Improving Community College Students' Success in Math: Findings from Two Utility-Value Studies

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Author Note

This work was supported by the National Science Foundation under award number 2000507. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Science Foundation.

We have no conflicts of interest to disclose.

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Abstract

Although designed to prepare students for future coursework or to fulfill basic degree requirements, introductory math courses often serve as barriers to student success. In two double-blind randomized field experiments, we tested the efficacy of a utility-value intervention on improving community college students' perceived math relevance and achievement in introductory math courses. Building upon prior research, we examined whether the intervention particularly benefited first-generation and racially marginalized students. Study 1 ($N = 696$) was conducted before the COVID-19 pandemic and within in-person classrooms, whereas Study 2 ($N = 1,318$) was conducted during the pandemic and within virtual learning environments. Across Studies 1 and 2, students in the utility-value condition benefited more in terms of their perceived relevance compared to their peers in the control condition. Additionally, in both studies, math relevance mediated the effects of the intervention on math grades. In Study 2, with a larger sample, the positive effect of the intervention on math relevance was more pronounced for first-generation students. Our findings imply that community colleges could significantly improve students' academic experiences by investing in motivation-enhancing activities such as utility-value interventions in introductory math courses. This strategy could especially help first-generation students' academic achievement and retention rates.

Keywords: utility-value intervention, motivation, randomized controlled trial, math education, community college, first-generation student

Improving Community College Students' Success in Math: Findings from Two Utility-Value Studies

Introductory science, technology, engineering, and math (STEM) courses often serve as barriers for degree completion and student success (e.g., Meaders et al., 2020; Watkins & Mazur, 2013). This is particularly true for first-generation and racially marginalized students, who face greater structural barriers to success in these courses compared to their continuing-generation and non-marginalized counterparts, resulting in significantly lower pass rates (Chen & Carroll, 2005; Lisberg & Woods, 2018). One psychological factor related to student success in STEM is student motivation. Unfortunately, an abundance of research demonstrates that student motivation substantially declines over time, leading to lower academic performance and retention (Kosovich et al., 2017; Totonchi et al., 2021).

A variety of psychological interventions seek to sustain or increase students' motivation, achievement, and persistence in STEM domains. For example, grounded in expectancy-value-cost theory (Barron & Hulleman, 2015; Eccles et al., 1983), utility-value interventions are found to increase students' math interest and achievement in four-year colleges (e.g., Hulleman & Harackiewicz, 2020; Rosenzweig et al., 2020). However, more research is needed on the efficacy of these interventions at two-year colleges, which report low rates of STEM persistence (e.g., Chen, 2013). Given that a large proportion of community college students are from first-generation and racially marginalized backgrounds (ACT, 2017; Skomsvold, 2014), it is important to test the effects of the utility-value intervention for this population. Therefore, we investigated the effects of a utility-value intervention on improving community college students' math achievement. Further, we explored the psychological mechanisms through which utility-value interventions impact student achievement and tested whether, consistent with prior research (e.g., Harackiewicz et al., 2016), the intervention particularly benefited first-generation and racially marginalized students.

A Brief Overview of Expectancy-Value-Cost Model of Achievement Motivation

According to the expectancy-value-cost model (Barron & Hulleman, 2015; Eccles et al., 1983; Eccles & Wigfield, 2020), students' motivation to engage and persist in a task is determined by their expectations for success in the task (expectancies), their values for the task (values), and their perceived drawbacks associated with the task (costs). All three components of this theory have been found to predict learning outcomes. For instance, expectancies positively predict performance, persistence, and course-taking (see Richardson et al., 2012, for a review). Task values are multifaceted and relate to students' enjoyment in a task (intrinsic value), perceived importance to one's identity (attainment value), and perceived usefulness of a task (utility value). Numerous studies have reported on the positive relations of task values with other motivational beliefs and achievement-related outcomes such as grades and persistence (see Wigfield & Cambria, 2010, for a review). On the other hand, costs, which are relatively understudied in the educational psychology field, negatively predict these achievement outcomes (e.g., Kosovich et al., 2017).

Utility value is the focus of this study. Students' perceptions of utility value (or usefulness of a task/domain) have been correlated with a variety of achievement-related behaviors and outcomes (e.g., Bong, 2001; Durik et al., 2006). Eccles and her colleagues argued that students find utility value in a task when they can connect the task to future short- and long-term goals (Eccles & Wigfield, 2020). Therefore, many utility-value measures are created to assess that exact connection. For example, utility-value items such as "math will be useful to me later in life" (Conley, 2012, p. 47) have been positively associated with a variety of motivational beliefs (e.g., Hulleman et al., 2010), course achievement (e.g., Hulleman et al., 2008), and course-taking (e.g., Durik et al., 2006). Given the role of utility value on learning outcomes and its malleability in the face of interventions (Hulleman & Harackiewicz, 2020), these motivational beliefs become good candidates for targeted classroom-based interventions.

Utility-Value Interventions

Utility-value interventions are designed to enhance students' perceptions of the usefulness of a learning task (e.g., Gaspard et al., 2015; Hulleman & Cordray, 2009; Hulleman et al., 2010; Hulleman et al., 2017). The theory is that helping students draw connections between course content and their daily lives will increase students' perceived utility value for the course. Several intervention studies enhanced students' perceived utility value for their course through a relevance-finding writing activity (Hulleman & Cordray, 2009; Hulleman et al., 2010). In these interventions, students were randomly assigned to either write about the relevance of the course to their lives (utility-value condition) or to summarize what they were currently learning in the course (control condition). Studies conducted with students in different academic levels (high school and four-year college) and disciplines (science and psychology) suggested that engaging in utility-value writing activities enhanced students' interest and academic performance in the course (Hulleman et al., 2017; Hulleman & Harackiewicz, 2009).

However, utility-value interventions do not affect all students the same way. Existing research suggests that utility-value interventions particularly benefit students with lower prior achievement (Hulleman et al., 2017; Rosenzweig et al., 2020). Students with lower initial exam grades who were in the utility-value condition expressed higher interest in the course and achieved better grades compared to similar students who were in the control condition. Utility-value interventions are also more effective for students who doubt their competence and abilities to succeed (Durik et al., 2015; Hulleman et al., 2010; Hulleman & Harackiewicz, 2009). When students report lower competence beliefs, those in the utility-value condition demonstrate an increase in their end-of-semester GPA.

The discussed results could have important implications for the efficacy of utility-value interventions for first-generation and racially marginalized students. First-generation students are less likely to have access to rigorous high school preparation (Warburton et al., 2001), so many enter college with fewer completed math and science courses in high school, and, expectedly, they tend to have lower self-efficacy compared to their continuing-generation counterparts (Bettencourt et al., 2020). Students who are racially marginalized commonly experience stereotypes that question their competence and intellectual ability in academic environments.

Chronic exposure to these stereotypes may eventually lead to anxiety about inadvertently confirming them, leading to lower competence beliefs and higher deidentification from the academic domain (Steele & Aronson, 1995; Woodcock et al., 2012). Because many first-generation students are disproportionately from racially marginalized groups, they may experience a combination of racism and classism on college campuses (Quaye et al., 2015; Vaccaro & Newman, 2016), which could undermine their college experience and negatively impact their academic achievement and persistence. Indeed, research suggests that compared to continuing-generation and racial majority students, first-generation and racially marginalized students express stronger intentions to leave their STEM majors prior to graduation (Chen, 2013; Xu, 2016). Given that utility-value interventions primarily benefit students with lower prior achievement and competence beliefs, it stands to reason that these interventions may have stronger, more positive effects on first-generation and racially marginalized students.

Relatedly, Harackiewicz and her colleagues (2016) examined the effects of a utility-value intervention on biology students at a four-year institution and reported that the intervention was particularly beneficial for first-generation students and those who were racially marginalized. In their study, the utility-value intervention resulted in a significantly higher increase in science achievement for each of these underserved groups than for other students. Also, the utility-value intervention narrowed the performance equity gap by 61% for students who were both first-generation and racially marginalized. Examining the efficacy of psychological interventions for underserved students is important, as it helps narrow the equity gaps that exist in schools in general and STEM disciplines in particular (e.g., Bettencourt et al., 2020).

Utility-value interventions affect learning outcomes through a variety of psychological processes (e.g., Hulleman & Harackiewicz, 2020; Rosenzweig et al., 2021). One such process is perceived relevance for learning tasks. The writing activities for utility-value interventions increase students' perceived relevance for tasks by enabling them to identify new relationships between themselves and learning tasks (Hulleman et al., 2017; Hulleman & Harackiewicz, 2009). Identifying such connections helps students learn better as they engage in deeper integration of old (related to the self) and new (related to learning tasks) knowledge (Bransford & Schwartz, 1999). In line with these theoretical expectations, Hulleman and colleagues (2017) found that students who made more frequent connections between their coursework and their lives reported higher expectations for success, value, and continuing interest for their coursework. Higher success expectancies, in turn, led to better performance in the course. In the present study, we investigated whether perceived relevance serves as a psychological mechanism for the effects of a utility-value intervention on achievement.

The Importance of Context and the Current Study

Most utility-value intervention research has been conducted in elite four-year universities; research on the efficacy of these interventions in two-year colleges is limited (Hulleman et al., 2022). Community colleges are open-access institutions, serving more than one-third of degree-seeking students in the U.S. and disproportionately enrolling students who are marginalized (Hoachlander et al., 2003; Juszkiewicz, 2020). Compared to four-year institutions, larger numbers of community college students are adult learners, many of whom enroll part-time to accommodate work schedules and other responsibilities (e.g., Skomsvold, 2014). Therefore, many community college students enter with rich workforce and life experience. The diversity in the community college population also means different levels of recent academic preparation, especially preparation required for STEM coursework.

Students are often required to earn credit in an introductory STEM course before advancing to main degree-related courses. Introductory math courses, for instance, are designed to increase students' baseline knowledge of algebra or statistics and help prepare students for subsequent courses. Despite their purpose, introductory courses often serve as barriers to success. Identifying the various aspects of these gateway math courses that community college students perceive as useful is imperative for at least two reasons: first, it will support students in achieving their goals, which may center upon preparing for a timely entrance to workforce, second, it will provide a unique opportunity to narrow several equity gaps (e.g., race, social class, age) in our education and workforce systems.

In two double-blind randomized field experiments (both studies were approved by the Institutional Review Board at the last author's affiliated institution), we examined the efficacy of the utility-value intervention within the community college math context. Specifically, Study 1 was implemented at one institution serving a majority White population of students from rural counties in the eastern region of a large state. Study 2 then scaled the intervention across three institutions serving students from both rural and urban counties across three distinct geographic regions of the state. In addition, the two urban institutions added in Study 2 served significantly more racially diverse student populations, with one of the institutions serving a majority Black population. Study 1 was initially implemented across two introductory math courses (Introduction to College Math and Introductory Statistics), and Study 2 added an additional two courses to the implementation plan (College Algebra and Finite Math), for a total of four math courses. These course syllabi contained several overlapping topics, including decimals and percentages, probability, and sampling. The majority of the course sections that participated in both studies were Introductory Statistics courses, since this course is required for the degree pathways with the highest student enrollment at participating institutions.

Besides the differences in demographic diversity and type of math courses, the two studies were also different on two important contextual factors. First, Study 2 took place in Spring 2021 during the COVID-19 pandemic, whereas Study 1 was conducted in Spring 2019 before the onset of the pandemic. Second, all of the participating courses in Study 2 were taught virtually as a result of the extended pandemic shutdowns, while the majority of Study 1 courses were taught in person. The negative effects of the pandemic and the forced move to a virtual environment on students' motivation and achievement have been documented (e.g., Daniels et al., 2021; Erentaitė et al., 2022). However, it has remained unclear whether the existing motivation-enhancing interventions would still demonstrate efficacy in improving students' outcomes in such environments. Positive intervention effects in this sort of unprecedented environment would lend more confidence to the notion that utility-value interventions can support students across a variety of diverse learning contexts, thereby expanding the external validity of the results. Accordingly, we examined the efficacy of the utility-value interventions across two studies and addressed the following research questions:

RQ1: Is there an overall effect of the utility-value intervention on students' math achievement in community college contexts?

RQ2: Does perceived math relevance serve as a psychological mechanism for the effects of the utility-value intervention on math achievement in community college contexts?

RQ3: Is the utility-value intervention more effective for first-generation and racially marginalized students compared to their continuing-generation and racially non-marginalized counterparts?

Study 1

We randomly assigned community college students to either a control condition or the utility-value condition. We hypothesized that students in the utility-value condition would perceive more relevance for math following the intervention compared to students in the control condition. Also, we hypothesized that higher perceived relevance, in turn, would predict higher math grades. Lastly, we hypothesized that the positive effects of the intervention on relevance and grades would be stronger for first-generation and racially marginalized students.

Methods

Participants and Procedure

In order to invite students to participate in our project, we first invited introductory math instructors in a community college in the Southeastern United States to enroll in our project. Twenty-two instructors teaching 44 course sections were recruited by the Math Department Chair via emails, announcements during departmental meetings, and individual outreach in Spring 2019. Instructors then enrolled their full course sections in the project. All students in those course sections were given the opportunity to participate in the research project as part of their course, though instructors were kept blind to student condition. Using this approach, we recruited 813 students from two introductory math courses (27.7% from Introduction to College Math and 72.3% from Introductory Statistics). During the first week of the semester (week 1), students completed the pre-intervention survey assessing their perceived relevance for mathematics at the baseline. By the end of week 2, we assigned student participants to either a control condition or the utility-value condition. Students were randomized to an intervention condition based on their unique student ID number and were required to log-in to each intervention activity using this number to ensure they received the correct intervention materials, minimizing the threat of contamination. At week 3, students completed the first intervention activity. At week 5, students completed the second intervention activity. We also assessed students' perceived relevance after they completed each intervention activity at weeks 3 and 5. Each activity took about 15 minutes to complete. Surveys and intervention materials were administered using the Qualtrics online platform.

In order to be included in analyses, students must have participated in at least one of the two intervention activities, resulting in a final sample of 696 students ($M_{age} = 23.33$, $SD_{age} = 7.84$). Participants were 65.6% female, 56.9% first-generation, 71.0% White, 14.4% African-American, 4.7% Hispanic/Latine, 6.0% multi-racial, and 2.5% Asian, with the remainder selecting other races or declining to answer. Of these 696 students, 543 (78%) completed the pre-intervention perceived relevance survey at Week 1, 587 (84%) completed the first intervention activity at Week 3, and 528 (76%) completed the second intervention activity at Week 5. Importantly, 451 (65%) completed both intervention activities. The researchers tracked student participation and provided instructors with lists of students who should be compensated with course credit for completing each activity.

Intervention

In the first intervention activity, students in the control condition were asked to summarize a concept from their current math course. Students in the intervention condition were asked to read eight quotations from previous students about how math was important to their lives, rank these quotes based on how relevant they found them, and then complete a short writing prompt explaining why they ranked the top two quotes as the most personally relevant.

In the second intervention activity, students in the control condition were asked to write about the study strategies they used to prepare for their math class, as well as answer some additional survey questions about their experience in their math course. Students in the utility-value intervention condition were asked to read several student quotes about how math could be used to solve real-world problems and were then prompted to write about how they could use recently-learned math concepts to solve a problem. The intervention materials and procedures were adapted from previous utility-value literature by the authors (Kosovich et al., 2019; Hulleman et al., 2022). See the Appendix for sample intervention materials.

Measures

Measures included perceived math relevance and student demographic questions. Math relevance was assessed prior to implementing the intervention activities (pre-intervention) and after implementing each of the two intervention activities (post-intervention) using two items ("How important is the course material to your future?" and "How relevant is the course material to your future career plans?"). These items were adapted from the Expectancy-Value-Cost Scale (Hulleman et al., 2017) and assessed on a 5-point scale (1 = *Not at all important* to 5 = *Extremely important*). The scores on the two post-intervention activity surveys were averaged to create a comprehensive post-intervention relevance scale. Both pre- and post-intervention relevance scales demonstrated adequate reliability (pre-intervention, $r = .76$; post-intervention, $r = .84$). Student race and gender demographic characteristics were obtained from administrative records. We created a dichotomous variable to indicate students' racially marginalized status. Black, Latine, and Native-American students, as well as multiracial students who selected at least one of these races were grouped into the racially marginalized category and White and Asian students, as well as multiracial students who selected one of these races were grouped in the racially non-marginalized category. Students' high school GPA and end-of-semester math grades were also obtained from administrative records and were used as proxies for prior achievement and math achievement, respectively. The scale for high school GPA and end-of-semester math grades ranged from 0 to 4.

To measure generation status, we asked students: "To the best of your knowledge, what is the highest level of education earned by your primary guardian, such as your mother or father? If your mother/father was not the person who raised you, then answer this question thinking about the adult who you spent a lot of time with growing up (such as your grandparent, step-parent, or legal guardian)." Using participants' responses, we then computed a binary first-generation variable. Participants not reporting a parent or guardian with a Bachelor's degree or higher were coded as first-generation, whereas students who reported one or both parents or guardians having a Bachelor's degree or higher were coded as continuing-generation (first-generation = 1; continuing-generation = 0).

Results

We performed path analyses to investigate the direct and indirect effects of condition on math achievement. Course section—the specific course offering in which a student was enrolled, with a unique meeting day and time, location, and instructor—was added as a cluster variable to the path models to account for the interdependence of individuals' scores within each course section. We handled missing data using full information maximum likelihood (FIML), which uses all available data to estimate a likelihood function for each individual (Davey & Salva, 2009). See Table 1 for the scale level missing data for each variable. We did not have any missingness at the item level for students for whom we had scale level data. Additionally, we found no evidence to suggest missingness did not occur at random. The result of Little's (1998) Missing Completely at Random (MCAR) test was non-significant, χ^2 (9) = 10.58, p = .305. To reduce the impact of non-normality and outliers, we used bootstrapping with 5,000 replications (Mooney et al., 1993). The significance of direct and indirect effects was determined based on 95% bootstrapped confidence intervals. The categorical predictor variable was coded as 0 = control condition and 1 = utility-value condition. The descriptive analyses were performed using SPSS (v.28), and the inferential statistics were conducted using MPLUS (v. 8.6).

Preliminary Analyses

See Table 1 for descriptive statistics and correlations among the variables. Before conducting the main analyses to address our research questions, we tested the baseline equivalency of students in the control versus utility-value conditions on demographic variables and prior achievement. There were no significant differences in any of our main demographic variables including gender [$X^2(1) = .02$, $p = .900$], generation status [$X^2(1) = .45$, $p = .500$], racially marginalized status [$X^2(1) = .04$, $p = .847$], prior achievement [$t(663) = .72$, $p = .473$], and pre-intervention relevance [$t(541) = 1.42$, $p = .155$], indicating successful randomization among the two intervention conditions. See Table 2 for descriptive information for students in each intervention condition. To reduce any potential bias caused by minor differences between groups at the baseline, we statistically controlled for gender, generation status, racially marginalized status, and high school GPA (proxy for prior achievement) in our analyses.

Additionally, to account for the potential effects of the math course type (algebra versus introductory statistics) on our outcome, we added the dichotomous course variable as a covariate in our path models. Pre-intervention relevance was controlled for in models that included post-intervention relevance. Controlling for baseline beliefs is in accordance with best practices in experimental studies that aim to change a belief (e.g., Gaspard et al., 2015, 2021; Hulleman et al., 2009, 2010, 2017; Landau et al., 2018; McKenzie, 2012).

Intervention Fidelity. To assess the fidelity of the intervention, participants' essay responses in both the control and intervention conditions were coded to examine whether students connected the math course materials to their goals and lives in personal and specific ways. We used procedures similar to other utility-value intervention studies that assessed fidelity (e.g., Brisson et al., 2020; Hulleman & Cordray, 2009: Nagengast et al., 2018). Two coders coded 40% of the essays together and achieved a 92.5% agreement rate. Then, the coders each coded half of the remaining essays independently. Lastly, a third coder with more expertise in utility-value essay coding reviewed all the coded essays for accuracy and triangulation. Ratings on both the personal and specific indicators ranged from 0 (no connection was made) to 3 (connection was highly personal/specific to math topic). After the essays were coded, we conducted independent samples t tests to examine whether students in the utility-value condition made higher quality connections. Results indicated that, as expected, participants in the utility-value condition made significantly more personal [$t(509) = 25.18$, $p < .001$] and specific connections [$t(509) = 24.17$, $p < .001$] than students in the control condition.

RQ1: Is There an Overall Effect of the Utility-Value Intervention on Students' Math Achievement?

To address our first research question, we regressed students' math grades on the intervention. Results indicated that the overall effect of intervention on math grades was not statistically significant (b = .13, 95% CI [-.08, .34]). See Table 3 for results.

RQ2: Does Perceived Math Relevance Serve as a Psychological Mechanism for the Effects of the Utility-Value Intervention on Math Achievement?

To address the second research question, we tested the indirect effect of intervention on math grades through perceived relevance. The path analysis revealed that the effect of intervention on post-intervention relevance was significant (b = .17, 95% CI [.05, .29]).[1] Contrary to the students in the control condition whose perceived relevance did not change significantly over time [t (165)= -.71, p = .481; M = -.05, SD = .85, d = -.06], students in the utility-value condition experienced significant increases in relevance [t (370)= 4.47, p < .001; M =.20, SD = .84, d = .20; see Figure 1]. Additionally, the effect of post-intervention relevance on math grades was significant, such that students who found math more relevant after the intervention received higher grades (b = .25, 95% CI [.10, .38]). See Table 4 for a summary of

[1] To complement these analyses, we conducted a 2x2 mixed models ANOVA to examine whether change in relevance from pre-intervention to post-intervention differs across the utility-value versus control conditions. Results revealed that, consistent with our path analyses, the interaction between condition (control vs. utility-value) and time (pre-intervention vs post-intervention) was significant F (1, 535) = 9.42, p = .002, suggesting that students in the control and utility-value conditions experienced different types of change in their perceived math relevance.

these effects. Further, the indirect effect of intervention on grades through relevance was significant (b = .04, 95% CI [.01, .09]). That is, the utility-value intervention increased perceived relevance, which, in turn, improved achievement.

RQ3: Is the Utility-Value Intervention More Effective for First-Generation and Racially Marginalized Students Compared to Their Continuing-Generation and Racially Non-Marginalized Counterparts?

To address the third research question, we examined the role of generation status and racially marginalized status in moderating the effect of intervention on perceived math relevance. Results suggested that the intervention did not significantly interact with either generation status or racially marginalized status to predict math perceived relevance and achievement (see Table 5). That is, the intervention was equally beneficial to first-generation and continuing-generation students and also equally beneficial to racially marginalized and non-marginalized students.

Discussion

Although an overall effect of the utility-value intervention on math achievement was not statistically significant, we established an indirect effect of the utility-value intervention on achievement through the predicted psychological process. Specifically, the findings suggested that asking students to find relevance in math increased their perceived relevance for the course. The increase in relevance, in turn, positively predicted students' math grades. These findings contribute to the literature in several ways. First, the unique community college context of this study allowed us to examine the efficacy of the utility-value intervention in two-year colleges, where retention is a significant issue (Chen, 2013). These findings extend prior research that is mostly conducted in selective four-year universities. Second, results also supported the theoretical expectation that perceived relevance would serve as a psychological mechanism for the effect of the utility-value intervention on achievement. However, inconsistent with prior research, which suggests utility-value interventions benefit students from underserved groups the most (Harackiewicz et al., 2016), our results did not provide evidence for the higher efficacy of the intervention for first-generation and racially marginalized students. Sample size limitations might partially explain these non-significant moderation effects. We had a limited number of students in each demographic group/intervention condition cell (e.g., we had only 91 continuing-generation students in the control condition). In response, we collected a larger, more diverse sample in Study 2 to obtain sufficient statistical power to examine these effects with more confidence.

Study 2

Study 2 followed the same research design, methodology, and data analyses approach as Study 1. However, Study 2 was unique in that intervention and data collection were implemented during the pandemic, in a completely virtual learning environment, and with a more diverse sample of students. In Study 2, students were once again randomly assigned into the utility-value intervention condition or a control condition, and we tested the same hypotheses in Study 2 as we did in Study 1. That is, we expected that students in the utility-value condition would report higher perceived math relevance, which would in turn result in higher math grades. Additionally, we hypothesized that the intervention would be more effective for first-generation and racially marginalized students. Even though this last hypothesis was not supported in Study 1, we believed that a larger and more diverse sample in Study 2 would yield results aligned with prior utility-value research on narrowing socioeconomic and racial equity gaps (Harackiewicz et al., 2016). Results consistent with our hypotheses would provide evidence for the efficacy of utility-value interventions in a virtual setting as well as during the pandemic when decreases in motivation and achievement were substantial, thereby extending the external validity of our results.

Method

Participants and Procedure

The data collection procedure and timeline for this study was the same as for Study 1. Participants were 1,609 students recruited across four introductory math courses (12.4% from Math for General Studies, 8.6% from College Algebra, 70.6% from Introductory Statistics, and 8.5% from Finite Math) in three community colleges in one Southeastern state. Participants were recruited from 98 course sections taught by 39 instructors. In order to be included in analyses, students must have participated in at least one of the intervention activities, resulting in a final sample of 1,318 students ($M_{\text{age}} = 25.59$, $SD_{\text{age}} = 9.26$) who were randomly assigned to the control ($N = 586$) or utility-value ($N = 732$) conditions.

The survey measures, intervention materials, and implementation timeline were the same across both studies. Both pre- and post-intervention relevance scales demonstrated excellent reliability (*r* = .75 for pre-intervention relevance; *r* = .85 for post-intervention relevance). Of the 1,318 students included in the study, 1,122 (85%) completed the pre-intervention perceived relevance survey at week 1, 1,107 (84%) completed the first intervention activity at week 3, and 852 (65%) completed the second intervention activity at week 5. Further, 696 (53%) completed both intervention activities. Participants were 71.3% female, 55.2% first-generation, 51.9% White, 26.4% African-American, 8.1% multi-racial, 6.1% Hispanic/Latine, and 3.2% Asian, with the remainder selecting other races or declining to answer.

Results

We performed path analyses to investigate the direct and indirect effects of intervention on math grades. We again added course section as the cluster variable to our path models. We found no evidence to suggest missingness did not occur at random. The result of Little's (1998) Missing Completely at Random (MCAR) test was non-significant, χ^2 (9) = 10.68, $p = .298$.

Preliminary Analyses

See Table 6 for descriptive statistics and correlations. We tested the baseline equivalence of students in the control and intervention conditions. There were no significant differences in gender [$X^2(1) < .01$, $p = .957$], generation status [$X^2(1) = .06$, $p = .808$], racially marginalized status [$X^2(1) = 2.31$, $p = .129$], and pre-intervention relevance [$t(1116) = -.89$, $p = .372$]. However, students in the intervention condition had higher high school GPAs than students in the control condition [$t(1069) = -2.69$, $p = .007$]. Table 7 breaks down descriptive information by intervention condition. To reduce any potential bias caused by differences between groups at the baseline, we statistically controlled for gender, generation status, racially marginalized status, and high school GPA in our analyses. Pre-intervention relevance was controlled for in models that included post-intervention relevance. Additionally, to account for the potential effects of the math course type (four different courses) and institution (three different institutions) on our outcomes, we created dummy-coded variables to represent these indicators and added them as covariates in our path models.

Intervention Fidelity. The process for testing the fidelity of the intervention by coding student essays in Study 2 was the same as Study 1. Participant essays in both the control and intervention conditions were coded for the quality of connections by two coders, with a third coder reviewing all coded essays for accuracy and triangulation. As expected, results indicated that participants in the utility-value condition mentioned significantly more personal [$t(817) = 22.90$, $p < .001$] and specific [$t(817) = 17.79$, $p < .001$] connections in their essays than those in the control condition.

RQ1: Is There an Overall Effect of the Utility-Value Intervention on Students' Math Achievement?

Contrary to our hypothesis, we found no significant overall effect of the intervention on math grades ($b = -.09$, 95% CI [-.29, .14]). See Table 8 for results.

RQ2: Does Perceived Math Relevance Serve as a Psychological Mechanism for the Effects of the Utility-Value Intervention on Math Achievement?

Supporting our hypothesis, results revealed that the effect of intervention on post-intervention perceived relevance was significant (*b* = .20, 95% CI [.10, .32]).[2] Although students in both conditions experienced significant decreases in relevance over time, students in the utility-value condition reported smaller decreases in relevance [*t* (596) = -2.97, *p* = .003; *M* = -.13, *SD* = 1.05, *d* = -.11] compared to those in the control condition [*t* (476)= -5.88, *p* < .001; *M* = -.30, *SD* = 1.10, *d* = -.24; see Figure 2]. Additionally, the direct effect of post-intervention relevance on math grades was significant (*b* = .17, 95% CI [.08, .26]), such that students who found math more relevant after the intervention earned higher grades. See Table 9 for a summary of these effects. The indirect effect of condition on grades through relevance was significant (*b* = .03, 95% CI [.01, .07]). That is, the utility-value intervention decelerated the decrease in students' perceived relevance, which in turn had positive effects on their math achievement.

RQ3: Is the Utility-Value Intervention More Effective for First-Generation and Racially Marginalized Students Compared to Their Continuing-Generation and Racially Non-Marginalized Counterparts?

With a larger and more diverse sample in Study 2, the effect of the interaction of intervention by generation status on post-intervention relevance was significant, which supported

[2] To complement these analyses, we also conducted a 2x2 mixed model ANOVA to examine whether change in relevance from pre-intervention to post-intervention differs across the utility-value versus control conditions. Results suggested that the interaction between condition (control vs. utility-value) and time (pre-intervention vs. post-intervention) was significant *F* (1, 1072) = 6.57, *p* = .011, suggesting that students in the control and utility-value conditions experienced different types of change in their perceived math relevance.

our hypothesis (*b* = .25, 95% CI [.02, .48]; see Table 10). This significant interaction revealed that the efficacy of the utility-value intervention differed by generation status. We followed up this significant interaction effect with simple slope tests. Results revealed that the positive effect of the intervention on relevance was significant for first-generation students (*b* = .26, 95% CI [.09, .43]) but not for continuing-generation students (*b* = .02, 95% CI [-.17, .20]).[3] For first-generation students in the control condition, perceived math relevance decreased significantly from pre- to post-intervention [t (249)= -4.57, p < .001; M = -.34, SD = 1.16, d = -.27], but for first-generation students in the utility-value condition, perceived math relevance remained mostly stable over time [t (328)= -1.28, p = .203; M = -.07, SD =.99, d = -.06]. That is, the utility-value intervention protected first-generation students' perceived math relevance from decreasing over time. This buffering effect was not observed for the continuing-generation students, who experienced similar decreases in math relevance in the control [t (211)= -3.51, p < .001; M = -.24, SD = 1.00, d = -.19] and utility-value conditions [t (254)= -3.34, p < .001; M = -.23, SD = 1.11, d = -.19]. See Figure 3 for a graphical representation of this effect.

The indirect effect of intervention on grades through relevance was significantly moderated by generation status (*b* = .04, 95% CI [.01, .10]). Simple slope tests revealed that, for

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[3] Results of mixed model ANOVA suggested that for first-generation students, the interaction of condition (utility-value vs control) and time (pre-intervention vs post intervention) was significant F (1, 576) = 8.77, p = .003. These results suggested that the change from pre-intervention relevance to post-intervention relevance differs across conditions for first-generation students. For continuing-generation students, on the other hand, this interaction was not significant F (1, 465) = .01, p =.926, suggesting that the change in relevance did not differ for students in the utility-value and control conditions for continuing-generation students.

first-generation students, the indirect effect of intervention on grades through perceived relevance was significant (b = .04, 95% CI [.01, .09]). This indirect effect was not significant for continuing-generation students (b = .002. 95% CI [-.03, .04]). Therefore, for first-generation students, but not for continuing-generation students, the intervention protected perceived relevance from decreasing, which in turn had positive effects on achievement. The effect of the interaction of racially marginalized by intervention did not significantly predict post-intervention relevance. Also, this interaction did not significantly predict the indirect relation of intervention with grades through relevance (see Table 10). The larger sample size in Study 2 also enabled us to examine the effects of the intervention on students with intersectional first-generation and racially marginalized identities, which we discuss in the Supplemental Materials for Study 2.

Discussion

Study 2 results indicated that although the utility-value intervention did not directly improve community college students' math achievement, it did protect students' perceptions of relevance from decreasing rapidly over the semester. Such protective effects, in turn, had implications for students' final grades. Supporting our hypothesis, findings suggested that perceived relevance served as a psychological mechanism for the effects of the utility-value intervention on achievement.

Also, Study 2 results indicated that generation status, but not racially marginalized status, significantly moderated the effects of the intervention on perceived math relevance and the indirect effect of intervention on math grades through perceived relevance. Specifically, we found that first-generation students benefited most from the protective effects of the utility-value intervention on their perceived relevance, and, in turn, math grades. Therefore, the utility-value intervention narrowed equity gaps between first-generation and continuing-generation students in math. Students who were racially marginalized and those who were racially non-marginalized benefited equally from the intervention. Therefore, our results were partially consistent with prior research that suggests utility-value interventions have higher efficacy for underserved populations (Harackiewicz et al., 2016).

General Discussion

Results from these studies add to the growing body of research that suggests brief psychological interventions can improve students' motivation. Consistent with prior research (e.g., Gaspard et al., 2015; Hulleman et al., 2010), our findings revealed that the theory-guided utility-value intervention is effective in improving students' motivation, which, in turn, improved math achievement. Additionally, results further confirmed the theoretical expectation (Hulleman & Harackiewicz, 2021) that perceived relevance serves as a psychological process that explains the effects of the utility-value intervention on students' learning outcomes. Reading and writing about the usefulness of math has a positive impact on students' perceived math relevance. Higher math relevance, in turn, improves students' math achievement in the course.

While perceived math relevance remained roughly stable for students in the control condition in Study 1, it decreased significantly for students in both the utility-value and control conditions in Study 2. We suspect that the context within which Study 2 was implemented—

which presented numerous challenges due to the COVID-19 pandemic and a forced move to a virtual learning environment—as well as the larger sample spanning additional math courses can partially explain why motivation decreased broadly and sharply in Study 2 while it remained roughly stable in Study 1. Nevertheless, the observed downward trajectory of motivation in Study 2 is consistent with existing research with STEM students (e.g., Kosovich et al., 2017; Totonchi et al., 2021) and further highlights the importance of implementing motivational interventions early within introductory STEM courses.

Since many community college students major in non-STEM fields, they may struggle to see the relevance of having to take required introductory math courses in their future coursework or careers. Additionally, as the semester progresses and students face the difficulties of a STEM course (e.g., increased study hours, difficult tests, negative feedback), their sense of relevance may decline. This speculation is consistent with the expectancy-value-cost research that suggests utility value and perceived costs (drawbacks associated with engaging in a course) are synergistically and negatively related (e.g., Eccles & Wigfield, 2020). Therefore, investing in a utility-value intervention that helps students see the connection between what they learn in their introductory STEM courses and their lives could protect them from the sharp decrease in perceived relevance by increasing their values and decreasing their perceived costs for the course (Rosenzweig et al., 2020).

Relatedly, in Study 2, the utility-value intervention decelerated the decrease in perceived math relevance. Additionally, in Study 1, the utility-value intervention increased students' perceived relevance, which remained roughly stable in the absence of the intervention. The positive effects on relevance, in turn, positively impacted math achievement for students in the intervention condition. The consistent positive effects of the intervention on perceived relevance, and, in turn, achievement, across these two studies increase the external validity of our findings and suggest that the intervention is effective for students in different contexts. These results also provide a cautionary tale for practitioners who are interested in supporting students' motivation: interventions do not always increase motivation. In many contexts, such as within Study 2, interventions help improve student outcomes by buffering motivation loss.

In Study 2, we found that our intervention particularly benefited first-generation students, which is consistent with prior research (Harackiewicz et al., 2016; Hulleman et al., 2022). Results suggested that while perceived math relevance decreased sharply for first-generation students in the control condition, perceived relevance remained mostly stable for first-generation students in the utility-value condition. Therefore, the utility-value intervention protected first-generation students from a significant decrease in math relevance. This effect was not observed in continuing-generation students. Thus, our findings suggested that the utility-value intervention was effective in narrowing equity gaps between first-generation and continuing-generation students. These findings can be substantiated by prior empirical evidence that suggests utility-value interventions are particularly effective for students with lower competence beliefs (Durik et al., 2015). First-generation students tend to enter college with lower perceived academic preparedness (Warburton et al., 2001). Therefore, they may doubt their academic abilities and have lower expectations for success compared to continuing-generation students. This theory could explain the differential effectiveness of the utility-value interventions by generation status.

We did not find evidence for the added benefits of the intervention for students who were racially marginalized and those who were both first-generation and racially marginalized, contradicting prior findings (Harackiewicz et al., 2016). This lack of finding may be due to our unique sample composition. Our sample in Study 2 was incredibly diverse with 42% of students who were racially marginalized. This is starkly different from the sample in Harackiewicz and colleagues' (2016) study in which only 8% of students were racially marginalized. In research examining the efficacy of an identify-affirming intervention with racially diverse students, Hanselman and colleagues (2014) found that the intervention was more effective for students who found their environment to be more threatening, as defined by a lower proportion of racial marginalized students and greater academic disparities between racially marginalized and non-marginalized students. So, it may be that the added benefits of the utility-value intervention for racially marginalized students are more pronounced in high-threat, less racially diverse environments. Also interestingly, generation status and racially marginalized status were uncorrelated in Study 1 and weakly correlated in Study 2, suggesting little overlap between these two groups. This is a rare sample composition in education research that provides novel insights into the experiences of community college students. Closing equity gaps in such samples might take a different meaning, and more research is needed to investigate the efficacy of the interventions on majority marginalized populations.

It is also important to note that contrary to our expectations, the utility-value intervention did not directly improve math achievement in either Study 1 or Study 2. Further, although the intervention significantly impacted perceived relevance in both Study 1 and Study 2, these effects were small. We believe that the null effects on achievement and small effects on relevance could be due to unexplored heterogeneity. In our study, some of this heterogeneity was explained by students' generation status in Study 2. However, there is also heterogeneity in the context within which students learn math, which could either lessen or maximize the effects of the intervention. Researchers argue that psychological interventions that are designed to enhance a particular belief (e.g., growth mindset) could be more effective in contexts that support the development of that belief (e.g., Hecht et al., 2021). Therefore, future research is needed to investigate the interaction of context by intervention, which could contribute significantly to our knowledge about for whom and in what contexts the interventions are effective.

Limitations

There are several limitations to this research. One limitation pertains to the results of the indirect and overall effects. Even though we found significant positive indirect effects of the intervention on grades through relevance, the overall effects of the intervention on grades were not significant. Further, in Study 2, this non-significant overall effect had a negative sign. These results could suggest that the intervention may have had some negative effects perhaps on some potential mediators that were not included in our models. This is a possibility that needs to be empirically tested in future research, and caution should be exercised when interpreting the significant indirect effect. Additionally, perceived relevance, the mediator examined in this study, could shape achievement through a variety of processes (e.g., increased engagement and perceived control/agency; Hulleman & Harackiewicz, 2021) that were not included in this study. Therefore, future research is encouraged to utilize sequential mediation modeling to test the sequence of processes that could explain the effects of the utility-value intervention on relevance and achievement.

Another limitation concerns the measurement of generation status in our study. There is great diversity in the literature in the way generation status is operationally defined. Most researchers include parents' level of education as an indicator for generation status (e.g., DeAngelo & Franke, 2016; Lohfink and Paulsen, 2005). Others include siblings' and other family members' levels of education in calculation of this construct (e.g., Kim et al., 2020). Further, the cutoff criteria in education level to indicate a first-generation student varies in range (from no postsecondary attendance to no Bachelor's or graduate level degree; e.g., Choy, 2001; Redford et al., 2017). We opted for the most common approach, which involved using parents' obtained Bachelor's degree as the indicator of generation status. The Bachelor's degree is also commonly used as a cutoff line to highlight social class disparities in the U.S. (e.g., NCES, 2020), which provided insights into the equity gaps in our sample. Nevertheless, we acknowledge that this binary representation is limited in capturing unique experiences of community college students.

Lastly, the pandemic and the move to online classes also added several unknown factors to our exploration of the efficacy of the intervention in Study 2. On the one hand, we might conclude that the intervention may have filled a gap and proved especially helpful in the context of Study 2, where motivational challenges were more salient (e.g., Daniels et al., 2021; Erentaitė et al., 2022). On the other hand, the established mental health consequences associated with social isolation, COVID anxiety, concerns about digital learning/online technology competencies, and the increase in students' responsibilities and other roles (e.g., Fong, 2022; Yang et al., 2021) may have diminished students' willingness, energy, and availability to invest in the intervention. Therefore, it is possible that the intervention did not have its full impact on students in Study 2 because of these contextual challenges. While our preliminary fidelity measures (intervention fidelity tests, response rates) did not indicate substantial differences between the two studies, the unplanned contextual differences between the two studies limit us in making strong comparisons of the findings between the studies.

Implications for Practice

This study has implications for community college practitioners and policymakers. With exposure to as few as one or two activities, utility-value interventions produce positive effects among students with different majors and demographic backgrounds, as well as in courses with different formats (e.g., Harackiewicz et al., 2016; Hulleman & Harackiewicz, 2009; Hulleman et al., 2010; Hulleman et al., 2017). Because first-generation students comprise a large proportion of community college populations (over 55% in the current studies' samples), community colleges could improve students' learning outcomes by investing in interventions that are designed to specifically address the needs of this population.

The primary motivation for many first-generation students who pursue two-year colleges is to obtain workforce training so they can enter the labor market quickly, which has numerous benefits for the individual, their families, and their communities. Therefore, for some of these students, the non-applied courses such as math, which might have no apparent connection to the students' current or future jobs, may be especially demotivating. Instructional practices that are consistent with the utility-value theory could prove particularly helpful in these contexts. By highlighting the real-world applications of math to a variety of jobs, community college instructors could help their students find these courses relevant to their goals. This recommendation is in line with research that suggests students whose instructors provide more rationale for learning the course tend to have higher values for the coursework (Patall et al., 2013). Further, by incorporating utility-value activities in the curriculum and allocating time in classrooms for students to write and talk about how they find mathematics useful, students will make their own personalized connections with math and also hear from their peers about new ways that math can be used in real life. By investing in motivation-enhancing utility-value practices, community college practitioners and policymakers could significantly improve students' academic experiences, contribute to narrowing equity gaps among first-generation and continuing-generation students, increase institutional achievement and retention rates, and, importantly, improve workforce development.

Conclusion

This two-study research examined the efficacy of a utility-value intervention in promoting community college students' motivation and achievement in math courses. Results of both studies revealed that the utility-value intervention had positive effects on students' perceived relevance for mathematics. Students with higher perceived math relevance, in turn, achieved higher math grades. Thus, results provided empirical evidence for the theoretical expectation that perceived relevance serves as a psychological process for the effects of the utility-value intervention on grades. Further, results of Study 2 suggested that the positive effects of the intervention on relevance and, in turn, on math grades were stronger for first-generation students. This research has implications for practitioners and policymakers. Investing in brief, motivation-enhancing reflection activities could increase STEM achievement for community college students, many of whom are first-generation students.

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Table 1

Study 1: Correlations and Descriptive Statistics for Variables of Interest

	1	2	3	4	5	6	7	8
1. Utility-Value Intervention	-							
2. Pre-Relevance	-.06	-						
3. Post-Relevance	.03	.65**	-					
4. Racially Marginalized	-.01	.11**	.14**	-				
5. First Generation	-.03	.05	.05	<.01	-			
6. Female	-.01	.001	-.02	<.01	.16**	-		
7. High School GPA	-.03	.01	-.03	-.17**	-.07	.11**	-	
8. Math Grade	.04	.11*	.15**	-.17**	-.08*	-.04	.26**	-
M	0.68	3.11	3.22	0.24	0.57	0.66	3.15	1.84
SD	-	1.05	1.02	-	-	-	0.64	1.55
N	696	543	690	670	692	696	665	661
% Missing	0%	22.0%	0.9%	3.7%	0.6%	0%	4.5%	5.0%

Note: Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized). Racially marginalized students include Black, Latine, Native American, as well as multiracial students who selected at least one of these races. Racially non-marginalized students include White, Asian, as well as multiracial White and Asian students. First Generation is coded as 0 = continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). The scale for high school GPA and end-of-semester math grades ranged from 0 to 4.

**p* < .05, ***p* < .01

Table 2

Study 1: Descriptive Statistics by Intervention Condition for Variables of Interest

	Control (N = 222)		Utility-Value (N = 474)		Overall (N = 696)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre-Relevance	3.20	0.99	3.07	1.07	3.11	1.05
Post-Relevance	3.17	1.04	3.23	1.01	3.22	1.02
High school GPA	3.17	0.66	3.13	0.63	3.15	0.64
Math Grade	1.76	1.56	1.88	1.55	1.84	1.55
	N	*%*	*N*	*%*	*N*	*%*
Racially Marginalized	53	24.9%	109	23.9%	162	24.2%
First Generation	131	59.0%	263	56.0%	394	56.9%
Female	147	66.2%	310	65.4%	457	65.7%

Note: Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first generation; Female = self-reported gender (0 = male, 1 = female).

Table 3

Study 1: Regression Coefficients for the Overall Effect of Intervention on Grade

	Math Grades					
	β	*b*	SE_b	*p*	CIs	R^2
						0.09
Utility-Value Intervention	0.04	0.13	0.11	0.22	[-.08, .34]	
Racially Marginalized	-0.13	-0.47	0.15	0.001	[-.74, -.17]	
First Generation	-0.05	-0.16	0.11	0.14	[-.36, .05]	
Female	-0.06	-0.21	0.14	0.14	[-.48, .09]	
High school GPA	0.25	0.61	0.10	<.001	[.41, .81]	

Note: β = standardized regression coefficient. *b* = unstandardized regression coefficient. SE_b = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility value intervention is coded as 0 = control, 1 = utility-value. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first generation; Female = self-reported gender (0 = male, 1 = female).

N = 664

Table 4

Study 1: Regression Coefficients for the Effects of Intervention on Grades Through Post-Intervention Relevance

	Post-Intervention Relevance						Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2	β	*b*	SE_b	*p*	CIs	R^2
						0.45						0.12
Utility-Value Intervention	0.08	0.17	0.06	.005	[.05, .29]		0.04	0.12	0.11	0.25	[-.10, .33]	
Pre-Relevance	0.66	0.63	0.04	<.001	[.56, .70]		0.01	0.02	0.08	0.82	[-.14, .18]	
Post-Relevance	–	–	–	–	–		0.16	0.25	0.07	<.001	[.10, .38]	
Racially Marginalized	0.06	0.13	0.08	0.08	[-.02, .29]		-0.15	-0.55	0.15	<.001	[-.83, -.23]	
First Generation	0.01	0.01	0.06	0.87	[-.12, .13]		-0.06	-0.18	0.10	0.07	[-.38, .02]	
Female	-0.01	-0.02	0.07	0.74	[-.16, .09]		-0.06	-0.20	0.14	0.16	[-.45, .09]	
High School GPA	-0.03	-0.04	0.06	0.50	[-.17, .07]		0.25	0.60	0.11	<.001	[.39, .81]	

Note: β = standardized regression coefficient. *b* = unstandardized regression coefficient. SE_b = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first generation; Female = self-reported gender (0 = male, 1 = female).

Math course subject was controlled for in analyses.

N = 664.

Table 5

Study 1: Regression Coefficients for the Effects of Intervention on Grades Through Post-Intervention Relevance Moderated by Generation and Racially Marginalized Status

	Post-Intervention Relevance						Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2	β	*b*	SE_b	*p*	CIs	R^2
						0.45						0.13
Utility-Value Intervention	0.10	0.23	0.12	0.050	[-.003, .45]		-0.02	-0.05	0.19	0.794	[-.43, .31]	
Pre-Relevance	0.66	0.63	0.03	<.001	[.56, .70]		0.01	0.02	0.08	0.850	[-.14, .17]	
Post-Relevance	–	–	–	–	–		0.16	0.25	0.08	0.001	[.10, .39]	
Racially Marginalized	0.12	0.29	0.14	0.045	[-.01, .56]		-0.09	-0.34	0.28	0.215	[-.86, .22]	
First Generation	0.01	0.02	0.11	0.888	[-.20, .23]		-0.15	-0.47	0.21	0.027	[-.88, -.05]	
Female	-0.01	-0.02	0.07	0.726	[-.16, .09]		-0.06	-0.20	0.14	0.153	[-.46, .09]	
High School GPA	-0.03	-0.04	0.06	0.487	[-.17, .07]		0.24	0.59	0.11	<.001	[.37, .79]	
Utility Value x First Generation	-0.001	-0.002	0.14	0.988	[-.28, .27]		0.14	0.44	0.25	0.078	[-.05, .93]	
Utility Value x Racially Marginalized	-0.08	-0.23	0.19	0.237	[-.60, .15]		-0.08	-0.34	0.28	0.230	[-.93, .21]	

Note: β = standardized regression coefficient. b = unstandardized regression coefficient. SEb = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially

marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first generation; Female = self-reported gender (0 = male, 1 = female). Utility Value x First Generation represents the interaction between the intervention and generation status; Utility Value x Racially Marginalized represents the interaction between the intervention and racially marginalized status. Math course subject was controlled for in analyses.
N = 664.

Table 6

Study 2: Correlations and Descriptive Statistics for Variables of Interest

	1	2	3	4	5	6	7	8
1. Utility-Value Intervention	-							
2. Pre-Relevance	.03	-						
3. Post-Relevance	.10**	.63**	-					
4. Racially Marginalized	-.04	.04	.04	-				
5. First Generation	.01	.04	.07*	.06*	-			
6. Female	.003	.05	.06*	.05	.21**	-		
7. High School GPA	.08**	.001	.01	-.16**	-.09**	.08**	-	
8. Math Grade	-.02	-.06	.04	-.20**	-.06*	-.06*	.21**	-
M	0.56	4.32	4.09	0.42	0.55	0.71	2.92	2.26
SD	-	1.19	1.30	-	-	-	0.69	1.60
N	1318	1118	1256	1318	1262	1318	1071	1318
% Missing	0%	15.2%	4.7%	0.0%	4.2%	0%	18.7%	0%

Note: Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance; Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized). Racially marginalized students include Black, Latine, Native American, as well as multiracial students who selected at least one of these races. Racially non-marginalized students include White, Asian, as well as multiracial White and Asian students. First Generation is coded as 0 = continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). The scale for high school GPA and end-of-semester math grades ranged from 0 to 4.

*$p < .05$, **$p < .01$

Table 7

Study 2: Descriptive Statistics by Intervention Condition for Variables of Interest

	Control (N = 586)		Utility Value (N = 732)		Overall (N = 1318)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre-Relevance	4.29	1.22	4.35	1.17	4.32	1.19
Post-Relevance	3.94	1.35	4.20	1.26	4.09	1.30
High School GPA	2.86	0.70	2.97	0.68	2.92	0.69
Math Grade	2.29	1.61	2.23	1.59	2.26	1.60
	N	*%*	*N*	*%*	*N*	*%*
Racially Marginalized	259	44.2%	292	39.9%	551	41.8%
First Generation	304	54.7%	392	55.5%	696	55.2%
Female	417	71.1%	523	71.4%	940	71.3%

Note: Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female).

Table 8

Study 2: Regression Coefficients for the Overall Effect of the Intervention on Grades

	Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2
						0.09
Utility-Value Intervention	-0.03	-0.09	0.11	0.43	[-.29, .14]	
Racially Marginalized	-0.18	-0.58	0.09	<.001	[-.76. -.39]	
First Generation	-0.02	-0.06	0.09	0.49	[-.26, .11]	
Female	-0.06	-0.21	0.10	0.04	[-.42, -.01]	
High School GPA	0.19	0.45	0.08	<.001	[.29, .62]	

Note: β = standardized regression coefficient. *b* = unstandardized regression coefficient. SE_b = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized). First Generation is coded as 0 = continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). Three dummy coded variables representing the four different math courses and two dummy coded variables representing the three different institutions were controlled for in our model.

N = 1,318.

Table 9

Study 2: Regression Coefficients for the Effects of Intervention on Grades Through Post-Intervention Relevance

	Post-Intervention Relevance						Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2	β	*b*	SE_b	*p*	CIs	R^2
						0.41						0.10
Utility-Value Intervention	0.08	0.20	0.06	<.001	[.10, .32]		-0.04	-0.12	0.11	0.28	[-.32, .10]	
Pre-Relevance	0.63	0.68	0.03	<.001	[.62, .74]		-0.13	-0.17	0.05	<.01	[-.28, -.07]	
Post-Relevance	–	–	–	–	–		0.14	0.17	0.05	<.001	[.08, .26]	
Racially Marginalized	0.02	0.04	0.06	0.45	[-.07, .15]		-0.18	-0.58	0.09	<.001	[-.76, -.39]	
First Generation	0.04	0.09	0.06	0.11	[-.02, .20]		-0.02	-0.07	0.09	0.43	[-.26, .10]	
Female	0.02	0.05	0.06	0.36	[-.06, .17]		-0.06	-0.21	0.10	0.04	[-.42, -.02]	
High School GPA	0.02	0.04	0.05	0.47	[-.07, .13]		0.19	0.44	0.08	<.001	[.29, .62]	

Note: β = standardized regression coefficient. *b* = unstandardized regression coefficient. SE_b = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). Three dummy coded variables representing the four different math courses and two dummy coded variables representing the three different institutions were controlled for in our model.

N = 1,318.

Table 10

Study 2: Regression Coefficients for the Effects of Intervention on Grades Through Post-Intervention Relevance Moderated by Generation and Racially Marginalized Status

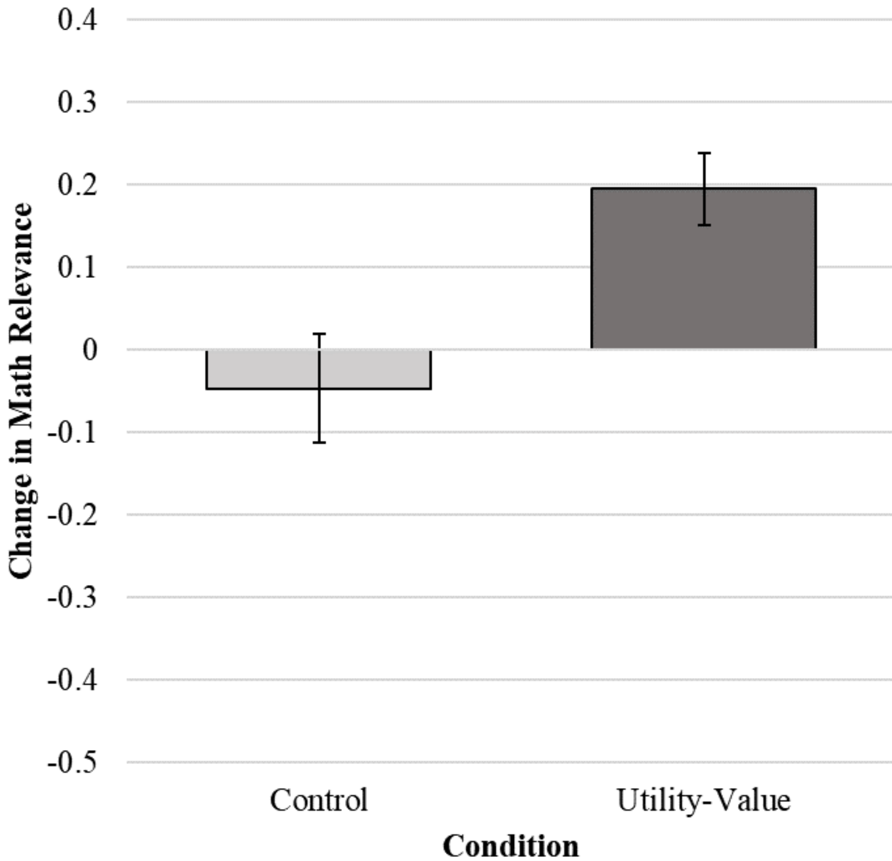
	Post-Intervention Relevance						Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2	β	*b*	SE_b	*p*	CIs	R^2
						0.41						0.10
Utility-Value Intervention	0.01	0.02	0.09	0.874	[-.17, .20]		-0.08	-0.27	0.16	0.083	[-.55, .05]	
Pre-Relevance	0.63	0.68	0.03	<.001	[.62, .74]		-0.13	-0.17	0.05	0.002	[-.28, -.07]	
Post-Relevance	–	–	–	–	–		0.13	0.16	0.05	<.001	[.08, .26]	
Racially Marginalized	-0.01	-0.02	0.09	0.779	[-.19, .14]		-0.22	-0.72	0.15	<.001	[-.99, -.41]	
First Generation	-0.02	-0.05	0.09	0.599	[-.23, .13]		-0.04	-0.12	0.14	0.397	[-.39, .15]	
Female	0.02	0.06	0.06	0.296	[-.05, .17]		-0.06	-0.21	0.10	0.040	[-.43, -.02]	
High School GPA	0.02	0.04	0.05	0.468	[-.07, .12]		0.19	0.44	0.09	<.001	[.28, .62]	
Utility Value x First Generation	0.09	0.25	0.12	0.037	[.02, .48]		0.02	0.08	0.20	0.685	[-.31, .46]	
Utility Value x Racially Marginalized	0.04	0.12	0.11	0.251	[-.09, .33]		0.07	0.26	0.20	0.181	[-.14, .63]	

Note: β = standardized regression coefficient. b = unstandardized regression coefficient. SEb = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0 = continuing

generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). Utility Value x First Generation represents the interaction between the intervention and generation status; Utility Value x Racially Marginalized represents the interaction between the intervention and racially marginalized status. Three dummy coded variables representing the four different math courses and two dummy coded variables representing the three different institutions were controlled for in our model.
N = 1,318.

Figure 1

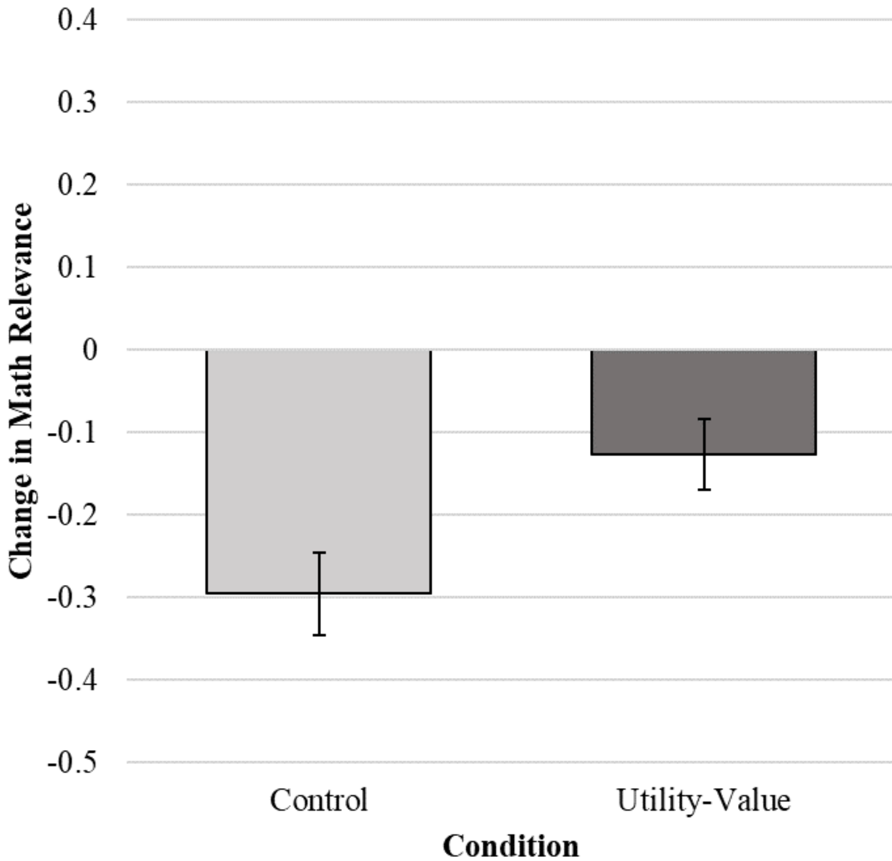
Study 1: Change in Math Relevance by Condition



Note: Change scores calculated from subtracting pre-intervention relevance for math from post-intervention relevance for math. Error bars represent +/- 1 standard error

Figure 2

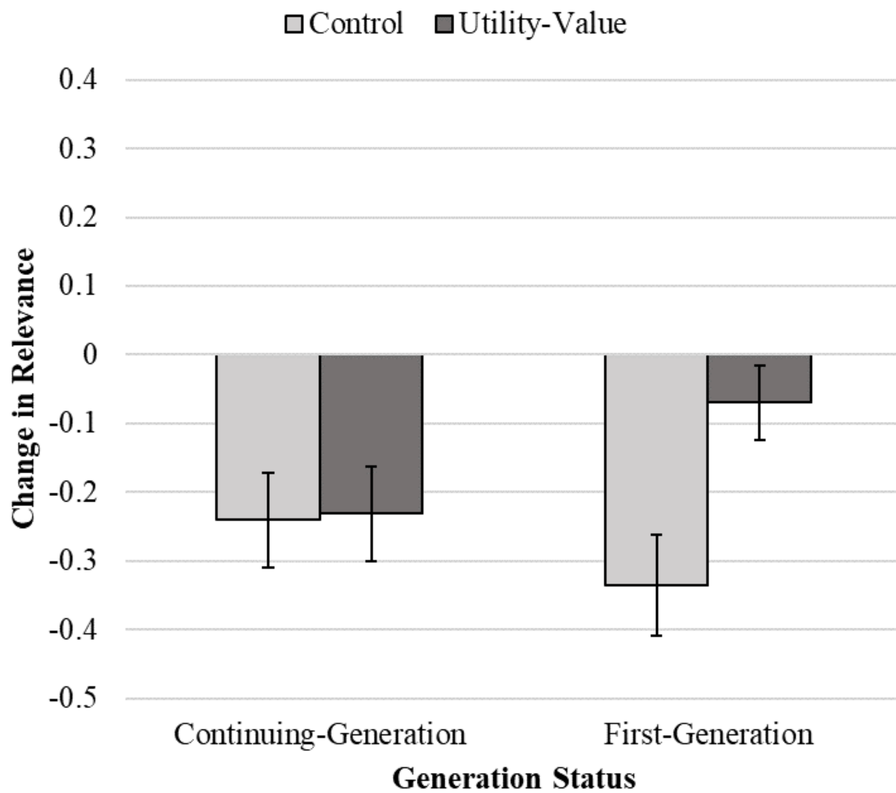
Study 2: Change in Math Relevance by Condition



Note: Change scores calculated from subtracting pre-intervention relevance for math from post-intervention relevance for math. Error bars represent +/- 1 standard error.

Figure 3

Study 2: Change in Math Relevance by Condition and Generation Status



Note: Change scores calculated from subtracting pre-intervention relevance for math from post-intervention relevance for math. Error bars represent +/- 1 standard error.

Appendix

Intervention Materials (adapted from Hulleman et al., 2022; Kosovich et al., 2019)

Student Intervention Activity #1: Utility-Value Condition Selected Materials

Which quotes are most relevant to you?

Put the quotes that are more relevant to you at the top, and the quotes that are less relevant to you at the bottom. When you are done, the quotes should be in order from most relevant to you at the top to least relevant at the bottom.

Sample Quotes

"As an EMT/paramedic I use algebra almost every workday. Be it for a patient's weight and drug calculations, or weights when it comes to building materials ... I've had to apologize to all my math teachers for my lack of foresight!" – **Robin, 30, EMT/Paramedic**

“My younger sister recently dropped and broke her phone. This was the third time she’s done this in the past year, so when the salesperson asked if she wanted insurance on it, I said she should consider it. After doing the math, we realized insurance is only a good option if there’s a high probability of breaking your phone. Based on my sister’s track record, we figured there was a 75% chance she’d break it again in the two-year coverage period. At $10 a month, two years of insurance coverage ($240) was still going to be less than the price of a replacement phone ($600 or more).” – **Maya, 23, Computer Science Major**

"Math is super helpful if you’re on a budget. Between paying for school, rent, and everything else, I always have to be careful with the amount of money I’m spending. Algebra makes this a lot easier by ensuring that I don't spend more than I have. For instance, every week I budget $15 for gas. So, if gas costs $2.98 per gallon, then I can figure out how many gallons I can buy each week to make sure I can get where I need to go. If gas prices go up, or I need to drive more, then I can calculate in advance how much I need to cut back in another area to stay on my budget." - **Cameron, 21, Economics Major**

Please explain briefly why you related to the quote you ranked the **highest**.

___

___

___

Please explain briefly why you related to the quote you ranked the **second highest**.

___

___

___

Student Intervention Activity #1: Control Condition Sample Materials

Write about Math in Your Own Words

Take a moment to think about some topics you've been learning about in your math class (e.g., solving equations, algebra, graphing, factoring, fractions). In the space below, type a brief summary (2-3 sentences) of the concept, focusing specifically on ***defining*** the concept in your own words. Try writing about a concept that you've had some trouble learning; your descriptions in the following questions may help future math students at your college with difficult problems.

Please think of ***a problem involving the math concept you chose above***. Write the problem and the correct answer (4-5 sentences).

Student Intervention Activity #2: Utility-Value Condition Selected Materials

In the space below, please write a brief paragraph about how one of the topics that you have covered in your math class relates to your life. (3-4 sentences)

Student Intervention Activity #2: Control Condition Selected Materials

In the space below, write a paragraph explaining the different methods you use for studying. Please identify which methods seem to help you the most.

Supplemental Material

Study 2

Analyses on the Intersectionality of Generation Status and Racially Marginalized Status

Based on past research (Harackiewicz et al., 2016), we hypothesized that students who are both first generation and racially marginalized would benefit the most from our interventions. Therefore, we followed the analytic approach published in Harackiewicz et al. (2016) and tested the intersectionality of social class and race as it related to the efficacy of our interventions. In the previous analyses we found that generation status significantly moderated the effects of the intervention on post-intervention relevance. We added additional interactions to the model to test the intersectional effect of generation and racially marginalized statuses. See Table S1 for the results. Findings suggested no significant two-way or three-way interactions among generation status, racially marginalized status, and intervention.

Table S1

Regression Coefficients Depicting Results for the Efficacy of Intervention for Students with Intersectional Identities.

	Post-Intervention Relevance						Math Grade					
	β	*b*	SE_b	*p*	CIs	R^2	β	*b*	SE_b	*p*	CIs	R^2
						.41						.11
Utility-Value Intervention	.01	.02	.10	.820	[-.18, .23]		-.10	-.32	.16	.044	[-.60, .02]	
Pre-Relevance	.63	.68	.03	<.001	[.62, .73]		-.13	-.17	.05	.002	[-.28, -.07]	
Post-Relevance	-	-	-	-	-		.13	.16	.05	<.001	[.08, .25]	
Racially Marginalized	-.02	-.06	.14	.661	[-.33. ,22]		-.30	-.97	.22	<.001	[-1.38, -.53]	
First Generation	-.03	-.08	.11	.491	[-.30, .14]		-.10	-.32	.18	.072	[-.67, .02]	
Female	.02	.06	.06	.288	[-.05, .17]		-.06	-.21	.10	.045	[-.42, -.01]	
High School GPA	.02	.03	.05	.484	[-.07, .13]		.19	.43	.09	<.001	[.27, .61]	
First Generation x Racially Marginalized	.02	.07	.21	.755	[-.35, .48]		.13	.46	.27	.079	[-.07, .98]	
Utility Value x First Generation	.08	.23	.15	.126	[-.06, .54]		.05	.17	.24	.474	[-.31, .62]	
Utility Value x Racially Marginalized	.03	.09	.18	.613	[-.26, .44]		.09	.35	.28	.204	[-.19, .89]	
First Generation x Racially Marginalized x Utility Value	.01	.05	.25	.840	[-.44, .56]		-.04	-.18	.37	.625	[-.91, .54]	

Note. Note: β = standardized regression coefficient. b = unstandardized regression coefficient. SEb = standard error of the unstandardized regression coefficient. R^2 = the amount of variance in the outcome explained by the predictors. Utility-Value Intervention is coded as 0 = control, 1 = utility-value. Pre-Relevance = pre-intervention relevance; Post-Relevance = post-intervention relevance. Racially marginalized is coded as (0 = racially non-marginalized, 1 = racially marginalized); First Generation is coded as 0

= continuing generation, 1 = first-generation; Female = self-reported gender (0 = male, 1 = female). Utility Value x First Generation represents the interaction between the intervention and generation status; Utility Value x Racially Marginalized represents the interaction between the intervention and racially marginalized status; Utility Value x First Generation x racially marginalized represent the interaction between the intervention, generation status, and racially marginalized status. Three dummy coded variables representing the four different math courses and two dummy coded variables representing the three different institutions were controlled for in our model.
N = 1,318.