Growth Mindset Messages from Instructors Improve Academic Performance Among First-Generation College Students

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ABSTRACT

First-generation (FG) college students (i.e., those for whom neither parent/guardian obtained a bachelor's degree) experience more barriers in college, compared with continuing-generation students. These barriers are compounded by subtle messages from instructors that convey the idea that natural talent is necessary for success in scientific fields. In contrast, growth mindset messages communicate that ability can improve with effort, help-seeking, and using productive study strategies. In a large enrollment introductory biology course, students were randomly assigned to receive email messages from their instructor after the first two exams containing either a growth mindset or control message. The intervention improved grades in the course for everyone, on average, compared with control messages, and were especially beneficial for FG students. This increase in performance was partially mediated by increased activity accessing course materials on the course website. This study provides preliminary evidence that instructors communicating growth mindset messages can support FG students' performance.

INTRODUCTION

Despite decades of effort to diversify the scientific workforce, first-generation (FG) college students (i.e., those for whom neither parent/guardian obtained a bachelor's degree) continue to experience worse academic outcomes and persist in science at far lower rates than would be expected based on representation in the college-going population, compared with continuing-generation (CG) students (i.e., students who have at least one parent/guardian who obtained a bachelor's degree). FG students comprise nearly one-third of all college attendees (Skomsvold, 2015), but they face a number of economic and social obstacles that make succeeding in college more difficult. Compared to CG students, FG students experience more difficulty adapting to college, earn lower course grades, and drop out at higher rates (Terenzini *et al.*, 1996; USDE, 2017; Cataldi *et al.*, 2018). For instance, FG students are less likely to seek help in office hours, ask their instructors to clarify material, or access helpful academic resources, compared with CG students (Kim and Sax, 2009; Calarco, 2014). These group differences are compounded by differences in cultural capital or college "know how", less familial guidance for navigating higher education, and by the approach, values, and structure of these environments that are not supportive of FG students (Calarco, 2014; Nichols and Islas, 2016; Covarrubias *et al.*, 2020).

While a number of economic and structural factors undoubtedly contribute to the underperformance and attrition of FG students in science fields, these differences may be exacerbated by subtle messages from science instructors that convey the idea that natural talent is necessary to be successful in scientific fields. Indeed, many introductory science courses are designed to "weed out" those students deemed capable and those that are not. Instructor's mindsets (also known as implicit or lay theories)

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are their beliefs about the fixedness or malleability of human characteristics like intelligence (Dweck, 1999). Instructors who endorse more of a fixed mindset believe that ability is innate and predetermined–that students either have a particular ability, or they don't. In contrast, instructors who endorse more of a growth mindset believe that ability is malleable–that it can be developed over time with effort, seeking help, and applying effective learning strategies (Dweck and Leggett, 1988; Dweck, 1999). From the perspective of FG students, instructor mindset beliefs may be salient cues that tell students what kind of person their instructors deem as having the potential to be successful in science fields (i.e., the "innately smart" students vs. the "dedicated or improving" students).

Instructors communicate their mindset beliefs through their interactions with students. Instructors who endorse a fixed (vs. growth) mindset are more likely to make quick judgments of students' ability based on a single-test performance, and are more likely to recommend that struggling students drop difficult courses rather than seek resources that will improve their learning (Rattan *et al.*, 2012). These fixed mindset messages suggest to students that seeking help and spending more time studying the course materials would be futile without inherent ability or talent. However, instructors who promote growth mindset messages can reverse these effects and motivate students to seek additional resources when they struggle (Good *et al.*, 2012; Rattan *et al.*, 2018; Canning *et al.*, 2019).

Recently, a university-wide study conducted with STEM instructors revealed that students earned higher grades when their instructor endorsed more of a growth (vs. fixed) mindset–and this was especially true for stigmatized students (Canning *et al.*, 2019). Further studies illuminate several potential mechanisms. Instructors with growth mindsets engender greater trust, sense of belonging, academic engagement, and fewer feelings of being an imposter among their students (Cavanagh *et al.*, 2018; Rattan *et al.*, 2018; LaCosse *et al.*, 2020; Muenks *et al.*, 2020; Canning *et al.*, 2022; Hecht *et al.*, 2022). In one study, a college instructor built trust with their students in part by communicating a growth mindset, which resulted in students becoming more engaged in the course and earning higher grades (Cavanagh *et al.*, 2018). Another study found that instructor emails containing growth mindset messages increased help-seeking (i.e., attending tutoring sessions) and grades among stigmatized STEM students (Covarrubias *et al.*, 2019). This research suggests that instructor mindset beliefs may be an overlooked barrier and potential point of intervention for FG students, particularly when it comes to academic engagement and performance. Yet, little is known about how instructors can best communicate growth mindset beliefs to students and there is little experimental evidence for specific strategies that instructors can implement in their classes to communicate growth mindset messages and support FG student success.

The current research experimentally examines whether growth mindset (vs. control) instructor messages increase performance among FG college students in an introductory biology course. We ground our research hypotheses in organizational mindset theory (Dweck, 1999; Murphy and Dweck, 2010; Canning *et al.*, 2019) and research on "light-touch" or "wise" intervention strategies (Dittmann and Stephens, 2017; Walton and Wilson, 2018; Hammarlund *et al.*, 2022). Wise interventions are designed to promote recursive change through the reconstrual of ambiguous contextual messages, and have been shown to be particularly effective for FG students (Oyserman *et al.*, 2006; Stephens *et al.*, 2014; Paunesku *et al.*, 2015; Stephens *et al.*, 2015; Harackiewicz *et al.*, 2016; Yeager *et al.*, 2016; Browman *et al.*, 2017). This approach can be powerful, because many situations in college are ambiguous and FG students can interpret them in multiple ways. For example, in the absence of intervention, FG students are at risk of construing challenges (e.g., poor exam grades) as a sign that they are not "college material." Wise interventions disrupt this maladaptive construal and suggest an alternative interpretation (e.g., poor exam grades signal the need to seek additional resources, rather than signal lack of innate ability). This reconstrual can lead to long-term positive outcomes by altering immediate behavior (e.g., accessing course resources), which then supports learning and improved performance in the course.

Wise interventions are administered at critical times in a students' development to elicit recursive processes over time (Yeager and Walton, 2011). We focus on two critical time points in a semester-long course that we hypothesize will have the most impact on students' performance: immediately after the first two exams. Students often use their exam grades to gauge whether they can be successful in the course (e.g., "Does this score mean that I have what it takes to succeed in this field?"). These time points are especially ripe for an instructor's growth mindset message to reconstrue the meaning of exam performance and provide a pathway for success (Sato *et al.*, 2018). We hypothesize that when instructors communicate growth mindset (vs. control) language immediately following the posting of exam grades, students will be motivated to engage more with the course material, ultimately earning higher grades in the course, and these messages will be most effective for FG students.

METHODS

This field experiment took place in a large enrollment Introductory Biology course at a research intensive public university in the Pacific Northwest. We chose an introductory biology course largely because the instructor was willing to collaborate with us and because most introductory biology courses serve as important gateways to persistence in STEM fields (Seymour and Hunter, 2019). This Introductory Biology course is a critical gateway course to further study in the biological sciences. Students typically take this course in their freshmen or sophomore year, and their experiences in this foundational course may determine whether they pursue subsequent coursework in a variety of STEM disciplines. The instructor for this course had 7.5 years of experience teaching the course. The experiment took place during the Spring 2021 semester. This semester was unique in a historical sense in that the course was taught completely online due to COVID-19 precautions. All lectures were delivered synchronously via Zoom and all exams were administered online and proctored by the instructor and graduate teaching assistants.

A total of 553 undergraduate students were enrolled in the Introductory Biology course. One hundred sixteen students were excluded from analysis (two students were erroneously excluded from random assignment and were not assigned a condition, 19 students withdrew from the course after random assignment to condition [nine in control condition, 10 in intervention condition], two students received an incomplete in the course, 64 students did not complete the survey at the beginning of the semester, 11 students failed the attention check on the survey, and 18 students were missing one or more covariates), leaving a final sample of 417 students (70.3% female; 34.3% FG; 67.4% White, 8.8% Asian/Asian American, 12.0% Hispanic, 4.8% Black, 2.2% Native American). We conducted a power analysis for an ANCOVA with four groups (2×2) using G*Power Version 3.1 (Faul *et al.*, 2007). Estimating 80% statistical power and an α of 0.05, a sample size of at least 200 (or 50 students per group) is needed to detect a small effect size ($f^2 = 0.2$).

Self-report Data

All students were asked to complete a survey at the beginning of the semester measuring their personal mindset beliefs, their current college GPA, and their demographics. Five items from the Dweck (1999) Theories of Intelligence Scale assessed students' personal mindset beliefs (e.g., "You have a certain amount of intelligence, and you can't really do much to change it," $\alpha = 0.85$). Students' current college GPA was obtained based on self-reported answers to the question: "What is your current college GPA?" FG status was determined based on participant's response to the following question: "What is the highest level of education your primary caregiver has attained?" (Less than high school graduate, High school graduate, Some college/vocational school, Associate's degree, Bachelor's degree, Some graduate school, Master's degree, Law degree, Medical degree, Doctoral degree, Don't know, Doesn't apply). This question was also asked in regards to the participant's secondary caregiver. Students for whom neither parent/guardian obtained a bachelor's degree or higher were coded as FG college students. Race and ethnicity was determined based on participant's response to the following question: "What is your race/ethnicity?" (White, Hispanic/Latino, Black/African American, Native American, Pacific Islander, Asian, Multiracial, Other). Students who selected "Multiracial" or "Other" were provided a text box to indicate their identity. Students who selected "Black/African American", "Hispanic/Latino", "Native American", or "Pacific Islander" were coded as underrepresented racial/ethnic minoritized (URM), a common demographic grouping based on historically marginalized groups that are underrepresented in science fields based on the general population (NCSES, 2019). All other students were coded as non-URM. Students were also asked to complete a survey at the end of the semester measuring other variables (see *Supplemental Materials*); however, only 53% of the sample completed this survey. Thus, the end-of-semester variables were not analyzed given lack of statistical power and disproportional response rates.

Intervention

All students were randomly assigned to be in the intervention or control condition. Randomization at the student level, as opposed to randomization of sections within the course, allowed us to control for instructor-level characteristics, such as their personality and teaching style, and section-level confounding variables, such as day/time and variation in student characteristics. This design allowed us more statistical power to detect effects and provides a better case for causality than most other educational field intervention studies, which typically use different sections, instructors, or terms as control groups. To randomize students to condition, the research team requested the course roster from the instructor and randomly created different email lists based on condition. The instructor of the course was quasiblind to experimental condition. This means that the instructor was given the email lists to send out the condition-based emails at the appropriate times. However, in a course with over 500 students, it was very unlikely the instructor was able to connect which students were in each condition, even if a student responded to the email. Although unlikely, there is a possibility of observer effects with this design. We risked this possibility, because we wanted the emails to appear as authentic as possible.

After the first exam of the semester, each student received a condition-based email from the instructor. In both conditions the email contained the same information about the mean and median exam score, how exam grades were calculated, and that the instructor was happy to meet with them to discuss their grade. The email sent to students in the intervention condition focused on communicating three messages grounded in mindset theory (Dweck, 1999): (1) *abilities can be improved* (e.g., "I believe that every student, regardless of how well they did on this exam, can improve their skills, learn from their mistakes, and be successful in this course. Remember, learning is a process and often occurs over time….Let me give you a secret to this class–you don't need to be 'smart' to perform at a high level. You can work hard and work effectively to master the material"), (2) *academic struggles are normal to experience* (e.g., "Here's how I know this-I have worked with multiple students every semester who performed poorly on Exam 1, but then turned things around and made 30–40 point improvements on their remaining exams"), and (3) *academic struggles are the result of controllable rather than uncontrollable factors* (e.g., "How did they do it? It wasn't by suddenly getting a higher IQ. Instead, they figured out better ways to learn in the course. Here's what they have told me about how they made those kind of improvements…").[1]

Following best practices for growth mindset field interventions (Yan and Schuetze, 2023), the intervention message also contained five learning strategies framed as strategies that previous students have tried that improved their performance (i.e., study every day after class instead of cramming, study with a group, create concept maps, identify information gaps instead of rereading or rewriting notes, and revisit lecture recordings for unclear material). We chose to include several learning strategies as part of the intervention to indicate that hard work alone will not always result in improvements–it also takes effective strategies and seeking help as needed. Growth mindset messaging that focuses only on effort (e.g., "you just need to try harder") or positivity (e.g., "you can do anything you set your mind to") perpetuates a "false growth mindset" and can have

[1]For the first email message, participants were separated into three performance tiers based on their first exam score (i.e., above average, average, below average) and received slightly modified growth mindset messages tailored to their exam performance. Analyses indicated no significant difference between tiers, so these tiers were collapsed into a single condition. The emails following the second exam did not differ by exam performance.

deleterious effects for students (Dweck, 2016; Barger *et al.*, 2022). Likewise, giving students learning strategies without a motivational framework, such as growth mindset messaging, is unlikely to change student behavior. Despite most undergraduate students having a relatively sophisticated knowledge of effective learning strategies, students are still unwilling to use them without a motivational framework (Morehead *et al.*, 2016; Rea *et al.*, 2022). We argue that students will be more willing to use effective learning strategies when their instructor communicates that ability is not fixed–it can be improved over time. Thus, the intervention message included the three theory-based growth mindset messages above, in addition to several learning strategies that provide students with a concrete plan to implement those improvements (Yan and Schuetze, 2023). It is important to note that all students were made aware of effective learning strategies during the lecture component of the course; however, only students in the intervention condition received these strategies in the context of growth mindset messaging after the exams. See *supplemental material* for complete email messages. After the second exam of the semester, each student was sent a second condition-based email to reinforce the manipulation. Thus, each student received either two doses of the intervention message or two doses of the control message.

Dependent Measures

After the semester was complete, the instructor provided the researchers with students' exam scores, final course GPA, and records of user activity on the course website, Blackboard. The course contained three midterm exams (100 points each, 15 true/false questions, 34 multiple choice questions). Each exam represented 10% of the student's final grade in the course. Exams were delivered through the online course website and proctored via webcam observation. We did not examine scores on the first exam because the intervention took place after the first exam scores were released. We examined scores on the second exam (after one dose of the intervention) and the third exam (after both doses of the intervention). We also examined students' final grade in the course on a 0.0–4.0 scale (A = 4.0, A– = 3.7, B+ = 3.3, B = 3.0, B– = 2.7, C+ = 2.3, C = 2.0, C– = 1.7, D+ = 1.3, D = 1.0, F = 0.0).

To understand the behavioral processes underlying the effects of the growth mindset messages on academic performance, we analyzed students' activity on the course website, Blackboard. The course website tracks how many times students' access different pages of the course website. This record contained how many total hits there were for each student for each webpage. Student performance has been positively correlated with higher course website activity (Heffner and Cohen, 2005; Perera and Richardson, 2010; Zhang, 2016; Atherton *et al.*, 2017), and access to online content is frequently used as a measure of course engagement due to the ease of tracking student behaviors and the connection between active accessibility and performance. Importantly, research indicates that merely spending more time on a course website is not correlated with higher performance. Instead, students' activity or the "clicks" a student makes that are related to specific course resources are correlated with performance (Perera and Richardson, 2010; Atherton *et al.*, 2017). Therefore, we examined the two most frequently visited webpages for this course: the page containing all lecture materials (e.g., PowerPoints, lecture recordings, weekly lecture quizzes), representing 78.56% of all user activity, and the page containing the student's gradebook, representing 13.0% of all user activity. Together, these two webpages represent more than 90% of all user activity.

Analytic Model

All analyses were conducted using SPSS Version 27. We conducted a two-way ANCOVA on all dependent variables to compare the intervention and control conditions and their interaction with FG status. Three covariates were included in the model: 1) students' college GPA, 2) personal mindset beliefs, and 3) URM status. Students' self-reported current college GPA was included as a covariate in all analyses to assess the effect of the instructor growth mindset manipulation independent of students' prior academic performance. Previous research examining intervention effects on students' performance typically controls for students' academic performance before the intervention (Harackiewicz *et al.*, 2016; Yeager *et al.*, 2016; Canning *et al.*, 2018). Students' personal mindset beliefs were entered as a covariate in all analyses to assess the effect of the instructor growth mindset intervention independent of students' personal mindset beliefs. Previous research examining the effects of instructor mindset on student outcomes has controlled for students' personal mindset beliefs when available (LaCosse *et al.*, 2020; Muenks *et al.*, 2020; Canning *et al.* 2022). URM status was included as a covariate to assess the effect of the manipulation for FG students independent of URM status. In our sample, 36% of the FG students were also URM. See Table 1 for model results for all dependent variables, see Table 2 for means and descriptive statistics by condition and FG status. See Supplemental Table S1 in *Supplemental Materials* for all model results without covariates.

RESULTS

Preliminary Analyses: Group Differences within Control Condition

To get a better understanding of the group performance differences within the course, we conducted t tests between CG (n = 137) and FG (n = 69) students, and URM (n = 37) and non-URM (n = 169) students within the control condition. CG students (M = 3.56, SD = 0.46) entered the course with significantly higher college GPAs than FG students (M = 3.34, SD = 0.57), t (204) = 3.11, p = 0.002, entering with almost one-fourth of a letter grade higher on average (0.23 GPA points). At the end of the course, CG students earned significantly higher final course grades (M = 2.63, SD = 1.06) than FG students (M = 1.89, SD = 1.29), t (204) = 4.39, $p < 0.001$, earning three-fourth of a letter grade higher on average (0.74 GPA points).

In contrast, non-URM students (M = 3.50, SD = 0.52) and URM students (M = 3.43, SD = 0.43) entered the course with roughly equal college GPAs, t (204) = 0.73, p = 0.469. However, by the end of the course, non-URM students earned significantly higher final course grades (M = 2.49, SD = 1.18) than URM students (M = 1.90, SD = 1.16), t (204) = 2.75, p = 0.006, earning over half of a letter grade higher on average (0.59 GPA points). Previous research suggests that URM students might also benefit from instructor growth mindset messaging (Yeager *et al.*, 2022); therefore, in supplementary analyses we also tested the interaction of the intervention with URM status, but

TABLE 1. Model results for all dependent variables

	Exam #2			Exam #3			Course GPA		
	F (1, 409)	*p*	η^2_p	*F* (1, 407)	*p*	η^2_p	*F* (1, 410)	*p*	η^2_p
Condition	1.26	0.263	0.003	3.87	0.050	0.009	4.61	0.032	0.011
FG status	0.03	0.866	0.000	4.12	0.043	0.010	3.23	0.073	0.008
Condition X FG	1.36	0.244	0.003	3.97	0.047	0.010	3.86	0.050	0.009
Personal fixed mindset	0.57	0.452	0.001	1.62	0.203	0.004	0.28	0.595	0.001
College GPA	136.14	0 < 0.001	0.250	121.55	0 < 0.001	0.230	285.24	0 < 0.001	0.410
URM status	8.94	0.003	0.021	14.55	0 < 0.001	0.035	5.22	0.023	0.013

	Course content access			Gradebook access		
	F (1, 410)	*p*	η^2_p	*F* (1, 410)	*p*	η^2_p
Condition	5.12	0.024	0.012	1.27	0.261	0.003
FG status	0.02	0.903	0.000	0.67	0.414	0.002
Condition X FG	0.12	0.731	0.000	0.13	0.719	0.000
Personal fixed mindset	3.04	0.082	0.007	0.91	0.341	0.002
College GPA	38.06	0 < 0.001	0.085	17.15	0 < 0.001	0.040
URM status	2.27	0.132	0.006	0.61	0.435	0.001

Note. FG = first-generation; URM = underrepresented racial/ethnic minority; Condition was coded: 1 = growth mindset, –1 = control; FG status was coded: 1 = FG, 0 = CG; URM status was coded: 1 = URM (Black, Hispanic, Native American, or Pacific Islander), 0 = non-URM (White or Asian).

these interactions were not significant for any dependent variable (see Table S2 in the *Supplemental Materials*), suggesting that our results are specific to generational status, not URM status. However, these supplemental results should be interpreted with caution given the small sample of URM students (37 in control; 44 in treatment). The power analysis estimated at least 50 students per condition to detect a small effect size; therefore, these analyses are underpowered. For this reason, we focus the rest of the analyses on FG status.

Dependent Variables

We first examined the effect of the intervention on students' exam scores. The main effect of condition on exam 2 grades was not significant, F (1, 409) = 1.258, p = 0.263, η^2_p = 0.003, and the interaction with FG status was also not significant, F (1, 409) = 1.359, p = 0.244, η^2_p = 0.003. It was not until exam 3, that we found significant effects of the intervention. When the professor communicated a growth mindset (vs. control), all students, on average, earned higher grades on the third exam, F (1, 407) = 3.871, p = 0.050, η^2_p = 0.009. However, this main effect was qualified by an interaction with FG status, F (1, 407) = 3.966, p = 0.047, η^2_p = 0.010 (Figure 1). In the control condition, CG students significantly outperformed FG students, F (1, 407) = 8.086, p = 0.005, earning over a full letter grade higher (10.23 percentage points) on the exam. However, when the professor communicated a growth mindset, there were no differences in exam 3 performance between FG and CG students, F (1, 407) = 0.011, p = 0.917. Examined another way, the effect of the growth mindset messages (vs. control) was significantly larger for FG students (d = 0.37) than it was for CG students (d = 0.02).

Next we examined the effect of the intervention on students' final course grade. When the professor communicated a growth mindset (vs. control), all students, on average, earned higher grades in the course, F (1, 410) = 4.613, p = 0.032, η^2_p = 0.011. However, this main effect was qualified by an interaction with FG status, F (1, 410) = 3.858, p = 0.050, η^2_p = 0.009 (Figure 2). In the control condition, CG students significantly outperformed FG students, F (1, 410) = 7.018, p = 0.008, earning 0.74 grade points (on a 4.0 scale) higher in the course, on average. However, when the professor communicated a growth mindset, this performance difference was eliminated, F (1, 410) = 0.002,

TABLE 2. Raw means and standard deviations by condition and generational status

		Growth mindset condition		Control condition	
Variable	Generational status	*M*	*SD*	*M*	*SD*
Exam #2	CG	72.00	14.36	71.69	14.69
	FG	69.07	15.12	65.44	14.90
Exam #3	CG	68.84	14.19	68.62	14.21
	FG	64.51	16.81	58.39	16.32
Course GPA	CG	2.67	1.09	2.63	1.06
	FG	2.34	1.22	1.89	1.29
Course Content Access	CG	369.80	198.82	334.43	164.02
	FG	347.41	171.86	294.46	199.72
Gradebook Access	CG	70.07	98.14	58.18	67.29
	FG	53.34	61.89	45.48	61.00

Note. FG = first-generation; CG = continuing-generation.

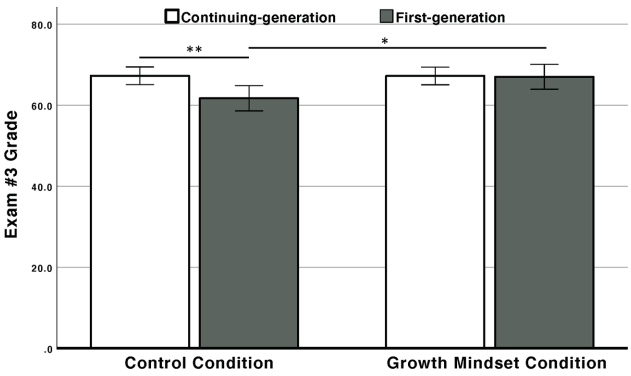

FIGURE 1. **Exam #3 grades as a function of condition and student generational status. *Note.* Error bars represent 95% CI. **p* < 0.05. ***p* <0.01.**

p = 0.962. That is, when the professor communicated growth mindset beliefs (vs. control) it significantly increased FG students' performance, *F* (1, 410) = 6.414, *p* = 0.012, but did not increase CG students' performance, *F* (1, 410) = 0.024, *p* = 0.877.

To understand the behavioral mechanism of the intervention, we examined the two most frequently visited webpages for the course. We found a significant effect of the intervention for the webpage containing course materials, but no significant effect for the webpage containing the gradebook. When the professor communicated a growth mindset (vs. control), all students, on average, had more activity on the webpage containing the course materials, *F* (1, 410) = 5.123, *p* = 0.024, η_p^2 = 0.012. Compared with students in the control, students who received the growth mindset instructor messages "clicked" on the page containing course materials 40.9 more times during the semester, on average. This represents approximately a 12% increase in webpage engagement across the semester. In contrast, the main effect of condition on course gradebook activity was not significant, *F* (1, 410) = 1.265, *p* = 0.261, η_p^2 = 0.003, suggesting that there were no differences in the amount of times students accessed their grades. There were no significant condition interactions with FG status for the webpage containing course materials, *F* (1, 410) = 0.119, *p* = 0.731, η_p^2 = 0.000, or the gradebook, *F* (1, 410) = 0.130, *p* = 0.719, η_p^2 = 0.000.

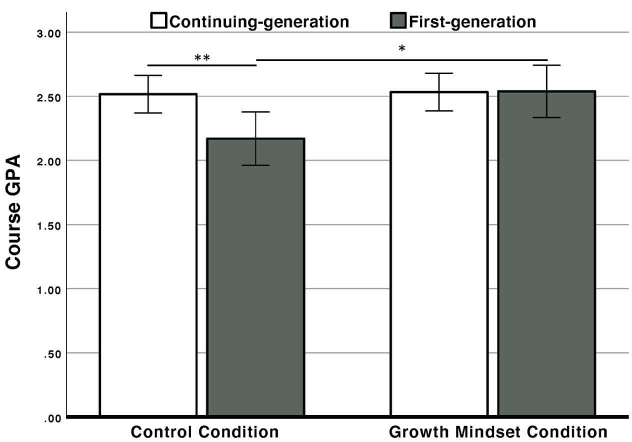

FIGURE 2. **Course GPA as a function of condition and student generational status. *Note.* Error bars represent 95% CI. **p* < 0.05. ***p* < 0.01. ****p* < 0.001.**

A test of moderated mediation explored the processes that mediated the effect of instructor growth mindset messages on course performance for FG and CG students. We conducted a moderated mediation analysis (Model 15) using Hayes' (2018) Process Macro for SPSS and 10000 bootstrapped samples. We tested the indirect effect of instructor growth mindset messages on students' course performance by accessing the course materials, with FG status as a moderator. The indirect effect was significant for both FG students, indirect effect = 0.027, 95% CI (0.0038, 0.0604), and CG students, indirect effect = 0.031, 95% CI (0.0046, 0.0632). This suggests that instructor growth mindset messages led students to access course materials on the course website, which increased course performance. The index of moderated mediation was not significant, index = –0.004, 95% CI (–0.0252, 0.0159), suggesting that the indirect effect did not differ by generational status.

DISCUSSION

In a large field study, we found that when a biology instructor communicated growth mindset messages at critical times during the semester (i.e., directly after exam grades were posted), students earned higher grades in the course, on average, compared with control messages. However, this effect was most pronounced for FG students. Consistent with other research in higher education, in this course CG students outperformed FG students in the control condition; however, when the instructor communicated a growth mindset belief, the performance difference between CG and FG students was eliminated. This study highlights how instructors' growth mindset messages can be motivating for FG students, particularly when it comes to academic engagement and performance.

How can such a subtle intervention–two emails–have such a large effect on students' downstream performance outcomes? We hypothesize two reasons. First, we drew from research on wise interventions when developing the content and timing of the intervention messages (Yeager and Walton, 2011; Walton and Wilson, 2018). Wise interventions leverage psychological theory and research to communicate targeted messages (e.g., growth mindset messages from instructors) at critical time points of uncertainty (e.g., directly after exams) to shape how students construe their educational experiences. We hypothesized that delivering growth mindset messages at a time when students may be questioning their ability (i.e., directly after receiving potentially negative performance information on an exam) would provide students with a pathway for subsequent improvements in their biology performance. Wise interventions are theorized to function by initiating a positive recursive cycle that compounds over time. Therefore, even subtle intervention messages can have profound impacts for students when the message is psychologically attuned to the situation and delivered during a time when students may be searching for meaning.

Second, our study provides some preliminary evidence for a behavioral mechanism that supports this recursive cycle. We found that growth mindset messages from the instructor encouraged more course engagement as measured by students' activity accessing course resources on the course website.

Students in the growth mindset condition accessed the course materials on the course website more than students in the control condition, indicating that the growth mindset messages encouraged students to utilize online resources, which in turn increased performance. Interestingly, although there were differences in how often students accessed course materials, there was no significant difference in how frequently students accessed their grades on the course website. In other words, the intervention impacted student engagement with learning materials but did not significantly change student engagement with performance indicators. This suggests that the growth mindset instructor messages may have led students to focus more attention on learning the course material and not on how many points they were earning in the course. When instructors communicate a growth mindset, students are given a pathway for improvement and success. These messages suggest to students that their ability is not defined by a single exam score, but with effort, improved strategies, and seeking-help, ability can improve over time. In turn, students responded to such messages with increased course engagement, which ultimately improved their performance in the course.

When looking at the timing of the intervention messages, it is important to note that performance effects were only found later in the semester, after students received two doses of the intervention. In our study students were sent two separate email communications: the first was sent immediately after exam 1 and the second was sent immediately after exam 2. If exposure to the intervention message in a single email (i.e., only one dose) was enough to influence immediate performance, we might expect to see a change in exam 2 scores. However, significant effects of the intervention were not detected until the third exam. One interpretation is that two doses of the intervention may be necessary to cement the message in this context. It may also be the case that communication later in the semester is more impactful, when students feel more pressure to improve their performance. It could also be the case that one dose was enough to cause a positive effect, but that the behavioral changes (e.g., study habits or strategies) take more time to compound before improved performance is detected in exam scores. Future research should continue to investigate dosage and timing effects. Multiple growth mindset messages conveyed at different times and with different methods (e.g., emails, syllabus messages, online announcements, messages in class) may have a much larger impact on engagement and performance.

Limitations and Future Directions

While the current study provides some promising strategies that instructors can use in their courses to promote the performance of FG students, it is important to acknowledge its limitations and generalizability. This study was conducted in the spring semester of 2021–a semester with its own unique adaptations and challenges. Due to precautions related to the COVID-19 pandemic, the course was offered online with synchronously delivered Zoom lectures and online proctored exams. In this online learning context, there was no face-to-face communication with the instructor. This environment may have made email communication more salient and potentially could have been more impactful than in a face-to-face course, where students have the chance to chat with the professor after each class period or attend office hours in person. Future research should test various ways to communicate mindset messages (e.g., course redesigns, messages in class, reflection assignments) and should test these techniques in face-to-face classrooms.

Additionally, this study was conducted in one course with one instructor. Randomization at the student level (as opposed to randomly assigning entire courses or sections to each condition), allowed us to control for instructor and course characteristics: all students were exposed to the same instructor personality, teaching style, and the instructor's preexisting mindset beliefs. Although this design allowed for a more controlled experiment, it is unclear whether these effects will generalize to other instructors, disciplines, and course designs. It will be important in future research to test this intervention in courses with instructors that have varying levels of mindset beliefs and teaching styles and within different course structures.

Finally, although we were able to control for instructor differences through random assignment at the student level, there were some notable differences between our control and intervention materials. First, students may have perceived the growth mindset messages as warmer, friendlier, or more encouraging that the control messages. Indeed, many instructor mindset manipulations in the field confound instructor mindset and instructor demeanor–students tend to perceive growth mindset instructors as warmer and warmer instructors as endorsing growth mindsets (LaCosse *et al.*, 2020; Muenks *et al.*, 2020). Communicating a growth mindset is inherently more encouraging and positive than communicating a fixed mindset message or a neutral message. To address these concerns, we conducted a laboratory experiment in which we separated these constructs (White *et al.*, 2024). We found that the positive effects of an instructors' growth mindset are not entirely driven by being warm and friendly, as some may have assumed, given how confounded these constructs are in the field. Instead, the growth mindset message had a persistent positive effect on students, even when the delivery was cold or unfriendly. Thus, while the encouraging messages in our intervention may have had a positive effect on students, it is unlikely that positivity alone is the key mechanism of this intervention.

CONCLUSION

By focusing on instructor mindset messages–rather than implementing mindset interventions directed at students–the current research takes an antideficit model of growth mindset interventions (Canning and Limeri, 2023). Focusing exclusively on changing students' mindset beliefs can potentially ignore contextual effects that present barriers to making this belief system realized (Dweck and Yeager, 2019). An antideficit approach to mindset beliefs considers the institutional, societal, and cultural context that students navigate (Valencia, 2010). The most innovative mindset research takes an antideficit perspective by asking how our institutions and instructors can create environments that allow all students to succeed. The current research is one step to investigate how instructor mindset messages influence students.

Nationwide, FG students represent a large pool of potential scientists, engineers, and mathematicians. To provide the most equitable learning environment for these individuals, and to maximize the number of FG students that are retained in scientific fields, it is imperative that we find new and better ways of supporting FG students. Most of the current solutions involve resource-intensive, large-scale institutional transformation that consists of additional advising or freshman seminar courses that teach FG students how to navigate college. In addition to these structural solutions, we propose that by using "wise" intervention techniques, faculty can fairly easily communicate growth mindset messages at critical time points. By providing an adaptive alternative construal–the idea that learning is a process and abilities can improve with effort and effective strategies–FG students may be more supported in college.

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