Reducing socioeconomic disparities in the STEM pipeline through student emotion regulation

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Educational attainment is one lever that can increase opportunity for economically disadvantaged families—especially in Science, Technology, Engineering, and Math (STEM). Unfortunately, students from lower-income backgrounds often perform poorly and fail high school STEM courses, which are a necessary step in pursuing fast-growing and lucrative STEM careers, graduating high school, and matriculating to college. We reasoned that, because high school STEM courses often use high-stakes tests to gauge performance, and such tests can be especially stressful for lower-income students, interventions that help students regulate their negative emotions during tests should reduce the achievement gap between higher- and lower-income students. In a large-scale ($n = 1,175$) field experiment conducted in ninth grade science classrooms, students were asked to complete a control exercise, or they were given the opportunity to complete an exercise to help them regulate their worries and reinterpret their anxious arousal before their tests. We found significant benefits of emotion regulation activities for lower-income students in terms of their science examination scores, science course passing rate, and students' attitudes toward examination stress, suggesting that students' emotions are one factor that impacts performance. For example, 39% of lower-income students failed the course in the control group compared with only 18% of students failing the course if they participated in the emotion regulation interventions—a reduction in course failure rate by half. Our work underscores the crucial importance of targeting students' emotions during impactful points in their academic trajectories for improving STEM preparedness and enhancing overall academic success.

academic achievement gaps | educational interventions | socioeconomic status | emotion regulation | test anxiety

In the United States, there are vast inequalities in educational attainment based on family socioeconomic status with children from lower-income backgrounds receiving worse grades, test scores, and rates of college attendance compared with their higher-income counterparts (1–4). In fact, the academic achievement gap between students from higher- and lower-income backgrounds can be two to three times as large as notable and persistent racial achievement gaps, such as the White-Black achievement gap (2). This lack of academic success reduces career opportunities, thereby helping to maintain the intergenerational transmission of poverty (2, 5).

Science, Technology, Engineering, and Mathematics (STEM) fields are increasingly viewed as one way to open up career opportunities in the evolving US economy. STEM jobs are projected to grow faster, provide greater earning potential, and produce lower rates of unemployment than non-STEM jobs over the next decade (5–7). STEM training also provides individuals with useful skills, such as numerical and computer literacy, which are broadly marketable across a variety of careers and allow students to pursue a variety of interests. High school science and mathematics courses impart the foundational knowledge and preparation for STEM careers as well as for STEM majors in college (7–10).

Given the benefits of facilitating STEM preparation, high school STEM course enrollment and success is one important focal point for increasing opportunities for the most disadvantaged students. Underlining this point, a study by ACT found that students who enroll in biology, chemistry, and physics in high school, compared with students who complete fewer science courses, are three times more likely to meet college readiness standards for science (8). Unfortunately, students from lower-income backgrounds are markedly less likely to enroll in the full sequence of high school STEM courses (9–12), partially because of low performance in those courses as they begin high school (12), and are therefore less prepared for STEM careers than their more advantaged peers (13).

The numerous structural barriers that stand between lower-income students and STEM preparation in high school—such as neighborhood factors, types of schools available, systemic prejudice based on social class—create the sense that the only ways to help involve needed large-scale changes to schools and society. However, targeting some of the downstream consequences of disadvantage can be part of helping improve STEM achievement and course enrollment for lower-income students. For example, students from lower-income backgrounds have been found to have particularly high levels of stress and performance anxiety during evaluative assessments in school (13–15). One reason for this is that individuals viewed as being lower in social status, importance, or standing in society, such as lower-income students, experience rejection sensitivity, which is a feeling of

Significance

Increasing access to Science, Technology, Engineering, and Math (STEM) fields can create career opportunities. Yet many students, especially those from lower-income backgrounds, find the high-stakes exams in courses necessary for STEM success to be stressful and anxiety provoking. Such experiences of stress can lead to underperformance and compromise students' ability to advance in STEM. We show that lower-income students given the opportunity to emotionally regulate their worries and reinterpret their arousal go on to perform better on their high school science exams and endorse a more adaptive interpretation of stress. Critically, emotion regulation interventions cut in half the course failure rate for lower-income students. For many students, success is based on more than STEM knowledge—their ability to regulate emotions is important too.

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anxiety about being rejected in evaluative assessment situations that emphasis rank and status (15–17). The additional anxiety created by rejection sensitivity can burden the cognitive resources that students rely on to perform well on tests (18). Indeed, research has demonstrated that individuals who experience rejection sensitivity have greater difficulty regulating or managing their negative emotions (19) and worse academic performance (15).

If anxiety associated with evaluative assessments undermines academic achievement and is particularly problematic for lower-income students, then intervening to help students to successfully regulate their negative emotions during important tests could improve test performance and course pass rates—especially for students from lower-income backgrounds. We tested this notion in the current work.

Anxiety during evaluative assessments undermines performance by eliciting two psychometrically distinct components: (*i*) worried thoughts about the possibility of failure and (*ii*) stress responses that heighten physiological arousal (see Fig. 1 for conceptual model). Two emotion regulation interventions that may reduce the negative effects of anxiety during evaluative assessments are expressive writing and arousal reappraisal. Expressive writing interventions target the cognitive component of anxiety (i.e., worries) by asking individuals to write about and express their thoughts and concerns (20). Expressive writing may help individuals develop insights that can aid emotion regulation and perceived control of stressful situations, thereby "offloading" worries and freeing cognitive resources that can be used to optimize performance. Arousal reappraisal interventions may help individuals manage the physiological component of anxiety (i.e., arousal) by asking them to reinterpret the utility of heightened arousal as a resource that can improve rather than harm performance (21). That is, rather than a sign of anxiety or failure, physiological arousal (e.g., a racing pulse) can be viewed as a beneficial and energizing force.

Several studies have separately demonstrated the potential of the expressive writing (22–24) and arousal reappraisal interventions (25, 26). However, neither intervention has been examined in large-scale, real-world academic performance contexts with economically diverse populations. Nor have the interventions been tested in combination, which is potentially powerful given the two psychometrically distinct components of anxiety on which the interventions are hypothesized to operate. Such work is crucial for targeting impactful points in lower-income students' academic trajectories for improving STEM preparedness and enhancing overall academic success.

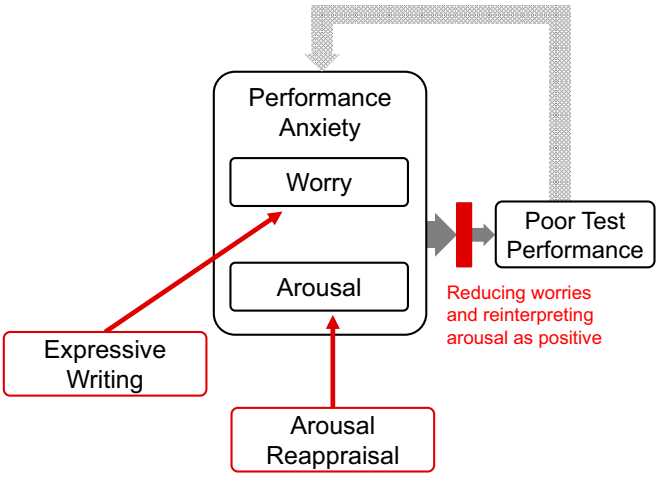

Fig. 1. Theoretical model of emotion regulation interventions that address specific components of performance anxiety. Worry and arousal are the two components of performance anxiety. There is a negative cycle between performance anxiety and poor test performance in which each factor reciprocally influences the other. Interventions that target the specific components of performance anxiety can interrupt this cycle of anxiety and poor performance.

Current Study

We conducted a large-scale field experiment involving the above-mentioned emotion regulation interventions in ninth grade science classrooms in an economically diverse high school (total n = 1,175; lower-income n = 285). We chose to intervene in ninth grade science courses for several reasons. First, this course serves as a foundational gateway course that is necessary to move on to additional science courses. Second, students at the beginning of high school often experience unexpectedly poor performance as they adjust to a new setting, course difficulty, and expectations, which is known as "9th grade shock," and is prevalent in high schools across the nation (27). Finally, students' grades during ninth grade are especially important predictors of overall high school success, including the likelihood of dropout (28). Thus, boosting performance in ninth grade may, in turn, help to increase subsequent science participation and improve students' odds of success in high school and beyond.

All ninth grade students in a large Midwestern high school were randomly assigned to engage in one of four writing exercises—active control, expressive writing, arousal reappraisal, or both expressive writing and arousal reappraisal—immediately before their first and second semester final examinations. Students in our study were enrolled in a single freshmen biology course for the academic year, and the same final examinations were used across all classrooms. Our main performance outcome consisted of students' average final examination performance across both semesters. We intervened before students' final examinations because these tests were especially high-stakes, being students' first final examinations in high school and also accounting for a significant proportion of their semester grade. We additionally explored the benefits of our interventions in generally improving students' overall course success: in particular, whether students passed the course and therefore were ready to move on to the next course in the high school science sequence. Lastly, we asked about the effects of the interventions on students' attitudes toward anxiety during tests. We reasoned that emotion regulation activities could help students to adopt more adaptive views about their affective experience during difficult examinations.

This study breaks ground in several ways. First, not only do we investigate effects of emotion regulation interventions on examination performance, but we also ask whether benefits of emotion regulation interventions generalize to additional student outcomes beyond the testing experience, such as course passing rate and attitudes about tests. Second, although the effects of expressive writing and arousal reappraisal have been tested independently in one small field study each previously (24, 25), we test both as well as the combination of these interventions, which enables us to conduct a test to directly compare the effects of these two types of emotion regulation interventions as well as to investigate the possibility that doing both interventions is better than doing either one alone. Although we predict that all of the interventions will be beneficial in comparison with the control condition, it is important to understand whether effects differ or are similar across interventions.

Third, by fielding these interventions across all biology classrooms in a diverse high school, our work helps address (*i*) whether emotion regulation interventions can be implemented at scale without heavy researcher oversight and (*ii*) whether there are benefits for adolescent students from diverse socioeconomic backgrounds. Not only is the current study larger than both prior

related intervention studies combined, but in contrast to the prior studies that only involved a small number of teachers and classrooms in a school, this study intervened at the organizational level, including all teachers, students, and classrooms within a school, providing a better test of scalability. Additionally, the previous studies were not conducted in school contexts with diverse groups of students, so studies with larger and heterogeneous samples of students are necessary to evaluate the efficacy and generalizability of emotion regulation interventions to reduce STEM retention problems. Such data provides helpful evidence for educators and education policymakers that these interventions should be included as one (of hopefully many other) activities designed to improve student achievement and emotional experiences in school.

Results

Overview of Analyses. The analyses of our primary outcomes—average examination performance (average percentage correct across students' two semester final examinations), course passing rate, and students' reappraisal of test anxiety—involved multiple regression with a set of planned orthogonal contrasts. Because very little of the variance in study outcomes was explained by students being in different classrooms (~2%), single-level regressions were used for the primary analyses. Additional information about robustness checks involving multilevel modeling is included in the *SI Appendix*. Given that our a priori expectation was that all three interventions would be beneficial compared with the control group, the first contrast tested for the effects of the students being randomly assigned to any of the intervention groups, compared with students who were assigned to the control group. Moreover, because we hypothesized that the interventions would be particularly beneficial for lower-income students, a key test of interest in each model was the interaction between the intervention contrast and our indicator of whether students came from a lower-income background, which was based on being designated for free or reduced lunch status by their school. If the interaction was significant, we tested whether there was a significant intervention effect for students from higher- and lower-income backgrounds, respectively. Each model also included two additional orthogonal contrasts to test whether there were differences in the effectiveness of each of the interventions (e.g., was expressive writing more beneficial than arousal reappraisal).

There were six base predictors in the model: students' prior achievement (middle school standardized test scores) as a control variable, the intervention contrast (coded with a centered contrast as +1 for students in any of the three intervention groups and −3 for students in the control group), students' economic background (coded with a centered contrast with +1 for lower-income students who were eligible for free/reduced lunch and −1 for higher-income students who were ineligible for free/reduced lunch), the interaction between these two variables, a contrast that compared expressive writing and reappraisal conditions to the combined intervention condition (coded +1 for expressive writing and reappraisal, −2 for the combined intervention condition, 0 for the control condition), and a contrast that compared the expressive writing and reappraisal exercises to each other (coded +1 for expressive writing, −1 for reappraisal, and 0s for control and combined conditions). We reported effects of the main intervention contrast and students' economic background here, and the full model, including effects of prior achievement and comparing intervention conditions to each other, in the *SI Appendix* (see also *SI Appendix*, Tables S1–S3). Generally, the interventions did not differ in effectiveness.

Experimental Balance. There were no significant differences in students' demographic characteristics or on prior academic achievement across each of the experimental and control groups (all *p*s > 0.54), which suggests that randomization to condition was successful (see *SI Appendix* for more details).

Effects on Examination Performance. Students' final examination performance averaged across both semesters was regressed on the base predictors (Fig. 2*A*). Students' two semester final examination scores were averaged, providing a composite measure of student examination performance. There was a significant effect of student income, $F(1,1174) = 139.84$, $P < 0.001$, such that students from lower-income backgrounds performed worse on the examinations than students from higher-income backgrounds. Furthermore, students in the intervention conditions scored significantly higher on the examinations than those in the control

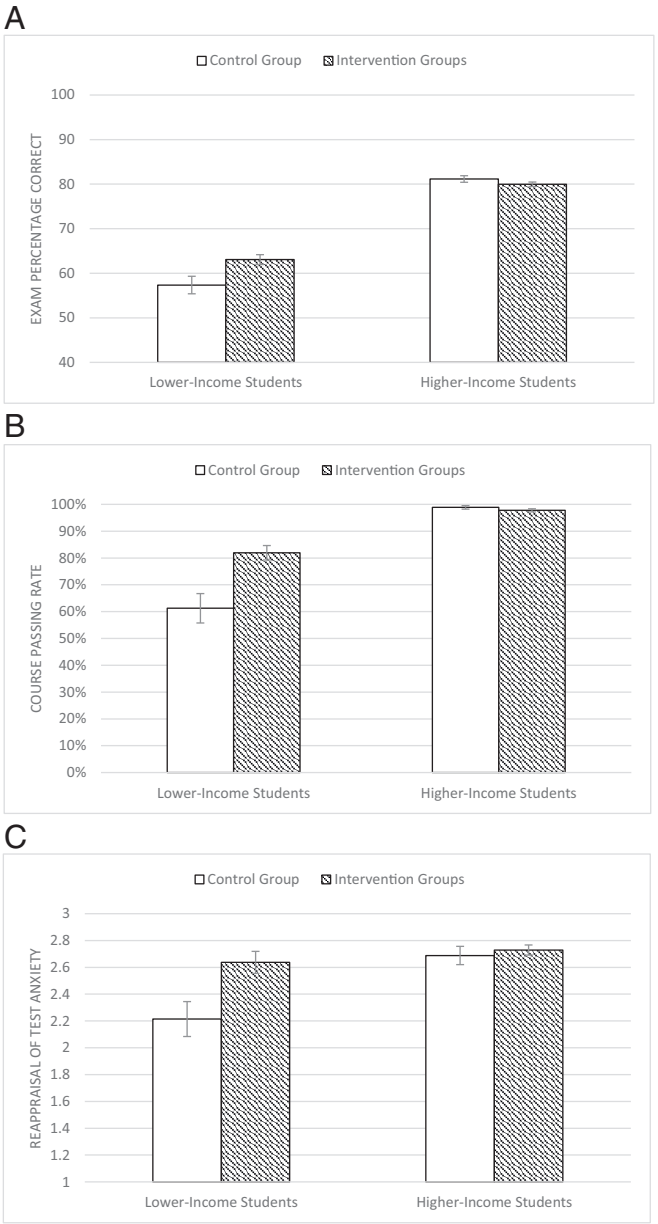

Fig. 2. Effects of emotion regulation interventions on examination performance (*A*), course passing rate (*B*), and reappraisal of test anxiety (*C*). Comparisons are between students given any of the three interventions and students given the control exercises. Students are defined as lower- or higher-income based on free or reduced lunch status. Error bars represent ±1 SE of the mean.

condition, $F(1,1174) = 8.39$, $P < 0.01$. However, there was a significant interaction between student income and the intervention contrast, $F(1,1174) = 8.96$, $P < 0.01$. There was no significant effect of the interventions for students from higher-income backgrounds, $F(1,889) = 0.07$, $P = 0.79$, but the interventions significantly improved examination performance for students from lower-income backgrounds, $F(1,284) = 6.07$, $P = 0.01$, $d = 0.51$, 95% CI = [0.09, 0.61].

Thus, the intervention significantly reduced the raw examination achievement gap between higher- and lower-income students by 29% ($P < 0.01$). The gap in the control group between higher- and lower-income students was 24% points, and the income gap among students given the interventions was reduced to 17% points. Both of those performance gaps were significantly different from 0 ($ps < 0.001$), suggesting that helping students manage their emotions is just one factor of many to intervene on to reduce these achievement gaps. Finally, tests showed that the effectiveness of the interventions did not significantly differ from each other (see *SI Appendix* for these tests across models and dependent variables).

Effects on Course Passing Rate. In addition to examination performance, the base predictors were used to predict students' course passing rate, which was defined as whether students passed both semesters of the course as opposed to failing at least one semester of the course (Fig. 2*B*). Logistic regression was used for this analysis because of the binary nature of the data. We found that a significantly higher proportion of students from lower-income backgrounds failed the course than students from higher-income backgrounds, χ^2 $(1, n = 1175) = 29.46$, $P < 0.001$. Although there was no significant main effect of the interventions on course passing rates, χ^2 $(1, n = 1175) = 0.34$, $P = 0.56$, there was a significant interaction between student income and the intervention contrast, χ^2 $(1, n = 1175) = 4.31$, $P = 0.04$ indicating that the course passing rate gap between higher- and lower-income students was significantly reduced by the interventions.

The interventions did not significantly affect the course passing rates of higher-income students, χ^2 $(1, n = 890) = 0.48$, $P = 0.49$, but the interventions did significantly increase the proportion of students from lower-income backgrounds who passed the course, χ^2 $(1, n = 285) = 7.73$, $P < 0.01$, odds ratio: 2.87, 95% CI = [1.62, 5.10]. In raw proportions, 39% of lower-income students failed the course in the control group, but this failure rate was cut in half for lower-income students who were given one of the interventions (18% failure rate for lower-income students in intervention groups). This represents a 58% reduction in the higher- and lower-income student gap on course passing rate. However, the course passing rate gap between higher- and lower-income students was significantly different from 0 for students who received the control and intervention exercises ($ps < 0.001$), suggesting that these interventions reduced but did not eliminate this course passing gap. Finally, tests showed that the effectiveness of the interventions did not significantly differ from each other (*SI Appendix*).

Effects on Students' Reappraisal of Test Anxiety. Students completed a survey at the end of the school year to assess their attitudes about whether test anxiety could be reappraised as enhancing rather than debilitating (i.e., with self-report items in which participants were asked whether they agreed or disagreed with statements such as, "A test will go well if I am a little nervous before taking it"; completion rate: 73%). In particular, we were interested in whether students would reappraise test anxiety as enhancing after receiving the interventions (Fig. 2*C*). There was not a significant effect of income on reappraisal of test anxiety in our model, $F(1,860) = 0.62$, $P = 0.43$, though we note a raw gap between higher- and lower-income students when not controlling for prior performance, $F(1,860) = 6.28$, $P = 0.01$. Students in intervention conditions more positively appraised test anxiety compared with students in the control condition, $F(1,860) = 7.98$, $P = 0.01$. Additionally, there was a significant interaction between student income and the intervention contrast, $F(1,860) = 4.86$, $P = 0.03$, indicating a significant reduction in the gap between higher- and lower-income students. There was no significant intervention effect for students from higher-income backgrounds, $F(1,685) = 0.38$, $P = 0.54$, but the intervention significantly increased reappraisal of test anxiety for students from lower-income backgrounds $F(1,174) = 7.93$, $P = 0.01$, $d = 0.46$, 95% CI = [0.12, 0.79]. This reduced the raw reappraisal of test anxiety gap between students from higher- and lower-income backgrounds by 81%. Among control group students, there was a significant gap between higher- and lower-income students on reappraisal of test anxiety ($P < 0.01$), but among intervention group students, there was no student income gap ($P = 0.28$). Finally, tests showed that the effectiveness of the interventions for reappraisal of test anxiety did significantly differ from each other (*SI Appendix*).

Discussion

To succeed in school, students in today's educational landscape must perform at a high level on a variety of evaluative assessments despite the academic performance anxiety that often permeates these high-stakes situations. Students from lower-income backgrounds may shoulder an unequal burden as they must perform at a high level even though they experience increased anxiety about academic performance in testing contexts, which can undermine the cognitive resources available to devote to the task at hand (13, 14, 16, 18). Additionally, the stakes of failure can be higher for lower-income students because they have less margin for error than their better-resourced higher-income peers who often have more accessible alternative pathways to success in school (e.g., hiring a tutor) and beyond (2). We ask whether intervening during important ninth grade evaluative assessments might improve examination performance and open additional educational opportunities for students from lower-income backgrounds. We find that students from lower-income backgrounds who are given the opportunity to adaptively regulate their emotional experience before an examination (with either expressive writing, reappraisal, or both) outperformed lower-income students who were not given a similar opportunity.

The benefits of improving examination performance extended beyond high-stakes test scores, particularly in terms of the proportion of students who passed their gateway science course, which is a key predictor of success in high school and progress in STEM. Many students from lower-income backgrounds are at a high risk for failure, so even a small boost in performance can have a substantial impact on the important distinction between passing or failing a course. Indeed, this is what we find: students from lower-income backgrounds in our active control group failed the course at a 39% rate. However, that rate was cut in half for students from lower-income backgrounds who received the interventions (18% course failure rate).

Looking beyond academic performance, small changes in students' lives can help shape the personal narratives that students tell about common sources of stress. Previous work suggests that students possess particular stories (29), interpretations (30), or appraisals (31) that they draw on to make sense of themselves and the situations they are in. One particular story that people carry with them is that stress and heightened arousal during examinations harms performance (21). We found that lower-income students were, in general, less likely to view examination stress in an adaptive fashion, which could shape their interpretation of stress and preferred manner for regulating emotion during examinations (32). However, after being given the opportunity to regulate their emotions with targeted interventions, lower-income students in our study were more likely to report seeing adaptive benefits in experiencing stress during examinations. This finding underscores the potential for emotion

regulation interventions to change students' personal narratives about academic stress. Theories of emotion regulation posit that changing how students perceive or appraise one stressful event (e.g., a test) can lead to long-term changes in the likelihood of viewing future stress more positively in precisely this way (31, 33).

The current large-scale study shows that brief emotion regulation interventions can be implemented in diverse contexts, at scale, and without heavy researcher oversight. This is especially important because it helps address whether emotion regulation interventions are effective among students from diverse socioeconomic backgrounds, which could not be assessed in the previous smaller and homogenous studies (24, 25). When other types of psychological interventions have been tested at a larger scale, the effects have not always generalized as predicted from the smaller-scale studies (34–36). The larger and heterogeneous sample of this study is a necessary next step to rigorously evaluate the efficacy and generalizability of these interventions.

However, there is more to do. Future studies should investigate whether differences between schools might moderate the effects of these interventions. In the school context of the current study, lower-income students were a minority group in the school, and there were sizable achievement gaps. Contexts like this might make social class salient and therefore could give rise to rejection sensitivity and feelings of performance pressure, making emotion regulation interventions particularly effective for lower-income students. In other school contexts, such as remedial community college math courses, which can send the signal that students lack math ability and tend to include mostly math anxious students, research has shown that all students benefited from a reappraisal intervention (25). Theory on rejection sensitivity and identity threat posits that student factors (e.g., student socioeconomic status [SES], gender, or race) and school context interact to create heightened stress and anxiety when an important aspect of students' identities is salient and undermined in some way. Future studies should continue to investigate how context can create more highly pressurized situations for particular groups of students to understand better when and for whom these interventions yield a boost in performance.

One way to interpret the effectiveness of the interventions is in the context of the extended process model of emotion regulation (31). This model posits that emotion regulation occurs in three stages: (*i*) identification of the emotion, which involves noticing and evaluating whether to regulate the emotion, (*ii*) selection of an emotion regulation strategy if necessary, and (*iii*) implementing the emotion regulation strategy. Since both expressive writing and reappraisal were effective as singular interventions, both may be helping students to regulate their emotions effectively. However, this theoretical model points to differences in the underlying focus and mechanisms of each intervention. The reappraisal intervention focuses on selecting and implementing an emotion regulation strategy that instantiates the cognitive change necessary to reinterpret a situation in such a way that the meaning of that situation invokes a different emotional experience. Expressive writing focuses more on noticing, experiencing, and identifying one's emotions and is less specific on structuring the particular ways in which individuals should react to and manage their emotions. Prior research suggests that those who engage in expressive writing regulate their emotions by creating distance (37) and insight about their emotional experiences, but ultimately, expressive writing allows individuals to choose their own strategy for managing their emotions.

The lack of additional benefits of combining both expressive writing and reappraisal interventions was surprising since we hypothesized that allowing students to experience and identify their emotions through expressive writing and then scaffolding an effective reappraisal strategy would facilitate the emotion regulation process. It may be that since each intervention helps students regulate their emotional experience, combining them is redundant. Alternatively, there may be different ways to structure the combination of these interventions that could be effective. For instance, giving students the goal to reappraise their emotions before expressing them on paper could be more advantageous than asking students to express and then reappraise their emotions (as we did here). Structured in this way, students would have reappraisal in mind while writing about their emotions in the expressive writing exercise.

In conclusion, the recent research on applying psychological theory to improve student outcomes in educational settings has demonstrated potential to generate substantial and lasting change as one of many tools policymakers can use in the fight against inequality (18, 30). However, few studies have focused specifically on helping students regulate their emotions more adaptively during critical evaluative assessments that hold a great degree of influence over course grades. In this large-scale study, we show that such brief but psychologically precise emotion regulation interventions can benefit students' examination performance, the rate at which they pass their courses, and the attitudes they hold about the efficacy of stress during tests. Importantly, there are considerable and seemingly intransigent gaps between economically advantaged and disadvantaged students on these outcomes, and the emotion regulation interventions tested in this study reduced the size of those gaps. Of course, the current interventions are only targeting one part of the problem of student underperformance. Nonetheless, emotion regulation interventions—which are implementable at the school level—appear to be one tool that can help students from lower-income backgrounds participate in STEM fields that can increase opportunities for success.

Materials and Methods

Participants. Participants were 1,175 ninth grade students taking the freshman biology course at a large, diverse public school across 2 y of data collection. The students were 53% female, 24% were from lower-income backgrounds (as indicated by free or reduced lunch status), 56% were White, 21% were African American, 15% were Latino, 7% were Asian, and the remaining 1% of students identified as being members of other groups (e.g., Pacific Islander).

Procedure. All students in the biology courses completed two writing exercises and a survey at the end of the school year. Parents were sent a letter informing them of the study and how they could opt out of sharing their student's data with researchers. Students were similarly allowed to opt out of sharing their data with researchers. In total, 17 students opted out of sharing their data, leaving the study with a highly representative sample of the student population (more than 98% of the population participating). The reported analytic sample does not include the 17 students who opted out of the study. These procedures were approved by the Institutional Review Board at the University of Chicago.

During the school year, students completed the following activities: (*i*) short writing exercises before their first semester final examination in January and second semester final examination in May and (*ii*) a survey on the last days of school. For 10 min directly preceding each semester final examination, students completed a writing exercise as part of the study. Students were randomly assigned to the following conditions: (*i*) an expressive writing intervention in which students wrote freely about their thoughts before the test, (*ii*) a reappraisal intervention in which students were asked to evaluate their symptoms of stress as helpful for test taking, (*iii*) an intervention that combines the expressive writing and reappraisal interventions, and (*iv*) a an active control condition that instructed students to ignore symptoms of their stress and nervousness. Students received the same type of writing exercise before both finals.

Data were collected over 2 y. The control condition had 346 students, the expressive writing condition had 347 students, the reappraisal condition had 345 students, and the combined expressive writing and reappraisal condition had 137 students (a smaller number in this group because this condition was only included in 1 y of the data collection). See *SI Appendix* for more detailed information on the interventions and procedure.

Writing Exercises. The writing exercises were created by modifying exercises used in the two previous field studies in schools. The expressive writing exercise asked students to think about their emotions and thoughts before the examination and express them in writing (24). The reappraisal writing exercise was a modified version (adapted for high school students) of the intervention developed by Jamieson et al. (25). This writing exercise asked students to answer brief comprehension questions after completing a reading ostensibly written by scientists that explained that the anxious arousal felt before stressful events is actually meant to be helpful instead of harmful. The combined intervention involved slightly shortened versions of each exercise with the expressive writing component first and the reappraisal component second. The active control condition asked students to ignore their anxiety, which has been shown to be helpful compared with a neutral control condition in prior studies (e.g., ref. 38) and was based on prior research (25). Students in the expressive writing condition received the exact same prompt before each examination whereas students in the reappraisal, combined, and control conditions received different prompts in semester 1 compared with semester 2, but the prompts gave a similar message. The difference in these prompts from semester to semester was to avoid repetition since reappraisal and control writing exercises involved a longer reading component that would be repetitive if it were exactly the same reading selection used in each semester.

Survey Measures. A postintervention survey of reappraisal of test anxiety (39) was given to students at the very end of the school year to assess whether they viewed anxiety during tests as potentially enhancing (example item rated on a 1–5, never true about me-always true about me, scale: "A test will go well if I am a little nervous before taking it"). The four-item scale had high reliability ($\alpha = 0.87$), and the majority of students completed the survey measure (73%).

Academic Records. Academic records were collected from the school district to assess effects of the interventions on examination performance and course passing rate. Further, to increase statistical precision, prior year MAP (Measures of Academic Progress) standardized test scores were collected to use as a covariate in the analyses.

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