College algebra is often the lowest level math course offered by universities. According to a recent investigation of 911 two-and four-year colleges, 209 placed more than half of their first-year students in at least one remedial course (The Hechinger Report, 2017, para. 4). Often referred to as "college-prep," remedial courses do not seem to ready students for success in college. For example, at the national level, students enrolled in remedial math are passing at a rate of 40% (Thompson & McCann, 2010). Other than poor academic performance, taking remedial math courses affect students' efficacy, or the degree to which they believe in their ability to achieve (Spaniol, 2017). Students who believe in their ability to succeed or accomplish a task do better in school. Education practitioners are tasked with finding ways to increase the self-efficacy of at-risk students to help them persist and achieve. One way to enhance students' self-efficacy, and subsequently their performance, is through implementing growth mindset interventions designed to change beliefs about intelligence and effort. These types of interventions have shown promise in helping students succeed in the classroom (Dweck, 2006). Currently, studies on growth mindset interventions lack students in remedial math at private, four-year institutions as samples. The purpose of this present study was to explore the effects of a growth mindset intervention on the self-efficacy and achievement of students within a remedial college algebra course at a private, four-year institution.

Remediation in Higher Education

Remediation, or developmental education, is nothing new to higher education. As early as the 1600s, Harvard College, America's first institution of higher learning, began providing Greek and Latin tutors for underprepared students (Spann & McCrimmon, 1998). In 2008, 20% of first-year undergraduates enrolled in institutions of higher learning reported taking a remedial course (National Center for Education Statistics). Moreover, remedial enrollment is highest for math (Bailey, Jeong, & Cho, 2010). Remedial math is the most common remedial course with the lowest pass rate, suggesting that although it is meant to prepare students for success in later math courses, it is often ineffective in doing so (Bailey, Jeong, & Cho, 2010; Noel-Levitz, 2006). Bettinger and Long (2009) found that remedial math courses are more likely to help students who fare better on standardized tests such as the ACT. A 2016 report by the ACT showed that only 13% of Black or African-American and 27% of Hispanic ACT test takers were prepared for college math, compared to the 50% of White and 70% of Asian ACT takers who met the college readiness benchmark for math. Although shocking, this information is supported with data that also shows students of color disproportionately make up the students in remedial math courses (Walker & Plata, 2000). Even more disturbing, White students are three times more likely to pass their developmental sequencing than Black students and almost twice as likely than Hispanic students (Bahr, 2010). Students of color who start remedial often stay remedial. Additionally, remediation is expensive. According to a recent report by Barry and Dannenberg (2016), remedial education costs families nearly 1.5 billion dollars annually, increasing the amount of money students borrow while simultaneously extending the time to degree completion. As evidenced from the research highlighted above, students are often stuck at this remedial impasse, which not only may be perpetuating a cycle of educational inequality, but is also demoralizing

for students taking the course. Hall and Ponton (2005) have reported that students taking remedial courses have low levels of self-efficacy compared to students taking other, higher level math courses, which negatively influences their performance and persistence.

Self-efficacy as an Achievement Indicator

Self-efficacy is defined as a person's beliefs regarding their capability to succeed at any given task and exists as one of the core tenants to human motivation and achievement (Bandura, 1994). Bandura (1977) posits that efficacy expectations, what people believe their ability to achieve is, dictates how much effort one is willing to exert. Specifically, those with high self-efficacy will put forth more effort to achieve an outcome compared to those with low self-efficacy. There are four main sources of efficacy: performance accomplishments, the degree to which one has mastered a task; vicarious experience, seeing the task modeled by others; verbal persuasion, the encouragement of others to perform a task; and emotional arousal, what we perceive the level of our physiological arousal to be (Bandura, 1977). Bandura (1993) also asserts that self-efficacy operates through four major processes—cognitive, motivational, affective, and selection—that contribute to cognitive and developmental functioning.

In cognitive processes, efficacy determines the type of mental model one chooses to employ. Specifically, those with strong efficacy beliefs create mental images of, or visualize, scenes in which they are successful, which then supports their performance compared to people who visualize failure. In motivational processes, self-efficacy influences cognitive motivators such as causal attributions, outcome expectancies, and perceived goals. People with strong efficacy beliefs attribute successes to a high degree of effort, have more positive outcome expectancies, and set higher goals for themselves. Affective processes, or people's beliefs about their abilities, can determine how much stress one experiences when faced with hardship. People

who believe they can exert control over threats or setbacks (high self-efficacy) do not experience as much stress compared to people who believe they cannot. And in selection processes, people with low self-efficacy avoid tasks they believe to be outside the scope of their abilities compared to people with high self-efficacy (Bandura, 1993).

Self-efficacy has long been applied to educational contexts (Lane & Lane 2001; Lent, Brown, & Larkin, 1984; Zimmerman, 2000). The literature highlights the positive effects of self-efficacy on academic achievement. Namely, students who score high on self-efficacy assessments have better education outcomes (Lane & Lane 2001; Lent, Brown, & Larkin, 1984; Zimmerman, 2000). This is particularly true with math education in college (Hackett & Betz, 1989) where math self-efficacy has been shown to be strongly correlated with whether students choose a math related major (Hackett, 1985). Efficacy has also been linked to goal setting (Locke & Latham, 1990), problem solving (Larson, Piersel, Imao, & Allen, 1990), and self-regulation (Bandura, 1991); which are all integral to achievement. To help low-achieving students succeed and overcome the challenges they face in school, psychological interventions have been used by education practitioners to facilitate positive change (Dweck, 2006; Paunesku, et al., 2015; Yeager & Walton, 2011).

Growth Mindset Interventions

Growth mindset interventions have been implemented in classrooms to help at-risk students succeed. Mindset builds upon attribution theory, which refers to one's perception of causal attribution. According to Weiner (1986), there are three major influences to how people attribute cause: locus, whether one ascribes a cause to internal or external factors; stability, describing a cause as constant or varying over time; and controllability, one's degree of personal responsibility. Each are related to expectations of success. For example, people who attribute

success to internal factors and personal responsibility (i.e. effort), compared to external factors and lack of responsibility have better expectations of success (Weiner, 1986). Also, if success is attributed to stable factors (i.e. intelligence), success expectancy is consistent compared to unstable factors (i.e. luck), which doesn't affect success expectancy at all (Weiner, 1986). These attributions are foundational to the theory of mindset.

According to Dweck (2006), people can have a growth or fixed mindset. These mindsets, also referred to as implicit theories, influence people's perception of themselves and their abilities. A fixed mindset is the belief that one's successes and failures are based on innate abilities and therefore cannot be changed. A growth mindset on the other hand is the belief that one's successes and failures are a result of effort and hard work (or lack thereof). Mindset is mostly applied to intelligence; that is, people can have a fixed or growth mindset about their own degree of intelligence—both shape and inform behavior. For example, a person with a fixed mindset does not like failing nor trying new things because he or she attributes failing to an innate deficiency that cannot be changed, but someone with a growth mindset uses failure as an opportunity to learn and grow. Blackwell, Trzesniewki, and Dweck (2007) found that adolescents who participated in a workshop series teaching them that brains are muscles that grow through practice and effort showed higher math achievement than those in the control condition, who were taught study skills. Additionally, Saunders (2013) found a significant impact on the reading ability of at-risk students who went through Brainology, a growth mindset intervention created by Dweck and her colleagues. While many studies have illustrated positive effects of mindset interventions, a recent meta-analysis of these types of interventions by Sisk and colleagues (2018) found that overall the effect sizes were small and more likely to help

students from low socioeconomic contexts and who are academically at-risk, such as students in remedial math.

Bandura (1986) suggested that attributional factors, such as effort, influence performance via self-efficacy; that how students assess their efficacy depends on certain attributional factors; mindset being an example. Wood and Bandura (1989) were the first to theorize the relationship between mindset, or self-theories, and self-efficacy. They posit that incremental theorists, those who believe that their intelligence is malleable and can change through effort (i.e., a growth mindset), will have high levels of self-efficacy, whereas entity theorists, those who believe that their intelligence is unchangeable (i.e., a fixed-mindset), will have low levels of self-efficacy. To test this, they randomly assigned graduate business students to an incremental condition or entity condition where they were each instructed to complete a decision-making project. Those in the incremental condition were told that decision-making is developed through practice, while those in the entity condition were told that decision-making is illustrative of cognitive ability. Using qualitative methods, they found that the graduate students in the entity condition reported lower self-efficacy than those in the incremental condition. Although Wood and Bandura (1989) found a significant difference, studies find that the correlation between self-efficacy and mindset is weak (Palazzolo, 2016), but these findings lacked the current population of interest.

As illustrated, college remediation is an important topic when it comes to higher education and student success. More students need remediation, but often aren't successful at attempts to remediate. Additionally, it is costly and extends the time students are in school. Psychological theories, such as self-efficacy and mindset, can help low-achieving students, like the ones who remediate, succeed. Education practitioners have options to create interventions based on these theories or use empirically tested, pre-existing interventions to close achievement

gaps between low and high achieving students. The purpose of this present study was to explore the effects of a growth mindset intervention on the self-efficacy and academic performance of students taking a remedial math course at a four-year, private institution. It was hypothesized that the students in a remedial math course exposed to a growth mindset intervention would report higher levels of self-efficacy and test scores compared to students who were not afforded such an opportunity.

Method

Participants

Undergraduate students (N = 15) from a college algebra course at a four-year, private, liberal arts university, were conveniently sampled to participate. Most participants were-first-year students (n = 14, sophomore n =1) and varied slightly in their majors (science n = 10, business n = 2, education n = 1, human services n = 1, and undecided n = 1). In regards to sex and race/ethnicity, female participants (n = 12) outnumbered male participants (n = 3) and Blacks/African-Americans (n = 6) outnumbered every other racial group (White n = 5, Asian n = 2, Hispanic n = 1).

Measures

Demographics questionnaire. A self-report demographics questionnaire was used to capture characteristics of the population being tested. The questionnaire asked for major, race, gender, class, varsity sports team status, highest education of parents, current numerical math grade, numerical math grade in high school, and single versus two parent household.

Mathematics Self-Efficacy and Anxiety Questionnaire – Self-Efficacy (MSEAQ-SE). Developed by May (2009), the 13 item math self-efficacy scale of the MSEAQ was used to determine self-efficacy in math. A sample item is: “I believe I am the type of person who can do

mathematics". Each item on the scale was scored from one to five where one equaled "Never", two equaled "Seldom", three equaled "Sometimes", four equaled "Often", and five equaled "Usually". Possible scores ranged from 13-65. The reliability of the scale was good (α =.93).

Design

This present study was an independent-groups with a pretest/posttest design. The independent variable was the growth mindset intervention and the dependent variables were self-efficacy and academic performance (measured by math test scores). Students were randomly assigned to the growth mindset intervention or the non-treatment control condition by assigning them numbers and pulling the numbers from a hat.

Intervention condition. Participants in this condition were exposed to a growth mindset intervention that was developed by Project for Education Research that Scales (PERTS), Stanford University's center on education research (Beaubien, Stahl, Herter, & Paunesku, 2016). The intervention took place towards the end of a class, and took approximately twenty minutes to complete. Students first watched a video about neuroplasticity and how the brain grows through effort and practice. Next, the researcher shared a story about his struggles in math and how he overcome them through practice. Finally, after the story, students in the intervention condition were asked to write down a time they struggled with a difficult task, how they used practice and effort to overcome it, and advice they would give to someone struggling with a difficult task.

Control condition. This was a no-treatment condition, participants in this condition were not exposed to any treatment.

Procedure

Half of the participants were randomly assigned to the intervention condition and the other half were assigned to the control condition. Towards the end of class, everyone received a

self-efficacy pretest to establish baseline scores. They were also given a demographic questionnaire. After the completion of these first tasks, the participants assigned to the control condition were asked to leave class while those in the intervention condition stayed and were exposed to the growth mindset intervention After the intervention was complete, participants in the intervention condition were asked to complete the self-efficacy posttest to see if there were immediate effects. Both conditions were followed up two weeks after the first round of data collection and completed self-efficacy post evaluations and self-reported their grade to see if the intervention had any lasting effects.

Results

Descriptive Statistics

Although the sample originally obtained 15 participants, complete data was only obtained for 11 participants. As such, all statistical reports and analyses are based on only the completed data. More participants had mothers with some college, including vocational/technical training (n = 6) than did with a bachelor's degree or higher (n = 4), high school diploma or equivalent (n = 3), and less than high school (n = 2). Also, more participants had fathers with a bachelor's degree or higher (n = 6) than did with a high school diploma or equivalent (n = 3), less than high school (n = 3), and some college, including vocational/technical training (n = 2). In addition to parent education, participants also self-reported parent marital status and a majority of the sample had parents who were married (n = 7) compared to divorced (n = 4), separated (n = 3), and widowed (n = 1). The average grade in the class was a C+ (M = 79.36, SD = 8.08).

For the intervention condition, there was an increase from the pre-self-efficacy test (M = 45.63, SD = 9.04) to the post-self-efficacy test (M = 51.67, SD = 14.88), with a moderate effect size observed (d = 0.5). Participants' self-reported test scores also increased from pre assessment

(*M* = 74.71, *SD* = 11.74) to post assessment (*M* = 79.21, *SD* = 12.65), with a small effect size observed from pre to post assessment (*d* = 0.39).

Within the control condition, there was a decrease in self-efficacy from the pre-test (*M* = 44.43, *SD* = 6.60) to the post-test (*M* = 41, *SD* = 1.15), with a large effect observed from the pre-test to post-test (*d* = 0.72). Participants' self-reported test scores decreased from the time of the pre-assessment (*M* = 71.57, *SD* = 4.86) to the post assessment (*M* = 70.13, *SD* = 7.98), with a small effect size observed from pre to post assessment (*d* = 0.22).

Overall, the self-efficacy change score was greater in the intervention condition (*M* = 7.33, *SD* = 9.29) than in the control condition (*M* = -2.75, *SD* = 6.85), with a large effect observed (*d* = 1.24). And the change in test score was also greater in the intervention condition (*M* = 4.25, *SD* = 4.27) than in the control condition (*M* = 1.88, *SD* = 6.28), with a moderate effect observed (*d* = 0.44).

Effect of growth mindset intervention on self-efficacy and academic performance

It was hypothesized students in a remedial math course exposed to a growth mindset intervention would report higher self-efficacy and test scores than students who did not. A change score was calculated for the pre-post scores on self-efficacy and test scores prompting an independent samples *t*-test to be run. The hypothesis was rejected, as results from independent samples *t*-test did not indicate a significant effect of condition for self-efficacy, $t(8) = -1.85$, $p > .05$, or test scores, $t(8) = -0.72$, $p > .05$.

Discussion

Students in remedial math courses have low-levels of self-efficacy (Spaniol 2017), which negatively affects academic outcomes (Zimmerman, 2000). To help this population of students succeed in classroom contexts, education practitioners sometimes employ psychological

interventions. Growth mindset interventions, which attempt to change students' beliefs about intelligence, success, and failure, have shown to have long term positive effects for students who participate (Dweck, 2006). The purpose of the present study was to see whether a growth mindset intervention would have any effect on the self-efficacy and performance of students in remedial math at a four-year, private instituition. It was hypothesized that that students who participated in the growth mindset intervention would report higher self-efficacy and test scores than students who did not. Although descriptively, the results were in the anticipated direction, this hypothesis was rejected as the difference in change scores from the pre-test to the post-test was non-significant.

Concerning the results of the non-treatment condition, college courses are typically scaffolded, meaning as the semester continues, the course material gets increasingly difficult. This said, without an intervention that reinforces students' belief in their ability as the content gets difficult, students with already low self-efficacy will not persist, which possibly explains the decrease in self-efficacy of the control condition. It is possible that participants in the intervention condition scored higher on their exams due to the change in mindset. Bailey and colleagues (2017) found that students who have high levels of self-efficacy also have higher test scores, which supports the present results.

Throughout the study, there was not a high level of internal and statistical validity maintained. The students' relationship with the professor was a confounding variable because prior experiences could determine how students respond to survey items, which would then compromise the study's internal validity. Specifically, whether a student believes they are the type of person to succeed in math may partially be influenced by the student's relationship with their teacher. Bandura and colleagues (1996) found that various psychosocial factors, such as

parent expectations and family socioeconomic factors, influence efficacy beliefs. Although the results did not yield statistical significance, descriptively they were in the anticipated direction. It is possible that the small sample size, and subsequent lack of power, resulted in non-significant differences in means. The attrition of participants from pre to post, also may have which decreased the study's statistical validity.

Limitations

Limitations to this study include the sample size, when data collection occurred, and the longevity of the intervention. In regards to the sample size, the pool of potential participants was limited because there is only one remedial math course offered during the fall semester at the university where the data was collected. Increasing the sample size could increase the power of the findings and subsequently help detect a significant difference. Regarding data collection, the limitations were compounding. The time of year during which the intervention data collection took place coincided with a holiday recess. This could lead to fatigue and affect how participants respond to surveys. Not only that, but the specific time the data was collected during the allotted class period also contributes to fatigue. The data was collected towards the end of class, after students had almost a full day of learning material. Additionally, the intervention occurred only after the research proposal was approved and a significant scan of the literature on mindset, self-efficacy, and performance was conducted, which was more than halfway through the academic semester. Interventions that span over weeks, even a full academic year, have been successful in producing significant results (Blackwell, Trzesniewski, & Dweck, 2007).

Future Directions

For researchers interested in studying growth mindset interventions, it is important for a study of this kind to be done with a larger sample size (i.e. more remedial courses offered). This

would allow researchers to cluster sample multiple remedial classes and randomly assign classes to the control and intervention conditions. This would inevitably increase the statistical validity of the study. Another future direction for researchers interested in studying growth mindset interventions is to consider how often the intervention should take place. Instead of conducting a brief intervention with limited time, an intervention that occurs at the same time weekly or bi-weekly may be beneficial in finding significant results. It may also be important to control for student-teacher relationships as it may influence self-efficacy.

As the present results indicate, more research is warranted on the use of growth mindset interventions in remedial math courses. Education practitioners interested in helping low-achieving students succeed and developing best practices may find this area of research advantageous as growth mindset becomes increasingly popular in education.

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