Journal of The First-Year Experience & Students in Transition, Vol. 31, No. 2, pp. 63-78

Conditions for Success: Fostering First-Year Students' Growth Mindset in Developmental Mathematics

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Abstract. A quasi-experiment was conducted to determine if a growth mindset intervention in a developmental modular mathematics course would enhance student performance, persistence to final exam, and retention. University students ($N = 227$) in seven randomly selected sections were exposed to one of three interventions: growth mindset article + letter writing, neutral article + letter writing, and letter writing only. Students primed with a growth mindset article persisted at a significantly higher rate than those receiving a neutral article letter-writing prompt or students only writing letters. Persistence is defined as completing all course modules at 80% or higher and continuing in the course to the final exam. The growth-mindset intervention did not have a significant impact on retention into the two following semesters. Individual instructor was not found to affect student persistence. The utility of using mindset interventions for increasing first-year performance and persistence is discussed.

Mathematics anxiety, including students' general lack of confidence in their mathematical abilities, has long been recognized as a major impediment to students' success in developmental mathematics courses (e.g., Goolsby, Dwindell, Higbee, & Bretscher, 1988; Hall & Ponton, 2005), which present a challenge for many students in their first year of college. As many as 1.5 million postsecondary students, or 42% of United States college students, started in remedial courses for mathematics, English writing, or both (Complete College America, 2016), with percentages slightly higher at community colleges (Horn & Nevill, 2006), and many students struggle to persist in these courses. Bailey, Jeong, and Cho (2010) found that only 31% of students referred to developmental mathematics in a cohort of Achieving the Dream colleges completed the developmental sequence within three years. Their research has been used to suggest that developmental mathematics courses are a major barrier to student persistence (Complete College America, 2012). Despite the challenges of developmental mathematics, instructors can increase students' confidence in their ability to be successful in learning mathematics (Hall & Ponton, 2005; Silva & White, 2013). Short, one-time psychological interventions have been found to increase student persistence beyond the subject area in which the intervention takes place and indicate the potential to last over multiple semesters (Stigler, Givven, & Thompson, 2010; Yeager & Dweck, 2012; Yeager, Paunesku, Walton, & Dweck, 2013)[1].

This study contributes to the research on persistence in developmental mathematics by exploring the impact of a mindset intervention on students enrolled in developmental mathematics courses at a regional university campus. Specifically, we replicated Yeager et al.'s (2016) lay theory interventions within the context of developmental mathematics courses at a regional university to explore the following research questions: How do growth mindset interventions affect persistence to the final exam in a developmental mathematics course? How do growth mindset interventions affect retention to the following semester? Findings from this study may encourage researchers and practitioners to consider the benefits of incorporating mindset interventions into larger campus engagement efforts and the establishment of a campus culture honoring students' potential for academic success.

Literature Review and Theoretical Framework

This study extends Yeager et al.'s (2016) research on introducing a growth mindset intervention for first-year students. Dweck (2006) described a growth mindset as one in which intelligence is adaptable and individuals possess the capacity for growth. The opposite of a growth mindset is a fixed (or entity) mindset, in which an individual perceives current limitations as a permanent condition. Combining growth mindset theory (Dweck, 2006) and developmental education theories of persistence, we explore how mindset interventions are relevant to students' persistence in developmental mathematics.

Developing Growth Mindsets

Mindsets are implicit theories about how academic and social resilience can be developed (Yeager & Dweck, 2012). Within first-year courses, instructors can successfully engage students through assignments that intentionally foster perseverance that is transferable beyond the first year (Olson, 2017). Short psychological interventions used at the middle school, community college, and university levels have taught students the basics of neuroplasticity and how the brain can "grow like a muscle" with hard work and good strategies (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2006, 2008; Yeager et al., 2016). Mindset interventions share an explicit focus on drawing students' attention to their ability to develop academic skills necessary for participation in the classroom or college and explicating how developing metacognitive skills supports their learning beyond the classroom in which the skills are taught.

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[1]*Persistence* and *retention* are commonly confused in the literature. In this study, we follow Tinto (2010), using the term retention to note the institution's retaining of students and persistence to indicate remaining in a higher education course from the students' perspective.

Studies have examined the effectiveness of mindset interventions in a variety of academic settings. Yeager et al. (2013) conducted a study in which they randomly assigned more than 7,500 students at a large state university to a growth mindset intervention as a part of their first-year orientation. Students were directed either to a placebo treatment or to a website where they read and responded to an article, "You Can Grow Your Brain: New Research Shows the Brain Can Be Developed Like a Muscle." The researchers found that the growth mindset treatment resulted in a 3-point increase in the percentage of students earning 12 or more GPA-bearing credits (Control: 60%; Treatment: 63%). Members from the research team have conducted similar studies at the middle school (Blackwell et al., 2007), high school (Yeager et al., 2016), and community college levels (Yeager et al., 2013) with similar positive results: Mindset interventions increased GPA and reduced postsecondary dropout rates, particularly among disadvantaged students.

In a study of 715 students, including 292 students enrolled in a developmental mathematics course at a community college, Yeager et al. (2013) examined the impact of a mindset intervention that involved reading an article about the brain's ability to restructure itself through effortful practice. The article specifically identified mathematics ability as a type of intelligence that can be developed, and students were asked to respond to the article through several related writing prompts, including offering advice to a hypothetical peer who thought of himself as "not smart enough" to succeed in school. The researchers found no difference between treatment students' and control students' grades in the developmental mathematics course, but the dropout rate of the intervention group was less than half that of the control group (9% and 20%, respectively). These findings suggest that although the intervention does not have an impact on students' mathematical abilities, it has a positive impact on students' beliefs about their ability to persist in a developmental mathematics class. Findings from this study and others like it (e.g., Aronson, Fried & Good, 2002; Blackwell et al., 2007; Cohen & Garcia, 2014; Dweck, 2008; Walton & Cohen, 2011) suggest that students who receive psychological interventions at key transition points, such as during a first college mathematics class, see results that persist throughout the semester. Importantly, although students were asked to respond to a message about brain growth, they also created their own positive messages during the intervention.

Lay theories, including growth or fixed mindsets, can help people make sense of their lives or experiences and interpret and process adversities (Walton & Cohen, 2011; Wilson & Linville, 1985). Mindset interventions may help students who draw negative inferences about their college experiences, particularly experiences related to group-based inequalities (Steele, 1997). Summarizing studies of mindset interventions with students in a community college and at a state university, Yeager et al. (2013) noted that students with a lay theory that "people like them" (i.e., first-generation or nontraditional college students) might not belong in college are less likely to persist through their first year. In their research, personality traits, growth mindset, SAT score, GPA, and IQ were not found to have significant effects on persistence. However, the researchers found that interventions can successfully teach the lay theory that many students come to feel that they belong in college. These results suggest that one-time pre-matriculation interventions can significantly increase persistence through the first year for disadvantaged full-time students. Based on these studies, Yeager et al. suggested that the necessary conditions for successful lay theory interventions include (a) customized materials to redirect problematic lay theories; (b) reframing an existing lay theory that hinders student motivation; and (c) instructional opportunities, relational opportunities, and financial supports. The present study examined how instilling a growth mindset can promote persistence and empowerment for developmental students who face challenges related to socioeconomic and demographic factors.

Student Persistence in Developmental Mathematics

On average, institutions of higher education offer three to four levels of developmental mathematics in a sequence covering arithmetic through intermediate algebra (Bailey et al., 2010). Students are typically placed into college-level or developmental mathematics based on test scores. Large-scale analyses of developmental mathematics suggest alarmingly low student persistence rates (Bailey et al., 2010; Bickerstaff, Fay, & Trimble, 2016). In an analysis of North Carolina and Virginia's modularized mathematics redesign, Bickerstaff et al. (2016) described tensions between modularization's theorized benefits of student-centered, personalized learning, content mastery, and acceleration. Although the researchers identified issues with student persistence and progression to college-level mathematics courses, they did not explore the impact of students' beliefs about resilience on their persistence in developmental-level mathematics courses.

Mathematics anxiety has a major impact on students' persistence in developmental mathematics courses. In fact, several studies indicate that students' confidence in their ability to learn mathematics is the only variable that significantly contributes to predicted performance in a developmental mathematics class (Dwindell & Higbee, 1991; Goolsby et al., 1988; Thomas & Higbee, 1999). These findings led Schwartz (2000) to conclude that developmental mathematics courses should include a plan for increasing student confidence and lowering mathematics anxiety. Studies document the positive outcomes of activities that decrease mathematics anxiety in the developmental mathematics classroom and that help students understand their attitudes toward learning beyond the developmental classroom (Levine-Brown, Bohnam, Saxon, & Boylan; 2008; Taylor, 2008).

Because growth mindset interventions have been found to reduce mathematics anxiety (Silva & White, 2013), they align well with the goals of developmental education, a system of student support that extends well beyond the remedial classroom to include "a comprehensive process that focuses on the intellectual, social, and emotional growth and development of all students" (National Organization for Student Success, n.d., Definition). Developmental education includes placement testing, advising, tutoring/learning assistance, and remedial coursework (Boylan, 2009); these support services exist in some form at every community college in the nation and at most four-year public schools (Saxon, Sullivan, Boylan, & Forrest, 2005). Much of the research on persistence in developmental education is informed by theories emphasizing the importance of sustained academic and social integration (e.g., Astin, 1984; Tinto, 1975, 1998), or what Astin refers to as involvement, particularly during the first year. Involvement can take multiple forms, but the literature highlights the importance of social relationships in fostering student persistence. Tinto's research examines causes of students' failures to acclimate to the educational setting and the resulting consequence of students' departures from college. Tinto's (1975) theory of student departure suggests that students come to college with certain beliefs and expectations and that their progression through college is influenced by their interactions with others at the college. Researchers have examined the impact of interventions that can challenge or shape student beliefs (e.g., Auten, 2013; Olson, 2017; Yeager & Dweck, 2012); however, further exploration is needed of the processes by which changing students' beliefs about their mathematical ability can successfully affect students' persistence beyond a single class. Growth mindset interventions in the first developmental mathematics course may provide an impactful way to influence students' beliefs about not only their mathematical intelligence but also their level of belonging in the college community, thereby fostering their expectations regarding their persistence beyond the developmental mathematics classroom.

Previous research in both developmental education and the utility of growth mindset interventions share a common commitment to increasing student persistence; this study occupies a similarly shared space between developmental education and educational psychology. In this study, we explore whether introducing first-year students enrolled in developmental mathematics courses to a theory of growth mindset has an impact on their persistence in developmental mathematics and future semesters. The study broadens existing research on growth mindsets by introducing mindset interventions in developmental mathematics at a regional university, a previously unstudied context.

Method

Research Site

On the four-year regional university campus in Indiana at which the present study was conducted, students who do not pass Topics in Algebra, MATH-M 101, are ineligible to graduate. At the research site, a public four-year regional campus with a majority commuter population, 43% of students tested into a developmental mathematics course that does not count toward their major. The 2012 cohort's four-year graduation rate was 17%, which followed the institution's upward trend, up from an 8% graduation rate in 2009.

According to institutional data, approximately 36% of the institution's students graduate within eight years (Indiana University, 2015-2016).

Participants

The intervention was applied to three cohorts of students ($N = 227$) in seven sections of Topics in Algebra class sections during the second or third week of the Fall 2015 semester. In this convenience sample of seven class sections, all students in the selected classes were given the intervention. Students ranged in age from 17 to 48, with the majority ($n = 200$) aged 17–19. The demographics of the sample were representative of the overall campus demographics (Table 1). Participants' ACT Mathematics Scores ranged from 12 (1st percentile of ACT-takers) to 26 (27th percentile). The majority of students in this study scored in the lower third of performers in the ACT distribution.

Table 1
Campus Demographics

	Study cohorts		All undergraduates	
Demographic	***n***	**%**	***N***	**%**
African American	19	8.5	58	6.3
European American	178	78.4	767	82.3
Female	156	60.2	552	59.6
Male	71	31.8	374	40.4
First-generation college	115	50.7	417	45.0

All Indiana high school graduates after 2011 must have a Core 40, Core 40 with Honors, or Core 40 with Technical Honors high school diploma to be admitted to this campus. The Core 40 diploma includes mathematics through Algebra II (Indiana Core 40, 2012). Campus policy requires out-of-state students or students graduating before 2011 to have completed 28 college-preparatory high school courses for admission. As a result, all incoming first-year students are assumed to have received some level of preparation for college-level mathematics; however, completion of these high school courses has not guaranteed students' college-level proficiency. Therefore, students are advised to take the college mathematics placement test if they have not previously completed transfer-level courses (i.e., dual credit). If students choose not to take the placement assessment or if their placement scores suggest they would benefit from a developmental mathematics course, students are placed into MATH-M 101, Topics in Algebra (M101), which is the lowest-level course.

M101 meets twice weekly for 70 minutes with an instructor and an undergraduate teaching assistant; the course covers linear equations, graphs, and inequalities. The course curriculum is modules-based, using Pearson's MyMathLab software. Students watch online instructional videos and practice mathematics problems until they are ready to test. Instructors provide mathematics instruction and course success strategies from previously successful students describing how they studied for exams. This 2-credit course does not count toward the mathematics requirements for graduation. Furthermore, these credits count against students' free elective credit hours, which can be problematic because the majority of college majors in Indiana are restricted to 120 college credits. During Fall 2014 and Fall 2013, 48% and 42% of all students who placed into M101, respectively, persisted to completing the course. Students who repeat M101 two or three times persist to completion at much lower rates than first-time students; many such students do not return to college at all.

Design and Measures

Following Dweck's (2008) Brainiology® study as reported in Blackwell and collegues (2007), the present study provided different interventions to two groups of students in developmental mathematics in order to answer the research questions: How do growth mindset interventions affect persistence to the final exam? How do growth mindset interventions affect retention to the following semester? Persistence was defined in conjunction with the class requirement of students completing all modules with a score of at least 80% in order to take the final exam. Retention was defined as enrollment in a future term.

In the present study, seven M101 sections were randomly assigned to receive one of three interventions: brain growth article, laughter–stress article, or advice only (no article). For the brain growth article interventions, students read the article, "You Can Grow Your Intelligence: New Research Shows the Brain Can Be Developed Like a Muscle" (Mindset Works, 2002) and responded to three essay prompts (Dweck, 2008): (a) summarizing the article, (b) describing a time in their lives when they learned something new, and (c) writing a letter to encourage another student who was feeling "dumb." Students in the second intervention read the article, "Laughter and the Brain" (Chudler, 2015), which discusses laughter and health and relaxation. This intervention was included to test whether an alternative lay theory (i.e., "laughter is the best medicine") could similarly affect student persistence. Students typed responses to a prompt that summarized the article and directed students to: Think about an example from your own life. What is a situation where you have laughed and improved your health? Write about it and explain how you became relaxed. In the third intervention, students received no article and wrote essay responses to two prompts: (a) write about a situation where you have succeeded in a class or topic and explain what contributed to you doing well, and (b) write a letter to a friend who is feeling "dumb" in school, giving tips for learning and getting smarter. (Intervention protocols are accessible through https://libguides.ius.edu/graduation.)

Results

A one-way ANOVA was conducted to determine if participants in each intervention (brain-growth, laughter, or advice only) differed in math ability prior to the intervention, as measured by their ACT math score. There was not a significant difference between the groups, $F(2, 213) = 0.355$, MSE = 5.77, $p = .702$, $\eta^2 = 0.003$. This was important to note because we did not randomly assign participants to the conditions but rather used preexisting class sections.

Persistence to Final Exam

A chi-square analysis to determine whether an equal number of students from each group took the final exam in the developmental math course showed the relation between these variables was significant, $\chi^2(2, n = 225) = 16.13$, $p < .001$. A higher percentage of the students in the brain growth article intervention were likely to persist to the final exam (see Table 2).

Table 2
Persistence to Final Exam by Intervention

		Did students take the final exam?	
Intervention	***N***	**Yes % (*n*)**	**No % (*n*)**
Brain growth article intervention	88	64.8% (57)	35.2% (31)
Advice-only intervention	69	50.7% (35)	49.3% (34)
Laughter–stress article intervention	68	32.4% (22)	67.6% (46)

Performance on the Final Exam

A one-way ANOVA was conducted on the data from students who took the final exam to determine if the intervention affected final exam scores. Among these students, the ANOVA indicated no significant differences between intervention groups, $F(3, 114) = 0.370$, $p = .692$, MSE = 171.75, $p = .702$, $\eta^2 = 0.007$; see Table 3.

Table 3
Exam Scores by Intervention for Students Who Took the Final Exam

	n	**Mean final score**	***SD***
Brain growth article intervention	57	73.68	12.58
Laughter–stress article intervention	22	74.24	15.08
Advice-only intervention	35	76.07	12.62

Impact on DFW Rate in Course by Intervention

A chi-square analysis was performed to determine if the groups differed in their likelihood to complete the course successfully with a passing grade. Grades were categorized as passing (i.e., A, B, or C) or as DFW (i.e., D, withdraw, or failing). The relationship among these variables was significant, $\chi^2(2, n = 218) = 15.93, p < .001$. Table 4 presents the percentages of students in each grade group. A higher percentage of the students in the brain growth intervention group than in the other groups passed the developmental math course.

Table 4
Relationship Between Intervention and Passing Grade

		Did students pass the course?	
Intervention	***N***	**Passing % (*n*)**	**DFW % (*n*)**
Brain growth article intervention	88	64.8% (57)	35.2% (31)
Advice-only intervention	63	55.6% (35)	44.4% (28)
Laughter–stress article intervention	67	32.8% (22)	67.2% (45)

Impact on Retention

A chi-square analysis was conducted to examine the relationship between type of intervention and whether the student was likely to persist to the spring semester. The relationship was not significant, $\chi^2(2, n = 227) = 2.597, p = .273$; see Table 5. In comparison, the retention rate for the entire incoming first-year class between Fall 2015 and Spring 2016 was 83%.

A chi-square analysis was also conducted to examine the relationship between type of condition and whether the student was likely to persist to the fall semester. The relationship between these variables was not significant, $\chi^2(2, n = 225) = 2.048, p = .359$. The university-wide first-year cohort's retention rate from Fall 2015 to Fall 2016 was 62.4%. Retention rates to the fall semester were not significantly different from the previous academic year.

Table 5
Relationship Between Intervention and Retention to Future Semester

		Student returned in subsequent semester?	
Intervention	***N***	**Returned Spring 2016 % (*n*)**	**Returned Fall 2016% (*n*)**
Brain growth article intervention	88	74.2% (66)	59.1% (52)
Laughter–stress article intervention	68	80.9% (55)	60.3% (41)
Advice-only intervention	69	84.3% (59)	69.6% (48))

Impact of Instructor on Percentage of Persisting Students

Because each section was taught by a different instructor, it was necessary to determine whether the instructor affected student persistence to final. A chi square was calculated to determine whether differences in persistence to the final exam were related to individual instructors. No relationship was found between instructors and whether the student took the final $\chi^2(3, N = 225) = 2.913, p = 0.405$. Students were equally likely to make it to the final with each of the four professors involved in the study (Professor A: 58.3%; Professor B: 54.0%; Professor C: 44.4%; Professor D: 55.6%). At the campus where the research occurred, only 50% of students who placed in the lowest-level developmental mathematics course, M101 persisted to completing the course at the end of the Fall 2015 semester.

Discussion

Persistence

Mindset interventions can help students reframe negative perceptions of academic experiences (Walton & Cohen, 2011; Yeager et al., 2016; Yeager & Dweck, 2012). Results from this research coincided with similar research indicating that utilizing a mindset intervention to introduce a lay theory can have a large impact on student persistence to the final exam. Students in the brain growth intervention are assumed to have internalized the lay theory that they could become a "math person," thereby enacting a growth mindset of mathematics success through effort and the adoption of good strategies. As a result of this mindset change, students were more likely to persist in the class and, subsequently, to the final exam.

However, findings from the laughter–stress intervention indicated that introduction of a non-growth mindset lay theory decreased the percentage of students who persisted to the final exam. A lay theory suggesting that mathematics is stressful may be detrimental to student persistence. This reifies an entity, or fixed, mindset belief (Rattan, Good, & Dweck, 2012) encouraging a passive response of "laughing it off and taking a break" instead of utilizing a growth strategy of applied effort to overcome challenges. According to Rattan et al. (2012), fixed responses can be comforting but also demotivating to students, negatively affecting persistence. The present findings affirm Yeager et al.'s (2016) recommendations for implementing a successful lay theory—specifically, customized materials must redirect problematic lay theories or reframe existing lay theories that hinder student motivation.

Although more students in the advice-only intervention persisted in the course and took the final exam than students in the laughter–stress condition, students in the advice-only condition were significantly less likely to persist to the final exam than students in the brain growth condition. The researchers created the advice-only intervention based on the hypothesis that prompting student reflection was sufficient to instill and internalize a growth mindset as students wrote advice. However, in this study, just writing advice without an explicit introduction to the growth mindset theory was not enough to have a significant impact on persistence to the final exam.

The findings suggest that growth mindset interventions may increase students' beliefs in their ability to develop necessary academic skills. Students' resulting academic integration in the first year is essential to their acclimation to college (Tinto, 1998). Specifically, growth mindset interventions may provide one measure to help shape students' beliefs about college and their sense of belonging therein. Although the developmental mathematics classroom was chosen as the site for this intervention and the findings suggest the utility of growth mindset interventions for students in developmental mathematics classes, the research suggests that introducing students to the concept of a growth mindset could have a beneficial impact in many classes in terms of academic achievement and persistence to course completion—issues in many first-year courses.

Timing is another factor to consider when implementing a mindset intervention. During this particular study, the intervention occurred over the second or third week of the semester. However, by this point, some students were already not attending or were absent the day of the intervention. Although a valuable tool in student persistence efforts, the brain growth treatment as a single, soft-touch intervention was insufficient for reaching these students. Mindset interventions must therefore be integrated continuously into the classroom and institutional culture, for example by offering the interventions to all students before the beginning of the fall semester of the first year (Yeager, et al., 2016).

Retention

Although more students who participated in the brain growth intervention were retained to the spring semester, there was not a significant difference in retention rates between the intervention groups or the campus-wide retention average. Although many studies show that mindset interventions aid in the persistence of students to the end of the term, less research documents the effect of mindset interventions on retention to subsequent terms.

Limitations

The study included a growth mindset intervention; however, following Yeager et al. (2016), it did not include a measure of changes in growth and fixed mindsets before and after students read the assigned article or wrote their letter of advice, nor did the study include a measure of mathematics anxiety. Future research should measure changes in mindset, such as through the PERTS Growth Mindset Assessment or Dweck's (2006) online "Test Your Mindset" instrument, along with the impact of growth mindset interventions on mathematics anxiety.

Implications

Delivering and Applying Psychological Interventions Wisely

This research illuminates several issues for embedding mindset interventions in first-year classes. The findings suggest the power of interventions where students actively construct images of themselves, and others, as successful students. The messages in the interventions led to a "saying-is-believing" effect as a result of the students' letter writing. In writing about their own personal successes and encouraging persistence in others, students may have benefited also from the positive emotional response of helping another person. Writing may also have helped students to internalize the message of brain growth and persistence.

The interventions were brief, taking less than an hour to implement. Furthermore, the purpose of these interventions was not made explicit to students. Rather than listening to a lecture, students independently read a scientific article, interpreting and constructing their own knowledge of how the brain grows and how they could apply strategies to be successful.

This study also revealed the need for continued emphasis on the importance of attendance and active participation from the first day of class. Of the 227 students who attended the developmental mathematics courses in which an intervention occurred, 17 students (7.5%) did not complete the intervention activity, presumably because they were absent on the day in which the intervention occurred and chose not to make up the assignment or because they chose not to participate in class. The intervention occurred during Weeks 2 and 3, suggesting that some students already were disengaging during these early weeks. Institutions are required to track and report attendance for federal funding. When instructors notice concerns about student participation, they should immediately reach out to students who show signs of disengagement from their classes. Encouraging this level of engagement from instructors, as well as students, requires the institution to cultivate a growth mindset culture. Further, literature on persistence emphasizes the importance of students' sustained academic and social involvement (Tinto, 1998). We posit that the intervention may have positively affected students' academic integration (e.g., their confidence in their ability to develop the skills necessary for their developmental mathematics classes) but that it did not provide the sustained interaction students may need to support their persistence in college beyond the term in which the intervention occurred.

Creating a Growth Mindset Culture Through Professional Development

The adoption of mindset interventions does not relieve college faculty and staff from their roles in creating a welcoming campus environment that fosters student engagement. Instead, mindset interventions that encourage students to view themselves as capable of growing into their academic responsibilities are one way to encourage increased academic integration within a classroom, an essential component for persistence (Tinto, 1975). Similarly, instructors need support to institute a successful intervention. Simply providing instructors with the material for a mindset intervention does not ensure the success of the intervention. Instructors who are unfamiliar with theories of postsecondary learning may be uncomfortable addressing students' affective needs. The researchers heard anecdotal arguments from some faculty members that providing this type of support was coddling—some students just were not "college material." These statements are suggestive of those individuals' own entity theories (i.e., fixed mindset) about the limited potential for the human brain to change and increase one's intellectual ability. Such entity theories have been found to demotivate students and have a negative correlation to student persistence (Duckworth & Yeager, 2015; Rattan et al., 2012). Although the results of this study suggest that bolstering students' confidence in their ability to grow their intelligence is a proactive application, it is also likely that faculty members need support and training in establishing a growth mindset culture on campus.

Some faculty members may also believe that time spent on the psychology of improving mindset limits time for discipline-specific instruction. However, that the present intervention was completed in a short amount of time and showed significant impact suggests that fears about lost instruction time are unfounded. Additionally, although instructors may fear teaching outside of their discipline area, the brain growth mindset intervention was easily implemented and tested without requiring extensive preparation or knowledge of psychology.

Professional development programs show promise for training instructors on the implementation of growth mindset interventions in the classroom. Auten (2013), for example, reported a positive effect of growth mindset training for community college English instructors. Auten's qualitative findings indicate that with in-depth training, instructors can foster a growth mindset environment in the college classroom that extends beyond standalone interventions. The present study joins several others as persuasive evidence of the powerful role of mindset interventions in supporting first-year students.

Conclusion

This quasi-experiment examined the impact of interventions in developmental mathematics. The findings indicate that students who were assigned a growth mindset article and letter-writing prompt persisted at a significantly higher rate than both those who received a neutral article and letter-writing prompt and those who only wrote letters. The interventions did not differentially affect performance on the final exam—they did not have an impact on students' content knowledge. The interventions also did not have a significant impact on retention to the following semester or following academic year. Additional research is needed to explore ways to increase the efficacy of growth mindset interventions when students are exposed to a growth mindset interventions multiple times or through interventions that support social as well as academic integration (e.g., student learning communities which engage in mindset interventions together). Further research is also needed to explore possible gender differences in the impact of mindset interventions, given the presence of stereotype threat and implicit bias that may negatively affect women and racial minorities in mathematics (Lindberg, Hyde, Petersen, & Linn, 2010; Nosek et al., 2009). Researchers should also examine how institutional culture shifts can incorporate a growth mindset into institutional and program missions, course objectives, and individual instructors' language to continuously support persistence and retention of first-year students.

Author Note

This research was supported in part by grants from the Indiana University Southeast Faculty Senate Research and Grants and Improvement of Teaching Committees and the Indiana University Librarians Association.

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