Research Article

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# Relative Impact of Values-Oriented and Mindset-Oriented Interventions on Academic Success of Introductory Biology Students Attending 2-Year or 4-Year Institutions

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**Diversifying the STEM workforce is a national priority, yet white males continue to dominate the ranks of professional scientists and engineers in the United States. This is partly due to disparities in academic success for women and minoritized students in prerequisite introductory STEM courses, leading to higher attrition from B.S. degree programs. Past research has demonstrated that when social-psychological interventions targeting "stereotype threat" or "fixed" mindsets are implemented in STEM courses, equity gaps may be significantly reduced. We incorporated two such interventions into introductory biology courses for life science B.S. majors and Associate's degree allied health students taught at a regional research university and a community college. We observed no significant effects of the values-affirmation interventions on grade outcomes for students in any of the courses, regardless of students' gender identity, race/ethnicity, or first-generation status, suggesting that students, on average, were not experiencing stereotype threat on either campus. We found a significant positive association between completing more weekly reflective journal entries and higher mean content-based grades for students in the university majors course overall, especially first-generation students, although the association was significantly negative for women. Our results confirm that context matters when implementing interventions aimed at reducing achievement gaps, and we propose that educators assess their students' social-psychological characteristics and then select interventions accordingly.**

**KEYWORDS** values-affirmation, growth mindset, interventions, introductory biology, equity gaps

## INTRODUCTION

Diversifying the Science, Technology, Engineering, and Mathematics (STEM) workforce is a national priority in the United States (1) to expand the nation's capacity for research and innovation (2, 3) while also increasing access to higher salaries in STEM professions compared to other occupations (4). Still, the ranks of professional scientists in the United States remain dominated by white males and those from economically secure backgrounds (5). Factors contributing to this disparity range from the influence of parental education and attitudes on the science achievement of elementary students (6) to unconscious workplace bias experienced by professional scientists (7), with inequitable access to high-quality K-12 and undergraduate STEM education often at the center.

Indeed, the minimum qualification for entry into STEM careers is a bachelor's degree in a STEM discipline (8), and a critical first step toward earning a Bachelor of Science (B.S.) degree is to complete the prerequisite introductory STEM courses. Unfortunately, numerous studies document significant achievement gaps in introductory course success, and subsequent attrition rates, for women and minoritized students in mathematical, physical, and biological sciences degree programs (9–15).

Students usually enroll in these high-stakes courses while they are also newly transitioning into (or re-entering) college life. Thus, students enter the introductory classroom with a swirl of emotions and expectations that influence their academic performance, in addition to their prior preparation. This highlights the importance of structuring introductory STEM courses to embrace all students' social-psychological and intellectual characteristics, so that these courses may serve as "gateways" and not "gatekeepers."

Along these lines, there is increasing attention among researchers to how college students' sense of belonging, self-efficacy, and social identity affect academic performance and retention in STEM courses and degree programs (16). Research conducted in K-12 settings has demonstrated that students' social identities may interact with their academic identities to moderate their motivation and success at

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school (17, 18). For students who self-identify with a group viewed negatively by others, such interaction may create a "stereotype threat" – a fear that performing badly in class will confirm the negative stereotype of their group (19, 20) – and may produce hypervigilance and stress, leading to reduced academic achievement of women and minoritized students in STEM disciplines (21, 22).

One approach to counteract classroom stereotype threat is to incorporate exercises that engage students in recognizing their self-integrity and adaptability (17, 23). Such "values-affirmation" interventions have, in some cases, been effective in improving grade outcomes of girls and minoritized youth in K-12 science and math classes (17, 24), as well as women, minoritized, and first-generation students in undergraduate classrooms, enough to reduce achievement gaps between these groups and white, male students (25–28).

While encouraging, comparable numbers of studies of values-affirmation interventions conducted in K-12 (29–31) and undergraduate (32–35) settings have resulted in null or even negative outcomes for some students. The common theme in the investigators' interpretations of these results is that the institutional and classroom contexts for implementing the intervention strongly influenced its potential impact on students' mindsets and sense of self and by extension their academic performance.

As biology faculty members from a regional research university and a community college, we were interested in testing the effects of a values-affirmation intervention when incorporated into a range of introductory biology courses offered at both institutions. We were further interested in examining whether augmenting the values-oriented intervention with a multiweek growth mindset-oriented reflective writing intervention would boost academic outcomes for students, because such interventions have had a significant impact on academic achievement of minoritized students and women/girls in K-12 and postsecondary settings (36–38).

We tested the following three hypotheses.

1. Students who complete values affirmation treatment surveys in life science major's-level introductory biology courses taught at a regional research university ("university-majors") and community college ("cc-majors"), as well as an Associate's-level introductory biology course, taught at a community college ("cc-non-majors"), perform better on one or more course grade outcomes than students who complete control surveys.
2. Students in a university-majors course who complete a full set of weekly reflective journal entries perform better on one or more course grade outcomes compared to students who complete fewer entries.
3. Minoritized, female-identifying, and first-generation students in the university-majors course show higher academic gains than white, male-identifying, and continuing-generation students because of completing both interventions.

## METHODS

### Study sites and courses

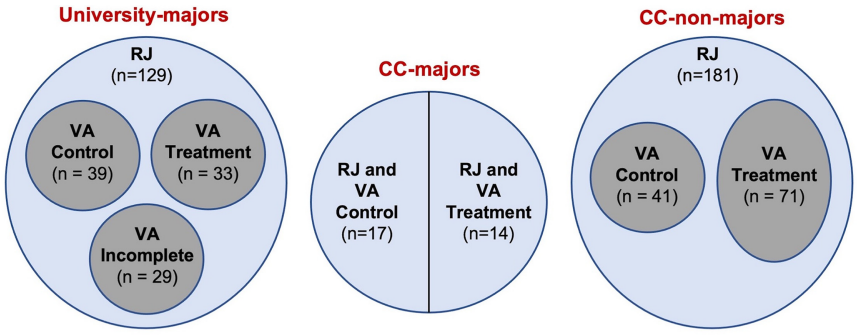
We implemented interventions at two public higher education institutions. The first was a non-residential regional campus of a multicampus land-grant research university, with an undergraduate enrollment of ~3,000 and a graduate enrollment of ~400 students. In 2021, the undergraduate profile was 33% black, indigenous, and people of color (BIPOC) and 44% first-generation college students. The second institution was a 2-year community college with a student body of ~10,000 full and part-time students, of which ~33% were BIPOC and 37% were the first generation.

The interventions were incorporated into 3 different introductory biology courses. The "university-majors" course is the first of a two-semester sequence required of all life sciences majors at the university. The "cc-majors" course is one of a three-quarter sequence equivalent to the introductory biology sequence at the university. The "cc-non-majors" course is aimed toward students in Associate's level nursing and allied health programs. The interventions were implemented in the university-majors course during the Fall 2020 semester, in the cc-majors course during the Fall 2021 quarter, and in the cc-non-majors' course during the Fall 2020 and Winter 2021 quarters.

### Implementation of interventions

We tested the effects of two interventions. The first was a values-affirmation survey administered to all students near the beginning of each term and again before the midterm examination, through an online platform (Canvas or Qualtrics) using the identical survey language and protocols reported in Jordt et al. (25). We randomly assigned half the students in each course into control and treatment groups. The treatment surveys presented each student with a list of personal values (e.g., athletic ability, empathy, patience) from which they selected 2 or 3 that were most important to them and wrote short statements, and answered 4 Likert-scale questions, about why they chose those values. The control surveys contained an identical list of values. However, the students selected values that were least important to them, then answered questions and wrote about why these values could be important to someone else.

The second intervention was a "reflective study journal" designed by one of us (Kibota) to engage early college students in exercises and self-reflections to build a growth mindset and develop metacognitive thinking skills. The study journal consisted of 9 weekly assignments that students completed online (Canvas or Blackboard Learn). The assignments ranged from watching short videos about growth mindset and then writing open-ended reflections about what interested them, to looking ahead to a future assignment and how they would prepare for it. The last step in each assignment was to create a schedule of study approaches for the coming week, and to write a brief reflection about how well their approaches worked for them over the previous week (see Supplemental File 1 for the




**Analysis 1: Effect of values affirmation intervention within university-majors, cc-majors, and cc-non-majors courses**
- Stepwise multiple linear regression (*VA control/treatment, institution, course level, interaction*)
- 2-tailed Welch's t-tests (control vs. treatment within each course)

**Analysis 2: Effect of reflective journal intervention within university-majors course**
- Stepwise multiple linear regression (*RJ entries, race, gender, generation, interaction*)

**Analysis 3: Additive effect of values affirmation and reflective journal interventions within university-majors course**
- Stepwise multiple linear regression (*VA control/treatment, RJ entries, race, gender, generation, interaction*)

FIG 1. Samples sizes of comparison groups within each of the three introductory biology courses included in this study, and analytical approaches to test each hypothesis. University-majors, life science majors' level course taught at regional research university. CC-majors, live science majors' level course taught at community college. CC-non-majors, associate's level course taught at community college. VA, values affirmation. RJ, reflective journal.

Reflective Study Journal prompts). Students earned ungraded course credit for submitting each journal entry, and the 9-week series was worth 10% of their final grade in each course.

There were differences in how the interventions were delivered to students between the three courses (Fig. 1). For the values affirmation, students in the cc-majors and cc-non-majors courses completed the surveys in Canvas as part of the reflective journal assignments. In the university-majors course, students were emailed links to a Qualtrics survey twice during the semester and received extra credit (equivalent to a 1% increase in their final course grade) only if they completed both.

Students in the cc-majors and cc-non-majors courses received credit for completing each of the 9 weekly reflective journal entries. However, in the university-majors course, students had the option to miss up to 2 of the 9 entries and still receive full credit for the reflective journal assignment. Thus, completion rates for the values affirmation and the journal were variable among the university-majors' students and allowed us to assess the effect of variable completion of each intervention on those students' grade outcomes.

Our research protocols, survey instruments, and consent forms were reviewed by the university's Institutional Review Board (IRB) and deemed exempt from federal regulations governing human subjects research (IRB number 18430). This exemption applied to the university and the community college faculty and students through institutional agreements.

## Data sources

We used three course grade outcomes to measure how the values affirmation and reflective study journal interventions may have influenced student success. First, we calculated a final grade percentage score for each student in each course based only on assignments that assessed biology content knowledge and/or scientific inquiry skill (e.g., exams, lab reports, writing assignments). Second, we calculated a mean exam percentage score for each student who completed all lecture exams in the course. Third, we calculated a mean lab % score based on all lab-related activities, quizzes, practical exams, and reports.

Demographic information was not available for the community college students during the study period. However, the students in the university-majors course during Fall 2020 were asked to self-report their racial and gender identities, and whether either of their parents or guardians had completed a bachelor's degree or higher. The students selected one or more racial identities from a list used by the university Institutional Research office: Asian, black, Hispanic, Native American/Alaska Native, Pacific Islander, white, and 2 or more races. We pooled white students into a "majority" racial category, and all of the other students into a "minoritized" category. We recognize that the Asian category could include populations not considered underrepresented in STEM. However, because of the small sample size and inability to distinguish subpopulations, we opted to categorize this racial group as minoritized. During Fall 2020, the gender identities used by the university Institutional Research office were binary (male and female).

## Analytical approaches

We removed data for those students who did not complete each lecture exam in each course and/or received zero points for the lab component of their course, and in the university-majors course, we excluded any students who did not respond to any of the race, gender, or generational status questions. We assessed each grade outcome data set for normality (e.g., Shapiro-Wilk and D'Agostino-Pearson omnibus tests) and heteroscedasticity

TABLE 1
Mean course grade outcomes in introductory biology courses offered on the regional research university and community college campuses during Fall 2020, Winter 2021, and Fall 2020[a]

| Grade outcome measure | University majors Fall 2020 | CC majors Fall 2020; Fall 2021 | CC non-majors Fall 2020; Winter 2021 |
|---|---|---|---|
| Final grade % | 79.8 (1.2) | 81.4 (2.5) | 83.4 (9.2) |
| Content-based final grade % | 78.4 (1.2) | 79.5 (3.2) | 82.7 (0.8) |
| Exam grade % | 79.6 (0.8) | 72.8 (2.7)[b] | 77.3 (0.8) |
| Lab grade % | 74.5 (1.9) | 80.5 (3.0) | 86.8 (1.1) |

[a]CC, community college. The numbers in parentheses represent SE.
[b]$P < 0.0001$ from Welch's *t* test.

(Spearman's test) and confirmed each data set met statistical test assumptions.

We constructed linear regression models to test each hypothesis, which we then assessed for best fit using a backward stepwise model selection approach (Fig. 1). Each preferred model was the one with the fewest terms and lowest Akaike information criterion value, corrected for sample size (Akaike information criterion with small sample correction [$AIC_c$]).

Hypothesis number 1 was a regression model applied to the student data across both institutions (regional university, community college) and course levels (majors, non-majors). The full model consisted of grade outcome $\sim$ values affirmation + institution + course level + interactions.

In addition, we tested for significant differences in each of the three grade outcomes between students who completed two treatment and/or two control values affirmation surveys within each course using 2-tailed Welch's t-tests assuming unequal variances and measured effect size as Hodges' *g* (39).

Hypothesis number 2 included applying the same regression modeling approach to students of different racial and gender identities and generational statuses in the university-majors course in Fall 2020, without considering the values affirmation: grade outcome $\sim$ journal + race + gender + generation + interactions.

Hypothesis number 3, included using a separate stepwise regression model in the form of grade outcome $\sim$ values affirmation + journal + race + gender + generation + interactions.

All statistical analyses were performed using GraphPad Prism version 9.3.1.

## RESULTS

We assessed the effect of the values affirmation intervention for 215 of 341 students who were included in the study across both campuses and both course levels (62.3%). We only assessed the effect of variable completion of the reflective journal for students in the university-majors course (Fig. 1). Using 1-way ANOVA, we found that the mean grade outcomes for the three courses did not significantly differ by institution or level, except for the mean exam grade, which was significantly ($F_{[2, 342]} = 10.09$, $P < 0.0001$) lower in the cc-majors course (Table 1).

In the university-majors course, the majority (>60%) of students identified as white or continuing generation, while 66% of the students identified as female. Asian, Hispanic, and students identifying with two or more racial categories were the next most abundant racial groups, with single individuals who identified as black, Native American, or Pacific Islander (Table 2).

### Effect of the values affirmation intervention (Hypothesis 1)

We found no significant ($P < 0.05$) differences in any grade outcome or interactive effect between treatment and control groups, regardless of whether the students attended the regional university or the community college, or if they were enrolled in the majors' or non-majors' introductory biology course (Fig. 2).

Similarly, we observed no significant effect of the intervention on any racial or gender identity, or generational status for students in the university-majors course. In all cases, this lack of significance was observed through both regression analyses and means testing.

We found significantly ($P < 0.05$) higher mean scores in every grade outcome measure for students in the university-majors course who completed 2 values affirmation surveys during

TABLE 2
Demographic profile of study participants in the introductory biology course for majors taught on the regional research university campus during Fall 2020

| Demographic category | % (no.) |
|---|---|
| Racial Identity | |
| White | 62.2 (79) |
| Asian | 39.6 (19) |
| Black | 2.1 (1) |
| Hispanic | 27.1 (13) |
| Native American | 2.1 (1) |
| Pacific Islander | 2.1 (1) |
| 2 or more races | 27.1 (13) |
| Gender | |
| Male | 33.1 (42) |
| Female | 66.1 (84) |
| Family Context | |
| First generation | 25.2 (32) |

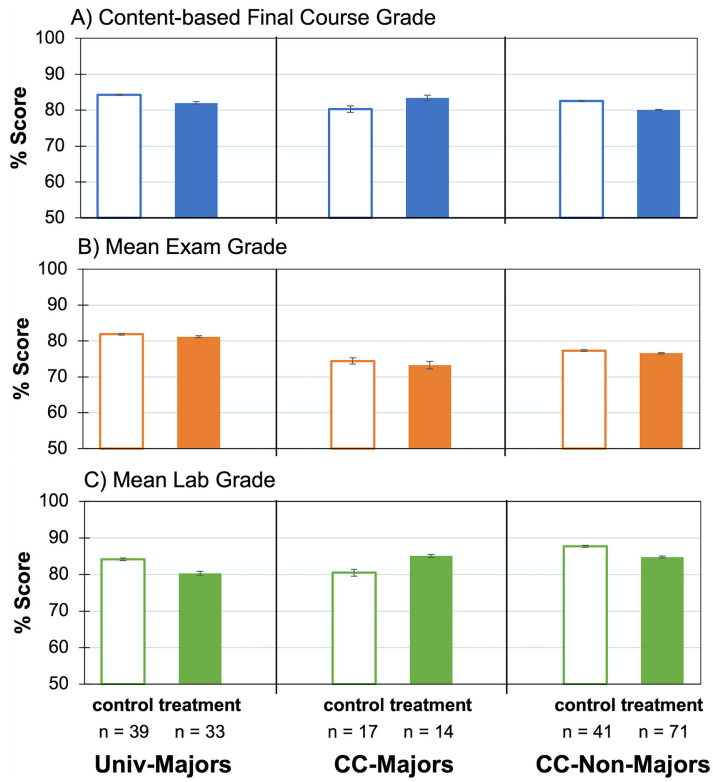



FIG 2. Comparison of outcomes for students who completed control (unfilled columns) or treatment (filled columns) versions of the values affirmation surveys in their majors or non-majors' introductory biology courses between Fall 2020 and Fall 2021. (A) Mean final course grade (based on points earned only on content assessments). (B) Mean exam grade. (C) Mean laboratory grade. Univ, regional research university; CC, community college. Error bars, 1 SE. None of the pairwise comparisons resulted in significant ($P < 0.05$) differences between control and treatment groups, based on Welch's *t* tests.

the term (regardless of treatment or control condition) compared to those who completed 0 to 1 survey, with medium to high effect sizes (Table 3). Notably, the significantly higher grades of students who completed two surveys were consistent across all racial and gender identities, and whether students were continuing or first-generation (data not shown).

### Effect of the reflective study journal (Hypothesis 2)

The weekly journal entry completion rate of university-majors students ranged from 0 to 100% and averaged 6.9 ± 0.2 entries out of 9 over the Fall 2020 semester. We tested the predictive effect of completing increasing numbers of weekly reflective journal entries on grade outcomes, and the preferred regression model included only the main effects and no interaction terms, with significantly ($P < 0.0001$) positive effects of completing increasing numbers of journal entries on every grade outcome measure. In addition, there was a significant ($P < 0.01$) positive effect for first-generation students and a significant ($P < 0.05$) negative effect for female students on both the final content-based grade and lab grade (Table 4).

Students in the university-majors course who completed 9 journal entries (26% of the class) uniformly scored the highest on all grade measures, regardless of their racial identity, gender identity, or family history of college degree attainment. However, for the 26% of the class who completed 8 entries (one more than required), the students from groups historically overrepresented in STEM (white, male, continuing generation) scored significantly higher on all grade measures than minoritized, female, and first-generation students. Alternatively, among the 23% of the class who completed the minimum required 7 weekly journal entries, first-generation students consistently scored higher than all other groups, although only 3 of the 34 students who completed 7 entries were in this category. Grade outcomes for students who completed 6 weekly entries (11% of the class) received substantially higher final grades than those who completed 0 to 5 entries (26%) (Fig. 2).

### Additive effects of the values affirmation and reflective study journal (Hypothesis 3)

Our regression analysis resulted in a final, preferred model, including only the main effects, and no significant interaction terms. Overall, completing increasing numbers of weekly journal entries (in addition to submitting two affirmation surveys) was strongly associated with significantly ($P < 0.0001$) higher scores

TABLE 3
Comparison of mean course grade outcomes between students who completed 2 values affirmation surveys (either control or treatment) and students who completed 0 to 1 survey in the regional research university introductory biology course for majors during Fall 2020[a]

| Grade outcome measure | Completed 2 surveys ($n$ = 72) | Completed 0–1 survey ($n$ = 60) | Difference | Effect size (Hedges' $g$) |
|---|---|---|---|---|
| Content-based final grade % | 83.2 (1.1) | 72.6 (2.0) | 10.7[b] | 0.79 |
| Exam grade % | 82.6 (1.0) | 78.9 (1.0) | 3.6[c] | 0.44 |
| Lab grade % | 82.4 (1.8) | 65.0 (3.0) | 17.4[b] | 0.81 |

[a]Numbers in parentheses represent SE.
[b]$P < 0.001$.
[c]$P < 0.05$.

on every grade measure, regardless of race, gender identity, or generational status (Fig. 3; Table 5).

While there were no significant beta-coefficients for terms other than the number of journal entries completed, the best-fit model did show a positive relationship between students' content-based final grade and (i) higher journal entry completion, (ii) values affirmation control group, and (iii) minoritized students; however, there was a negative relationship for male and first-generation college students. The relationships between journal completion and exam and lab scores showed negative outcomes for minoritized, male, and first-generation students on exams, and positive effects on lab scores (Fig. 3; Table 5).

## DISCUSSION

We observed mixed results in response to our implementation of a values-oriented and mindset-oriented intervention.

TABLE 4
Final model and regression coefficients testing the effects of completing multiple reflective journal entries on grade outcomes for students ($n$ = 127) in the university-majors introductory biology course during the Fall 2020 semester[a]

| Grade outcome ~ intercept + RJ number + minority + female + 1st-generation | | | |
|---|---|---|---|
| **Model output** | **Content-based final % score** | **Exam % score** | **Lab % score** |
| Intercept | 51.57[b] | 71.31[b] | 34.23[b] |
| $\beta_1$ | 4.051[b] | 1.376[c] | 5.950[b] |
| $\beta_2$ | −2.64 | −10.44 | −1.469 |
| $\beta_3$ | −13.46[d] | −1.600 | −24.81[d] |
| $\beta_4$ | 16.84[d] | 3.652 | 32.35[c] |
| $R^2$ | 0.5634 | 0.2191 | 0.5592 |
| adj-$R^2$ | 0.5248 | 0.1500 | 0.5202 |
| df | 113 | 113 | 113 |
| $AIC_c$ | 561.9 | 531.8 | 673.6 |

[a]RJ, number of reflective journal entries; minority, students of color; 1st-gen, first-generation college students.
[b]$P < 0.0001$.
[c]$P < 0.05$.
[d]$P < 0.01$.

Students who completed the treatment values-affirmation surveys did not score significantly higher or lower on any grade measure than students who completed the control values-affirmation surveys, regardless of their home institution, whether or not they were in a majors' or non-majors' course, or their demographic background. Conversely, content-based final grades were significantly positively associated with completing more reflective journal entries for students in the university-majors course, especially first-generation students, although the relationship was significantly negative for women.

### Why do values-affirmation interventions succeed in some situations and not others?

Our null results in response to the values-affirmation intervention were initially disappointing. However, reviewing meta-analyses of such interventions across multiple institutions and classroom settings (40, 41) suggested to us that minoritized students taking introductory biology at the regional research university and the community college may not have been experiencing stereotype threats to the same degree as students taking a comparable course at large, highly selective research universities. While other factors could also have contributed to the null results (described more fully below), we believe these findings reinforce the important role of student, course, and institutional context in determining whether a values-based intervention will be effective at reducing or removing equity gaps.

### The role of individual self-concept

Binning and Browman (40) proposed a "zone model of threat" to assist in determining when values-affirmation interventions are likely to be effective and for whom. The zone model assumes that a student's level of perceived threat is a product of (i) how much their self-regard depends on academic achievement, and (ii) their belief or expectation about how well they will do in school. The model proposes that a student's level of academic performance is contingent upon the level of threat they are experiencing and that this relationship follows a Gaussian function (see Fig. 1 in reference (40)). The model predicts an optimum level of academic performance when a student's perceived threat level aligns with their expectations about how well they will do in school (i.e., the "Goldilocks" zone). On either side of

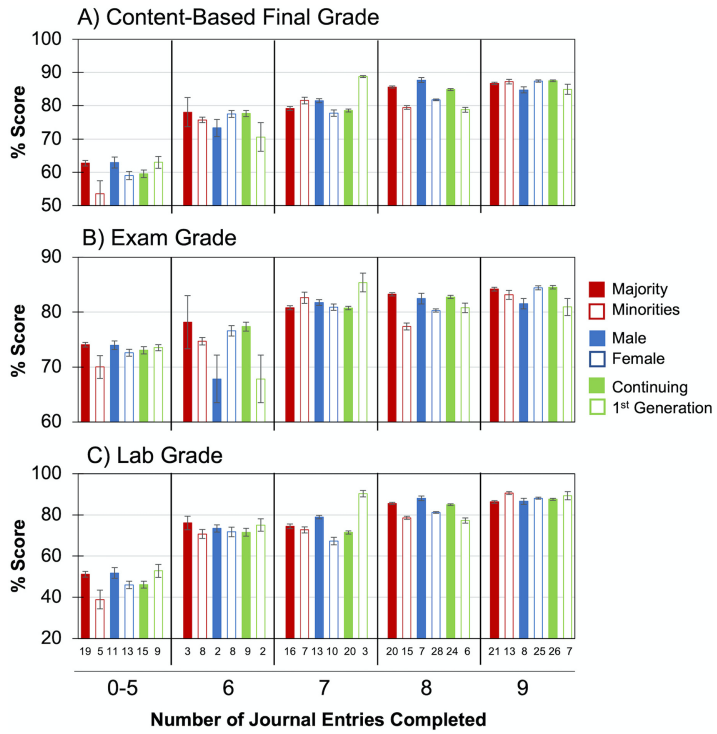



FIG 3. Comparison of outcomes for students sorted by race, gender identity, and generational status who completed variable numbers of 9 (total) weekly reflective journal entries in majors-level introductory biology at a regional research university during Fall 2020. (A) Mean final course grade (based on points earned only on content assessments). (B) Mean exam grade. (C) Mean laboratory grade. Note differences in scale in each panel. The numbers below columns represent the sample size. Error bars, 1 SE. See Table 5 for which groups showed significant differences based on the number of entries completed.

this optimal zone, students' academic performance will be lower when they want to succeed but do not believe they can do so (i.e., inadequacy), or when students feel confident that they will succeed but they do not think it is important enough to try very hard (i.e., overconfidence).

Binning and Browman (40) argue that a values-affirmation intervention is therefore an effective strategy to move students who feel inadequate toward the optimal performance zone by reducing their sense of threat; however, the same intervention could potentially decrease performance for students who are overconfident because their motivation may derive from their confidence in overcoming threats, i.e., as threat diminishes so does their motivation to succeed. An appropriate intervention for overconfident students could be to encourage them to think about how learning in school is useful to them and that learning will allow them to make an impact in society (40, 42).

According to the zone model, it followed that minoritized students in the courses we investigated did not feel an inordinate level of stereotype threat because confirming their values did not lead to improved grade outcomes in the treatment group compared to the control group. This suggested that students may have felt a sufficient sense of belonging in their introductory biology courses such that stereotype threat was not a significant factor affecting their academic performance. The null effects of the values-affirmation intervention suggest that students on average were also not overly confident. It is important to note that our investigations took place during the height of the coronavirus disease 2019 (COVID-19) pandemic, with all classes 100% virtual. Students were not gathered in physical classrooms, so threats associated with being identified with a racial or gender (i.e., visible) stereotype may have been diminished. As the instructors of these courses during 2020 and 2021 (one Asian male and two white females), we also note that our representation of academic success in STEM by women and people of color could have contributed to students' sense of belonging, as well as the extra care and flexibility we each gave to students during the early months of the pandemic.

Interestingly, we did observe significantly higher content-based grades for the university-majors' students who completed either two treatment or two control values-affirmation surveys compared to students who only completed one or no surveys. It is possible that simply taking a few minutes at two different time points to consider why certain individual attributes may be valuable to themselves or anyone else was enough to reinforce those students' self-integrity.

## The role of course and institutional setting

Our null results of the values-affirmation intervention are in stark contrast to some other studies (25, 27, 28). Notably, each of these investigations was conducted on a

TABLE 5
Final model and regression coefficients testing the effects of values affirmation and reflective journal interventions on grade outcomes for students ($n = 72$) in the introductory biology course for majors taught at the regional research university during the Fall 2020 semester[a]

| Grade outcome ~ intercept + VA-control + RJ number + minority + male + 1st-generation | | | |
|---|---|---|---|
| **Model output** | **Content-based final % score** | **Exam % score** | **Lab % score** |
| Intercept | 46.01[b] | 60.03[b] | 15.32 |
| $\beta_1$ | 1.78 | 0.5548 | 3.345 |
| $\beta_2$ | 5.08[b] | 3.115[b] | 7.987[b] |
| $\beta_3$ | 1.23 | −1.930 | 4.132 |
| $\beta_4$ | −0.355 | −2.317 | 1.714 |
| $\beta_5$ | −2.127 | −4.433 | 2.996 |
| $R^2$ | 0.4054 | 0.2783 | 0.4066 |
| Adj-$R^2$ | 0.3590 | 0.2219 | 0.3603 |
| df | 64 | 64 | 64 |
| $AIC_c$ | 297.5 | 287.4 | 362.3 |

[a]VA-control, values affirmation control group; RJ, number of reflective journal entries; minority, students of color; 1st-gen, first-generation college students. Reference levels, VA-control, white, male, and continuing generation.
[b]$P < 0.0001$.

large selective research university campus and in a high-enrollment course with a low proportion of minoritized students – a context in which those students may be more likely to experience stereotype threat and fears of inadequacy.

It is rare to find published studies of how social-psychological interventions impact introductory STEM students who do not attend a large research university (e.g., regional campuses of research university systems, comprehensive universities, small liberal arts colleges) or 2-year community colleges (43). To our knowledge, ours is the first report of outcomes from such interventions on a regional research university campus, and one of a very small number of studies conducted at a community college. Indeed, in the few investigations of values-affirmation intervention effects on community college STEM students, the investigators observed similar null results (34, 35, 44). Moreover, when investigators surveyed community college faculty about their colleges' values and norms and asked students at the same institutions about their motivations for attending college, they found these two measures to be closely aligned, suggesting students experienced low levels of identity threat and had a relatively high sense of belonging (35). On the other hand, in a study conducted with administrators and first-generation students from 60 highly ranked U.S. universities and liberal arts colleges, Stephens et al. (45) found a substantial mismatch between institutional and students' cultural norms, which they associated with lower grades for first-generation students.

Context matters when implementing values-affirmation interventions, at the level of individual students and the institutional setting. For these interventions to be most effective at reducing academic disparities, educators and researchers should first develop an accurate picture of the social-psychological status of students considering the norms typical for the institution they attend, and then strategically target interventions that best align with students' experiences and needs (33, 34, 40, 41, 43, 44).

### Moderating effects of a mindset-oriented intervention

Students in the university-majors course who completed 100% of the reflective journal entries consistently scored in the top tier on every content-based grade measure, and this was the case across every racial, gender identity, and generational category. However, among those that completed 8 of 9 entries, white, male, and continuing-generation students scored significantly higher than all other student groups.

Therefore, when some level of the mindset-oriented intervention was optional, completing more than the required minimum sometimes was associated with an achievement gap for minoritized and female students. This could have been due to the time it took to complete one "extra" journal entry, which may have cut into the study time of students who were more likely working full-time or part-time or had family obligations.

When students completed only the minimum required (7) entries of the reflective journal, there were no demographic differences in student grade outcomes except for a small number (3) of first-generation students who scored significantly higher than all other groups. These students may have made a conscious decision to devote the minimum needed to succeed in this ungraded assignment in favor of focusing their time on graded assignments (a decision that could have been facilitated by the self-reflections that they did complete). Future qualitative analysis of the students' reflective journal text entries will allow a more fine-grained analysis of how the journal assignment impacted students' success.

### Limitations to the study

Our study could have been improved in several ways. First, our sample size was small compared to other published reports (e.g., (25)). Thus, while statistically significant, our results may not be directly comparable to larger studies. Second, having the demographic backgrounds of the community college students in our study would have allowed us to examine how the interventions may have differentially impacted first-generation and students of color at a 2-year institution. Third, the disruption to students' lives due to the COVID-19 pandemic may have influenced their responses to the interventions. We recommend testing the effects of these interventions when courses are taught in person. Finally, we recommend using a uniform delivery system for survey tools to ease interpretation.

Our implementation of a values-affirmation intervention in introductory biology courses for majors and non-majors taught at a regional research university and a community college did not result in any significant effects on mean grade outcomes for students, regardless of race, gender identity, or generational

status. We conclude that these students were likely not experiencing stereotype threat and that their expectations and their identity norms may have aligned well with those of the institutions they attended.

Completing more reflective journal entries was significantly positively associated with higher grade outcomes in the university-majors course overall. However, among the group who completed 8 of 9 journal entries (more than required but less than the recommended total), the grade outcomes for minoritized students were significantly lower than white, male, and continuing-generation students. We speculate that the minoritized and first-generation students who committed the additional time for one "extra" journal entry may have done so at the expense of study time for graded aspects of the course, due to having more external demands of full- or part-time work and/or family obligations than other students.

We propose that instructors of early STEM courses assess the social-psychological characteristics of their students and then select interventions that are designed to address the challenges or threats that may be impacting their students' academic performance.

## SUPPLEMENTAL MATERIAL

Supplemental material is available online only.

**SUPPLEMENTAL FILE 1**, PDF file, 0.1 MB.

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