# Learning Contexts Matter: Having Value-Supportive Instructors Moderates the Efficacy of a Utility-Value Intervention in Community College Math

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## Abstract

Previous research has established the benefits of utility-value interventions in improving students' motivation and achievement outcomes. However, further investigation is needed to understand the heterogeneity of intervention effects and identify the contexts within which these interventions are more effective. Accordingly, in the present study, we tested the efficacy of a utility-value intervention in contexts with varying degrees of perceived instructor support in the development of values and relevance. Participants were 2,240 community college students enrolled in one of four math courses taught by 78 instructors. Results of multilevel models with Bayesian estimation suggested that the utility-value intervention increased students' relevance for mathematics, which in turn positively predicted their math achievement. Notably, the intervention predicted these outcomes only in contexts where students perceived less support from instructors for the development of values, highlighting its effectiveness in contexts where it was most needed. Additionally, the results revealed an unintended consequence of the utility-value intervention: a slight decrease in students' expectations for success in their math course compared to the control group. We propose that minor adjustments to the writing activities embedded within the intervention in future research could mitigate any negative effects on students' expectations for success. This study underscores the importance of examining the heterogeneity of intervention effects, highlighting that interventions do not produce uniform outcomes across all contexts. The results have implications for professional development opportunities for instructors seeking to foster value-supportive environments for their students.


*Keywords:* utility-value intervention; instructors; context; expectancy-value-cost; math achievement

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By providing affordable and accessible education often tailored to meet local job-market needs, community colleges are uniquely positioned to help maintain a robust STEM workforce in the U.S. Community colleges offer a range of introductory courses designed to equip students with foundational knowledge and help them attain competence in STEM fields (Goudas & Boylan, 2012). However, despite their intended goals, these courses often become barriers to graduation (Bailey et al., 2010; Hughes & Scott-Clayton, 2011). Research indicates that failure rates, particularly in introductory math courses, are significant (Counterman & Zeintek, 2021), with as few as 54% of students reaching college-level math proficiency (Lee et al., 2011). Consequently, introductory math courses in community colleges provide an opportune context for implementing interventions that support students' achievement and persistence.

Research suggests that psychological interventions that help students find coursework useful in achieving their goals and relevant to their lives (i.e., utility-value interventions; Hulleman et al., 2010; 2017; Hulleman & Cordroy, 2009) improve students' motivation to learn, increase their effort invested in the course, and consequently promote their achievement and persistence (Hulleman et al., 2022; Rosenzweig et al., 2020). More recent evidence also points to the benefits of these interventions for the community college population (e.g., Kosovich et al., 2019; Totonchi et al., 2023a), which serve a large number of racially marginalized and first-generation students. This growing body of evidence encourages the implementation of these interventions in diverse contexts and at greater scale.

While this research provides substantial evidence supporting the overall benefits of utility-value interventions, it tends to overlook the significant role that instructors play in shaping students' motivation and learning experiences, which could either enhance or diminish the efficacy of the intervention (Hecht et al., 2021). Assuming that intervention effects occur in isolation and are independent of the instructional context might lead to the erroneous conclusion that interventions yield uniform effects for students across all educational environments.

In our study, we initially assess the general effectiveness of a utility-value intervention in enhancing math motivation and achievement among community college students. In doing so, we examine motivational beliefs (i.e., expectancies, values, and costs) as proposed mechanisms for the effects of the intervention on students' outcomes. Also, we test whether the intervention has added benefits for students from marginalized groups (e.g., first-generation, Black, Latine) as has been documented in the past (e.g., Harackiewicz et al., 2016; Harackiewicz et al., 2023). Subsequently, aligning with the growing emphasis on exploring intervention heterogeneity (e.g., Bryan et al., 2021; Hecht et al., 2021), we investigate whether the strength of the intervention effects varies depending on the learning context aka whether or not students perceive their instructors to actively support the development of math motivation. Evidence from this research will help shed light on the heterogeneity of the intervention effects and allow researchers and practitioners to better understand in which contexts the intervention is more effective.

**Utility-Value Interventions and Their Overall Effectiveness**

Utility-value interventions are designed to help students make relevant connections between course topics and their own current or future goals (Hulleman et al., 2010; Hulleman & Harackiewicz, 2020). Utility-value interventions are grounded in the expectancy-value-cost model of motivation (Eccles et al., 1983; Barron & Hulleman, 2015; also see Eccles & Wigfield, 2020 for the situated expectancy-value theory), which suggests that students' motivation to engage and persist in a task or an academic domain is most proximally determined by their expectancy, value, and cost beliefs. Expectancy beliefs refer to students' beliefs in their abilities to succeed. Value beliefs refer to students' perceptions of values associated with tasks. Value beliefs are multifaceted, including intrinsic value (i.e., enjoyment in a task), utility value (i.e., perceived usefulness of a task), and attainment value (i.e., perceived importance to one's identity). Cost beliefs refer to students' perceived negative drawbacks associated with the task.

Utility-value interventions can enhance course outcomes by increasing success expectancies and values as well as reducing perceptions of cost. For example, reflecting on and making connections between course content and one's own lives can help students become aware of their understanding and knowledge of content, increasing their confidence in their ability (i.e., increasing success expectancies; Hulleman et al., 2017; Rosenzweig et al., 2019). Also, making connections between the course content and one's own life can enhance course outcomes by helping students perceive a course to be more useful and relevant (i.e., increasing utility value/relevance; Hulleman et al., 2022; Totonchi, Francis et al., 2023). Lastly, when students attribute more value to a course, the perceived negative drawbacks associated with that course (cost) are likely to decline. For example, Rosenzweig and colleagues (2019) found that a utility value intervention decreased students' perceptions of cost (in particular for lower performing students) and that perceived cost partially accounted for the positive effects of the intervention on achievement. Thus, expectancy, value, and cost beliefs serve as crucial mechanisms for the efficacy of utility-value interventions.

**Heterogeneity of Intervention Effects and the Role of Instructors**

Utility-value interventions have been shown to be particularly beneficial for students with low prior confidence (Canning & Harackiewicz, 2015; Hulleman & Harackiewicz, 2009), interest (Erickson et al., 2021), or performance (Harackiewicz et al., 2016; Hulleman et al., 2017; Rosenzweig et al., 2019). Moreover, research also suggest that these interventions are particularly effective for students from underrepresented and marginalized backgrounds. Students from marginalized groups often feel that their values and identities are not reflected in the curriculum and instruction (e.g., Gay et al., 2018), particularly in disciplines like math, which are often incorrectly perceived as culturally neutral (e.g., Nasir et al., 2008). This can make it more challenging for these students to find math course topics relevant and useful. For example, racially marginalized and first-generation college students often place greater importance on communal values (e.g., helping family members) rather than individual values (e.g., becoming a successful entrepreneur; Harackiewicz et al., 2023). However, the standard curriculum and instruction in predominantly White and middle-class institutions primarily promote individual values, often overlooking the needs of marginalized students (Stephens et al., 2012). By allowing students to make personal and unique connections to math, utility-value activities can increase marginalized students' perceived usefulness of mathematics, thereby enhancing their motivation and achievement. Research by Harackiewicz and colleagues in four-year colleges revealed that utility-value interventions reduced achievement inequities by 40% for racially marginalized students and by 61% for those who were both racially marginalized and first-generation college students (Harackiewicz et al., 2016). Furthermore, studies with students in two-year colleges highlight the added benefits of utility-value interventions for first-generation students (Hulleman et al., 2022; Totonchi, Francis et al., 2023).

While such studies explore individual-level heterogeneity such as race and generation status, the role of the learning environment (i.e., context-level heterogeneity such as instructional and institutional contexts) is rarely explored. Ignoring this heterogeneity could lead to overgeneralization of the findings as well as undermining the reliability, validity, and replicability of the intervention effects (e.g., Bryan et al., 2021). While enthusiasm for utility-value interventions is increasing, scaling this intervention across diverse contexts necessitates a more profound understanding of the conditions and educational contexts in which the intervention proves effective.

Instructors play a key role in creating educational contexts that could either support or thwart student motivation. For instance, instructors employing instructional methods that highlight the relevance of course materials in students' lives, offer autonomy and respect (Patall et al., 2013), and convey the malleability of intelligence (Muenks et al., 2020) tend to have more motivated students with better academic outcomes. Particularly for racially marginalized students, having instructors who demonstrate the real-world applications of math is associated with higher valuing of mathematics (Matthews, 2018). Therefore, it is anticipated that instructors fostering adaptive values for course materials could influence the effectiveness of utility-value interventions. The central question is the specific direction in which this moderating effect would manifest.

One hypothesis is that having an instructor who demonstrates the value and relevance of a course would amplify the effects of the utility-value intervention on students' motivation and achievement. This hypothesis is grounded in the notion that students look for cues in their social context to determine what beliefs and behaviors are appropriate and accepted (Murphey et al., 2007). As such, having instructors who demonstrate the value of the course materials would cue students to believe and behave in a manner that is aligned with their instructors' value-laden beliefs and behaviors. Thus, a value-supportive context, as created by the instructor, would provide *affordances* (e.g., Walton & Yeager, 2020) for the value-laden beliefs and behaviors instilled by the utility-value intervention.

A number of empirical studies have provided supporting evidence for this hypothesis. For instance, a nationally representative experiment with high school students revealed that a growth mindset intervention positively impacted students' math grades in contexts where the teachers endorsed growth mindset beliefs. This same intervention did not impact students' math grades in contexts where instructors endorsed fixed mindset beliefs (Yeager et al., 2021). Similarly, an experiment testing the effectiveness of a purpose intervention with 7th and 8th grade students found that the positive effects of the intervention on students' writing performance were stronger among students whose teachers portrayed assignments as means to develop skills, (i.e., supported students' development of purpose for the coursework; Reeves et al., 2020). In both studies, the instructors' beliefs and behaviors mirrored the beliefs and behaviors aimed to be instilled by the intervention. This research suggests having affordances in the context, in the shape of perceived support from the instructors, increases the efficacy of the intervention.

An alternative hypothesis proposes that the intervention might show greater efficacy in contexts lacking inherent instructor support. This expectation is aligned with the compensatory hypothesis (Rutter, 1987; Sameroff & Chandler, 1975), first introduced to explain the added benefits of interventions for students who experienced greater environmental vulnerabilities (e.g., students from disadvantaged home environments, those with parents possessing lower academic education). These students typically experience a mismatch between what they need to be successful at school and what their academic context offers them. The compensatory hypothesis suggests that a well-designed program or intervention addressing the needs of these students could compensate for the lack of support in their contexts and produce added benefits for these students (e.g., Duncan & Vandell, 2012). According to this hypothesis, we may expect that for students who do not receive value support from their instructors, the utility-value intervention could serve as a crucial support mechanism, aiding in the development of adaptive values for the course.

Consistent with this compensatory hypothesis, several studies offer empirical support for the enhanced effectiveness of psychological interventions in settings lacking support for the development of adaptive beliefs. For example, Hammarlund and colleagues (2022) examined the impact of a social belonging intervention on diverse college students in chemistry and biology classrooms where teaching assistants held either growth or fixed mindsets. The study revealed that the intervention improved scores for students with teaching assistants holding fixed mindsets but had no effect on those with teaching assistants endorsing growth mindsets. The authors speculated that the intervention equipped students in unsupportive environments with tools to counter fixed-mindset messaging. Conversely, students with supportive teaching assistants likely experienced less perceived threat to their belonging, reducing the need for intervention. This research highlighted the intervention's heightened efficacy in contexts where it was most needed.

In the present study, we investigated the plausibility of these hypotheses and examined whether or not and in what direction the educational context, as measured by students' perceptions of instructor value-supportive practices, could influence the efficacy of a utility-value intervention.

## The Community College Context

Partly due to their open-access nature, community colleges are renowned for their highly diverse student populations. Unlike traditional four-year institutions, community colleges enroll a broader range of students, including dual-enrolled high school students and returning adult learners. Many of these students attend part-time to manage work schedules, parenting responsibilities, and other commitments (e.g., Skomsvold, 2014). Additionally, this diverse population is more likely to come from lower-income families, be first-generation college students, and belong to racially marginalized groups (Hoachlander et al., 2003; Juszkiewicz, 2020). Therefore, community college students bring a wide array of academic and personal experiences, with varied reasons and goals for taking math courses and pursuing an associate degree. Given the diversity in goals and values among community college students, utility-value interventions that help students make personal and unique connections between their lives and their coursework could offer significant benefits for this population. Further, to fully support these students, community college instructors need to employ practices that demonstrate the relevance of the coursework for diverse personal and professional goals. Therefore, the role of instructors in supporting students' values for mathematics may be particularly crucial in community college settings, which have been less explored in educational research.

**The Current Study**

Consistent with past research (e.g., Harackiewicz et al., 2016; Hulleman et al., 2009; 2010), we expected to find positive overall effects of the intervention on students' motivation and academic outcomes. Further, based on existing research (Hulleman et al., 2017; Rosenzweig et al., 2019; Totonchi, Francis et al., 2023), we hypothesized that expectancies for success, relevance of math, and perceived costs would serve as mechanisms for the effects of the utility-value interventions on achievement outcomes. Moreover, given research suggesting utility-value interventions are particularly beneficial for students from historically marginalized populations (e.g., racially marginalized, first generation; Harackiewicz et al., 2016; Harackiewicz et al., 2023; Hulleman et al., 2022), we expected to find stronger positive effects of the intervention for these populations. It is important to note that our expectations were based on research primarily conducted in the context of four-year institutions. Less is known about the effectiveness and mechanisms of utility-value interventions in more heterogeneous contexts, such as two-year institutions. The present study will contribute to the utility-value literature by examining these mechanisms and processes within a community college context. Furthermore, given past research highlighting the influence of instructors' beliefs and practices on the efficacy of the interventions (e.g., Hammarlund et al., 2022; Reeves et al., 2020; Yeager et al., 2021), we expected that perceived instructor value-supportive practices would moderate the efficacy of the utility-value intervention. This investigation will contribute substantially to the research examining intervention heterogeneity. In sum, aligned with the proposed contributions of the study we addressed the following aims and research questions:

Aim 1. Testing the effectiveness, mediators, and student-level moderators of utility-value interventions in community colleges.

RQ1. Does the utility-value intervention improve community college students' math motivation (as measured by math expectancies, values, and costs) and achievement?

RQ2. Does math motivation serve as a mediator for the effects of the utility-value intervention on math achievement?

RQ3. Do student demographic characteristics (i.e., racially marginalized status and generation status) moderate the efficacy of the utility-value intervention on math motivation and grades?

Aim 2. Examining the role of instructional context in influencing the efficacy of the utility-value intervention.

RQ4. Does perceived value support from instructors moderate the efficacy of the utility-value intervention on students' math motivation and achievement?

## Methods

### Participants and Procedure

We identified one math instructor at each of the 12 participating community colleges in the Southeastern United States to help us recruit math instructors and students from their respective math departments. With the help of these liaisons, 81 instructors teaching 216 math course sections were recruited to participate in the project. The students enrolled in these course sections were invited to participate in the research project as part of their course, though instructors were kept blind to students' conditions. Overall, 3,919 students were recruited from four introductory math courses (66.1% Introductory Statistics, 14.4% Math for General Studies, 12.2% College Algebra, and 7.3% Finite Mathematics). We obtained approval from the Institutional Review Board.

In the first week of the semester, students were asked to complete the pre-intervention survey assessing their baseline motivation for math. Once enrollment rosters, which included Student ID numbers were finalized, researchers used these to randomly assign all enrolled students to either the control condition or the utility value condition. In the third week of the semester, students were asked to complete the first intervention activity and in the fifth week of the semester, students were asked to complete the second intervention activity. Student motivation was assessed after completion of each of the intervention activities. Each intervention activity took about 15 minutes to complete. Surveys and intervention activities were administered using the Qualtrics survey platform.

To be included in analyses for the current study, students must have completed at least one of the post-intervention surveys, indicating they participated in at least one of the intervention activities. Of these students, 59.4% participated in both intervention activities. This resulted in a final sample of 2,240 students ($M_{age} = 23.10$, $SD_{age} = 8.53$) from 194 course sections taught by 78 instructors. Participants were 66.8% female, 54.4% first-generation, 66.9% White, 18.0% African-American, 8.6% Hispanic/Latine, 3.6% multi-racial, and 2.5% Asian, with the remainder selecting other races. About 68.8% of these students were majoring in "General Studies," which signified their intentions to transfer to a four-year institution. Another 8.3% were majoring in Business, while no other major accounted for more than 3.1%.

**Intervention**

In the first intervention activity, students randomized to the control condition were asked to summarize a concept from their current math course, define it in their own words, and draft a practice problem and answer about that concept. This activity is based on an effective learning technique known as elaborative interrogation which has been found to boost learning and performance (Dunlosky et al., 2013) and has been used in prior utility-value intervention studies (e.g., Kosovich et al., 2019; Totonchi, Francis et al., 2023). Additionally, students randomized to the control condition answered survey questions about the degree to which their math instructor demonstrates the importance and value of the course. These survey items were used to create the perceived instructor value supportiveness variable. Students in the utility value condition read eight quotes, ostensibly written by previous students in their course, about how math was important to their lives and were then asked to rank these quotes based on how relevant they found them to their lives. Next, students wrote a short essay explaining why they ranked the top two quotes as relevant to their lives.

In the second intervention activity, students in the control condition completed survey items and writing prompts about their study habits for their math course. Students in the utility value condition were asked to write a short essay explaining how concepts from their current math course could be used to solve real-life problems and how these concepts were useful to them in their daily lives. The intervention materials and procedures were adapted from prior utility value studies (Kosovich et al., 2019; Hulleman et al., 2022; Totonchi, Francis et al, 2023). Specifically, in the prior studies, students who had previously taken introductory math courses provided written responses about how they connected math content to their own lives and these quotes were then refined by the research team and practitioner partners for clarity of communication and to accurately reflect math concepts covered in respective math courses. Over semesters of implementation, this set of quotes went through further design processes to capture new potential interests, goals, and future career prospects matching the representative student in the contexts the utility value intervention was implemented in. Thus, we were able to utilize largely the same quotes as the prior studies, but with further checks by the research team and practitioner partners to (1) ensure the math concepts mentioned reflected in the syllabi of the introductory math courses we implemented in, and (2) reflected the contexts and interests most salient to our population of community college students.

**Measures**

Measures included students' math expectancy, relevance, cost, perceptions of the value supportiveness of their math instructors, and student demographic questions. We measured math relevance as a proxy for math utility value as has been done in other utility-value intervention studies (e.g., Kosovich et al., 2019). Indeed, utility value is defined as the perceived relevance of a task or coursework to future goals (e.g., Wigfield, 1994). Sample items and reliability information for the items can be found in Table 1. Math expectancy, relevance, and cost were assessed each using two items. All items were adapted from the Expectancy-Value-Cost scale (Hulleman et al., 2017) and assessed on a 6-point Likert scale (1 = *Strongly disagree* to 6 = *Strongly agree*). Pre-intervention expectancies, relevance, and costs were measured at Week 1. Post-intervention expectancy, relevance, and cost were based on measures taken right after the implementation of the second intervention activity. For students who did not participate in the second intervention activity, their motivation scores after the first intervention activity were used to measure post-intervention expectancies, relevance, and costs.

Student perceptions of their instructors' value supportiveness was assessed using three items during the first intervention activity. These items were adapted from the "provision of rationale" subscale from the autonomy support practices scale created by Patall and colleagues (2013). These items were assessed on a 6-point Likert scale (1 = *Strongly disagree* to 6 = *Strongly agree*). Because we were concerned that the utility-value intervention would bias assessments of their instructors' value supportiveness, we used responses in the control group to create course-level aggregate assessments of each instructor's value supportiveness. We aggregated the ratings provided by students randomized to the control condition for each instructor and used that score for both control and utility value condition students in that course section. This score served as a feasible approximation for how students perceive the value supportiveness of their instructor in the absence of an intervention. This approach to creating a contextual variable by aggregating responses across the control condition and applying it to all participants has precedence in existing context heterogeneity research (e.g., Yeager et al., 2019).

Student race and gender were obtained from administrative data. We created an indicator of a students' underrepresented racially marginalized (URM) status by coding student race (racially marginalized = Black, Latine, Native-American, and multi-racial students; racially non-marginalized = White and Asian students). We used students' self-reported parent/guardian education levels to create an indicator for generation status. Participants who reported neither parent or guardian having a Bachelor's degree or higher were coded as first-generation, while students who reported one or both parents or guardians having a Bachelor's degree or higher were coded as continuing-generation. This method to operationally define generation status is common in relevant literature (e.g., Choy, 2001; Stephens et al., 2012). Students' high school GPA and end-of-semester math course grades were obtained from administrative data and were used as proxies for prior achievement and math achievement, respectively. Students' high school GPA was reported on a 0-4 GPA scale whereas students' math grades were reported as letter grades. These letter grades were then coded into a numeric grade on a 0-4 GPA scale (e.g., A = 4.0, B = 3.0, etc.).

**Data Analysis**

To address our research questions, we conducted multilevel models where Level 1 corresponded to students and Level 2 corresponded to instructors. To account for prior levels of motivation and potential confounds, we controlled for pre-intervention motivation, underrepresented racially marginalized (URM) status, first generation status, student gender, and student high-school GPA (representing prior achievement) as covariates at both the student and instructor levels in all models. The main predictor at the student level was the intervention condition (coded as 0 = control; 1 = intervention). The main predictor at the instructor level was perceived instructor value supportiveness. Perceived instructor value supportiveness was standardized to facilitate comparisons among models. We were specifically interested in the effects of the intervention on students' motivation and achievement at the student level (Level 1), the moderating role of students' demographics in the efficacy of intervention, which is at the student level, and the moderating effects of instructor value supportiveness on the efficacy of the intervention (cross-level interaction). Due to the extensive and complicated nature of the analyses, the presentation below focuses on results addressing these particular queries. Interested readers are invited to review the Supplemental Materials for a full description of all the findings.

All predictive models were estimated using Mplus version 8.6 (Muthén & Muthén, 1998-2021). Given our interest in examining indirect effects, which are known to possess a skewed distribution, we needed to use an estimation procedure that would allow the creation of asymmetric confidence intervals (MacKinnon et al., 2004). Such intervals are most commonly performed using bootstrapping, but Mplus does not have the ability to generate bootstrap confidence intervals for multilevel models. We therefore used Bayesian estimation implemented using a Markov Chain Monte Carlo algorithm based on the Gibbs sampler (Asparouhov & Muthén, 2023). This method appropriately handles missing data, can be applied in the context of multilevel models, and can create asymmetric confidence intervals. Coefficients obtained through Bayesian estimation can be interpreted in a manner similar to those estimated through least squares or maximum likelihood estimation.

## Results

### Missing data analysis

We first examined the presence and patterns of missing data among our focal variables (pre-intervention motivation, post-intervention motivation, grades, and perceived instructor value supportiveness) separately by condition. In the control condition, missingness for individual variables ranged from 0% to 18.8% with a median of 2.4%. Specifically, 77.1% of participants had no missing data, 18.1% were only missing pre-intervention motivation scores, and no other pattern of missingness explained more than 5% of the observations. In the utility-value condition, missingness for individual variables ranged from 0% to 18.7%% with a median of 2.6%. Specifically, 77.8% of participants had no missing data, 17.0% were only missing pre-intervention motivation scores, and no other pattern of missingness explained more than 5% of the observations. The patterns of missingness appear to be similar across conditions, and none of the patterns provide evidence that missingness was not at random. We therefore believe that our analyses are not unduly influenced by missing values in our data.

**Descriptives and Correlations**

Descriptive statistics and correlations for focal study variables separated by condition are provided in Table 2. We did not observe any significant mean differences between our groups on focal study variables at pre-intervention (see Table 2).

**Aim 1: Testing the Effectiveness, Mediators, and Student-Level Moderators of Utility-Value Interventions in Community Colleges**

***RQ1: Does the utility-value intervention improve community college students' math motivation and achievement?*** We examined the effects of the intervention on expectancies, relevance, and costs, and math grades[1]. To do this, we estimated the effect of the intervention on

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[1] Prior studies (e.g., Hulleman & Harackiewicz, 2009) found evidence that utility-value interventions were particularly effective for students starting with low confidence or ability. While we do not have a measure of confidence, we tested whether high school GPA, a measure of prior student ability, moderated the effects of the student intervention in the model presented above. We did not find evidence that high school GPA influenced the effect of the intervention on expectancies, costs, relevance, or grades (all p's > .05).

a post-intervention assessment of each outcome and our list of covariates. Each outcome was examined in a separate model to reduce the influence of collinearity. We observed a significant effect of the intervention on expectancies, indicating that students in the utility-value intervention condition had lower expectancies than those in the control condition (*estimate* = -.101, 95% credible interval = [-.170, -.030]). We also observed a significant effect of the utility-value intervention on relevance, indicating that students in the intervention condition had higher perceptions of relevance than those in the control condition (*estimate* = .132, 95% credible interval = [.047, .215]). The intervention did not have an impact on perceived costs (*estimate* = .032, 95% credible interval = [-.046, .118]) or an overall effect on grades (*estimate* = -.028, 95% credible interval = [-.146, .092]). Estimated effects of the intervention along with 95% credible intervals are provided in Figure 1. The results presented for this research question are at the student level. All other coefficients for focal study variables from these models at the student and instructor level are presented in Table S1.

***RQ2: Does math motivation serve as a mediator for the effects of the utility-value intervention on math achievement?*** Although the effect of the intervention on math achievement was not significant, we still examined whether motivation could mediate its effects. Tests of indirect effects can be more powerful than overall tests because they reduce variability by separating the total effect into smaller, more precise components (Kenny & Judd, 2014). Additionally, predictors can sometimes have multiple pathways to an outcome that operate in opposite directions that are detectable by tests of indirect effects, but which cancel each other out to create null effects in overall tests (Preacher et al., 2007).

We used a collection of multilevel models to determine whether expectancies, relevance, or costs mediated the impact of the intervention on math grades. To prevent collinearity from influencing our results, we again examined each motivation measure in a separate model. Given that we expected the mechanism for motivation to mediate the influence of the intervention to operate on a personal level, we focused our report of the results on student-level effects. Interested readers can review Table S2 for the results of all coefficients at the student and instructor levels. The indirect effect was identified as significant if a 95% credible interval excluded 0. Credible intervals obtained through Bayesian analysis can be asymmetric, allowing them to appropriately test indirect effects in mediation models which are known to have asymmetric distributions (Hox et al., 2014).

Based on these coefficients we determined that expectancies (indirect effect = -.032, 95% credible interval = [-.058, -.010]) and relevance (indirect effect = .016, 95% credible interval = [.004, .033]) significantly mediated the effect of the intervention on grades, while costs (indirect effect = -.006, 95% credible interval = [-.024, .011]) did not. These findings suggested that being in an intervention condition has a positive impact on students' perceived relevance and a negative impact on their expectancies for success, and these positive and negative impacts were carried over to students' math grades.

***RQ3. Do student demographic characteristics moderate the efficacy of the utility-value intervention on math motivation and grades?*** To address our third research question, we used a collection of multilevel models to determine whether racially marginalized status (URM) or first-generation status moderated the influence of the intervention on the motivation variables and grades. Coefficients for focal study variables from these models are presented in Table 3. We did not find any evidence that either racially marginalized status (URM) or first-generation status moderated the effects of the intervention on expectancies, costs, relevance, or grades. Given that these variables do not influence the effect of the intervention on expectancies, costs, or relevance, we also conclude that these demographic variables do not significantly influence the ability of these motivation variables to mediate the relation of the intervention with grades. All other coefficients for focal study variables from the moderated mediation models are presented in Table S3.

**Aim 2. Examining the Role of Instructional Context in Moderating the Efficacy of the Utility-Value Intervention.**

***RQ4. Does perceived value support from instructors moderate the efficacy of the utility- value intervention on students' math motivation and achievement?***

To address our final research question, we used multilevel models to determine whether perceived instructor value supportiveness moderated the influence of the intervention on the motivation variables and grades. The effects of the intervention on motivation and grades were also treated as a random effect and predicted at Level 2 by instructor value supportiveness. Coefficients for focal study variables from these models are presented in Table 4.

We observed that perceived instructor value supportiveness significantly moderated the effects of the intervention on relevance (*estimate* = -.114, 95% credible interval = [-.199, -.030]) but did not moderate the effects of the intervention on expectancies (*estimate* = -.069, 95% credible interval = [-.149, .011]), costs (*estimate* = .006, 95% credible interval = [-.097, .100]), or grades (estimate = -.035, 95% credible interval = [-.174, .051]). Figure 2 illustrates the significant effect, showing that the overall positive effect of the intervention on relevance is weaker when perceived teacher support is higher. An examination of simple slopes suggested that the intervention increased relevance in classes where students perceived their instructors to be minimally (*estimate* at 1 SD below mean = .248, 95% credible interval = [.121, .365]) or moderately value supportive (*estimate* at mean = .133, 95% credible interval = [.047, .217]). The intervention did not affect student motivation in classes where students perceived their instructors to be highly value supportive (*estimate* at 1 SD above mean = .021, 95% credible interval = [-.095, .133]).

This moderation effect also has implications for the ability of motivation to mediate the relation of the intervention with grades. Figure 3 shows that the indirect effect of the intervention on grades through relevance is significant at low (*estimate* at 1 SD below mean = .030, 95% credible interval = [.011, .057]) and moderate (*estimate* at mean = .016, 95% credible interval = [.005, .033]) levels of instructor value supportiveness but not at high levels of instructor value supportiveness (*estimate* at 1 SD above mean = .002, 95% credible interval = [-.013, .018]). These results suggest that the benefits of the intervention on math grades through increases in relevance is only true in classes where perceived instructor support is minimal or moderate. Coefficients for focal study variables from the moderated mediation models are presented in Table S4.

## Discussion

Consistent with the overwhelming evidence on utility-value interventions (e.g., Hulleman et al., 2022; Totonchi, Francis et al., 2023), our results revealed that engaging in activities highlighting the usefulness and relevance of math helped students find mathematics more relevant to their lives. Higher perceived math relevance, in turn, was positively related to students' math grades. As such, our research provided empirical evidence for the theoretical expectation that perceived relevance serves as a psychological mechanism for the efficacy of the utility-value intervention (Hulleman & Harackiewicz, 2021). When students make connections between themselves and learning tasks it facilitates their learning by facilitating the integration of old knowledge (the self) with the new knowledge (the course materials) that the student is trying to learn (Bransford & Schwartz, 1999). These mechanisms likely led to the positive effects of the intervention on relevance, which in turn positively predicted math grades. These benefits are particularly welcome in the context of community college math courses, where motivation loss (Kosovich et al., 2019; Totonchi, Francis et al., 2023) and retention concerns (e.g., Chen, 2013) are salient. Students in community colleges commonly have a variety of other commitments and responsibilities beyond schooling (e.g., being a parent, working full-time; Skomsvold, 2014), so, the relevance of a non-applied math course to their lives may be less tangible. The utility-value intervention provides an opportunity for these students to make personal and meaningful connections between these math courses and their lives, leading to increased motivation and positive associations with achievement.

Inconsistent with our expectations, we found a negative impact of the utility-value intervention on students' success expectancies that carried over to students' math grades. However, our expectations about the benefits of utility-value interventions on success expectancies were primarily based on research with four-year institutions (e.g., Harackiewicz et al., 2016). In fact, a recent study with several two-year institutions revealed that the utility-value intervention decreased students' beliefs about their preparedness in the course and their confidence in their capabilities, leading to lower interest and perceived value for the course, particularly for students with lower academic achievement (Canning et al., 2019b). It could be that community college students, who often demonstrate lower confidence in their writing abilities (Bickerstaff et al., 2017), found the utility-value activity challenging, which consequently undermined their competence beliefs in their math course. As such, it might be important for the utility-value interventions to be accompanied by instructional support as well as messages that decrease the perceived threat associated with performing a writing task. For instance, it can be communicated to students that they only need to make a few (versus many) connections between math topics and their lives in their utility-value essay (Lindeman et al., 2018). Strategies as such could potentially offset the unintended effects of utility-value interventions on students' success expectancies.

An alternative explanation for this unintended effect has to do with the summarization activity used in the control condition. This activity is based on an evidence-based learning technique called elaborative interrogation (Dunlosky et al., 2013) wherein students explain a concept in depth and in their own words. In the community college mathematics context, such a study strategy may not simply be an inert control activity but instead could provide students with deeper sense of competence in their knowledge. This could lead students to report having higher success expectancies. Indeed, in our study, as in the Canning et al. (2019) study, the overall average level of expectancies decreased in both the control and utility-value conditions. However, the decrease was less in the control condition, possibly due to the effects of elaboration in the summarization activity.

Contrary to our expectation, the intervention did not significantly impact students' perceptions of costs for their math course. We anticipated that finding coursework personally relevant and useful, particularly in a difficult course such as mathematics, would decrease students' perceptions of drawbacks associated with the course. This expectation was in line with the theoretical notion that expectancies, values, and costs develop synergistically; therefore, increases in relevance would likely be accompanied by decreases in cost (e.g., Eccles & Wigfield, 2020). Considering the community college context of our study, where a great proportion of students have full-time jobs and families to care for, the types of costs they experience may be different from those experienced by primarily 18-year-old students in four-year institutions. For students in our study, opportunity costs, or concerns about having to sacrifice too much in order to be successful in the course, may have been particularly prominent. These concerns reflect real-life challenges for community college students (e.g., having to miss a day at a paid job to prepare for a test; having to pay for childcare to attend a class), which may not be easily mitigated by a brief and generalized version of a utility-value intervention. Future research could distinguish between the different types of costs and examine the efficacy of the utility-value interventions in mitigating each type of cost. Additionally, utility-value interventions used at community colleges could use different examples more closely representing the real-life challenges faced by the incredibly diverse community-college students.

Contrary to our expectations, we did not find additional benefits of the utility-value intervention for students from marginalized groups. Our expectations were based on research with students attending highly selective, majority White, and middle-class institutions (Harackiewicz et al., 2016). In such competitive and demographically imbalanced environments, marginalized students face unique barriers to their identity and sense of belonging (Totonchi et al., 2021; Totonchi, Tibbetts et al., 2023), which interventions are designed to address. Indeed, some research suggests that psychological interventions are more beneficial for students who find their environment more identity-threatening (e.g., salient imbalances in the number of racially marginalized and non-marginalized students; Hanselman et al., 2014). In our study, however, marginalized and non-marginalized students benefited equally from the intervention. One possible explanation is that the commonalities more typical among community college students—such as being older, having family dependents, working full-time, and managing financial and time constraints—may result in a shared experience that enables the utility-value intervention to have similar effects (on average) among all community college students. This population might prioritize immediate, practical outcomes like job readiness over other academic goals. As a result, an intervention that helps them make connections between their coursework and future careers could be equally beneficial for all community college students, regardless of their marginalized status. It is worth noting that our preliminary analyses found no significant association between racially marginalized status and baseline motivation (all $r$'s < .06, all $p$'s > .05), indicating no motivation gap between racially marginalized and non-marginalized students. We found weak associations between generation status and baseline expectancies ($r = -.08$, $p = .044$) and costs ($r = .09$, $p$ .033), suggesting that first-generation students had slightly lower expectancies for success and slightly higher perceived costs compared to continuing-generation students. This small motivation gap was not filled by the intervention.

Lastly, consistent with prior research highlighting the benefits of value-supportive instructional practices (e.g., Patall et al., 2013), our correlation results suggested that perceiving instructors to be demonstrative of adaptive values positively related to control students' expectancies and values and negatively related to their perceived costs. Thus, instructors play a significant role in students' development of motivation. Importantly, our findings revealed that it was only in contexts where the support from instructors was lacking that the utility-value intervention positively impacted students' math value/relevance and, in turn, predicted their math grades. This finding is inconsistent with the affordances hypothesis and associated empirical evidence that suggests a supportive context would provide fuel to the spark initiated by the intervention (e.g., Brandenberger et al., 2018; Hecht et al., 2021; Walton & Yeager, 2020; Yeager et al., 2021). In contrast, this finding is consistent with the compensation hypothesis (Rutter, 1987; Sameroff & Chandler, 1975) and supporting empirical evidence (Hammarlund et al., 2022) that suggest interventions may work best in contexts where there is a mismatch between the individuals' needs and what their context provides. Indeed, we found that the utility-value intervention worked best in contexts that were not highly supportive of students' values, aka, where it was needed the most.

**Limitations and Future Directions**

When interpreting the findings of the present study, it is important to consider the following limitations. Firstly, the assessment of value-supportiveness of instructors relied on students' perceptions of instructors' practices rather than direct identification of supportive instructional strategies. While students' perceptions of instructors often strongly influence their beliefs and attitudes toward a course (e.g., Canning et al., 2019a), future research could benefit from complementing this approach with observations or rubrics to evaluate instructors' supportive practices more objectively. Secondly, we did not evaluate students' comfort and confidence in completing the utility-value intervention writing activities. It is possible that the unintended negative effects of the utility-value intervention on students' success expectancies were exacerbated for our sample of community college students who may have lower confidence in their writing abilities (e.g., Canning et al., 2019b). Future research could explore this hypothesis by assessing and controlling for this variable in their analyses. Finally, in investigating the differential effects of the intervention for students with different racially marginalized statuses, we grouped all students of historically marginalized races (e.g., African American, Latine, Native American) together and compared them with those not historically marginalized (e.g., White and Asian). While this dichotomization provided sufficient power for our statistical analyses, it also obscured important differences in how each racial group may respond to the intervention or experience the instructional context.

Despite these limitations, the present study makes a significant contribution to the utility-value literature by delving into the heterogeneity of its effects within different instructional contexts. Our findings offer valuable insights into where and for whom utility-value interventions yield the greatest benefits, advancing the replicability of findings in psychological science. Consistent with prior research suggesting that the efficacy of interventions depends on the contexts in which they are implemented (Van Bavel et al., 2016), we advocate for continued exploration of different aspects of the learning context that could influence intervention outcomes. Furthermore, investigating the long-term effects of the utility-value intervention and perceptions of instructor supportiveness holds promise. Previous research indicated that utility-value interventions can have long-term positive effects on students' educational and career trajectories, including course taking, persistence, and career intentions (Asher et al., 2023; Canning et al., 2018; Rozek et al., 2017). Thus, future studies could examine whether the influence of value-supportive instructors outweighs the long-term effects of utility-value interventions on student outcomes.

**Implications for Practice**

This study has implications for educators, administrators, and policymakers seeking to improve community college students' motivation, achievement, and overall experiences in introductory math courses. The results of our study revealed that the utility-value intervention was effective only in contexts that were minimally or moderately supportive. The intervention was not effective in highly value-supportive contexts, where the instructors successfully demonstrated the value and relevance of the coursework. In those contexts, students may already possess high levels of motivation, minimizing the need for additional enhancement. These results highlight the importance of supporting the professional development of instructors to assist them in fostering a value-supportive context. For example, backed by past experimental research (Reeve et al., 2021), instructors can be encouraged to integrate real-world applications into their teaching practices, highlighting the purpose of each learning topic.

We argue that while the eventual goal should be to make systemic institutional and structural changes to ensure that all students receive high levels of value supports from their instructors, the utility-value intervention can be introduced as an additional support where such structural changes are still in progress. Within our current educational systems, instructors often contend with a multitude of instructional and institutional demands, leaving very few learning contexts highly supportive of students' values (about 38% of instructors in our sample). It is not always feasible to create uniformly supportive course contexts at community colleges, where a significant percentage of courses are taught by part-time and adjunct instructors and where turnover for faculty, administrative, and leadership positions is common. Therefore, implementing brief, targeted activities such as utility-value interventions in classrooms could make up for the deficit created by minimally or moderately value-supportive contexts and provide much-needed support while institutions tackle the larger challenge of enhancing instructor training and scaling classroom-level supports.

## Conclusion

To address the replication crisis in intervention research, it is imperative to consider the heterogeneity in intervention effects. In pursuit of this goal, we investigated the efficacy of a utility-value intervention across varying levels of instructor support for value development. Our findings revealed that the intervention yielded positive outcomes only in contexts perceived as having limited or moderate instructor support for value development. In such environments, the intervention enhanced students' perceived relevance of mathematics, subsequently predicting their achievement in math courses. However, the intervention did not demonstrate effectiveness in contexts with high levels of instructor support. Essentially, the intervention proved efficacious in learning environments where support was lacking, thus serving a compensatory function by bridging gaps in unsupportive contexts. Furthermore, we uncovered an unintended negative effect of the intervention on students' success expectancies. This research not only illuminates the overall effectiveness of a utility-value intervention within the understudied community college population but also helps identify the specific contexts where such interventions are most potent. These findings offer valuable insights for designing more effective interventions.

**Declaration of Generative AI-Assisted Technologies**

In the course of preparing this paper, the authors utilized ChatGPT3.5 to refine and enhance grammar and language editing. Following the use of this tool, the authors carefully reviewed and edited the content as necessary, and they assume full responsibility for the publication's final content.

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Table 1

*Sample Items and Reliabilities for Constructs of Interest*

| Motivation Construct | # Items | Sample Item | Reliability |
|---|---|---|---|
| Expectancies | 2 | "I am confident I can learn the material in this math class" | $r_{pre} = .72$<br>$r_{post} = .80$ |
| Relevance | 2 | "The material in this math course is important for my future" | $r_{pre} = .76$<br>$r_{post} = .82$ |
| Costs | 2 | "This math class is too stressful for me" | $r_{pre} = .59$<br>$r_{post} = .82$ |
| Perceptions of Instructor Value Supportiveness | 3 | "My teacher demonstrates how what we are learning is useful" | α = 0.92 |

*Note.* Pre = pre-intervention; post = post-intervention.

Table 2

*Correlations and Descriptive Statistics by Condition*

| **Correlations** | Pre Expectancies | Pre Costs | Pre Relevance | Post Expectancies | Post Costs | Post Relevance | Final Grade | Instructor Supportiveness |
|---|---|---|---|---|---|---|---|---|
| Pre Expectancies | – | -0.51** | 0.38** | 0.56** | -0.30** | 0.29** | 0.07 | 0.18** |
| Pre Costs | -0.50** | – | -0.27** | -0.47** | 0.65** | -0.23** | -0.13** | -0.19** |
| Pre Relevance | 0.41** | -0.27** | – | 0.30** | -0.17** | 0.64** | -0.00 | 0.19** |
| Post Expectancies | 0.55** | -0.38** | 0.32** | – | -0.48** | 0.44** | 0.21** | 0.20** |
| Post Costs | -0.36** | 0.61** | -0.15** | -0.44** | – | -0.18** | -0.20** | -0.10** |
| Post Relevance | 0.33** | -0.26** | 0.62** | 0.51** | -0.25** | – | 0.07 | 0.21** |
| Final Grade | 0.12** | -0.12** | 0.04 | 0.22** | -0.21** | 0.10** | – | 0.08* |
| Instructor Supportiveness | 0.02 | -0.06* | 0.05 | 0.05 | -0.05* | 0.04 | 0.04 | – |
| **Descriptives** | | | | *Mean (SD)* | | | | |
| Overall | 4.85 (0.87) | 2.79 (1.05) | 4.19 (1.19) | 4.66 (0.93) | 3.09 (1.21) | 4.07 (1.21) | 2.35 (1.48) | 4.72 (0.60) |
| Control | 4.81 (0.90) | 2.79 (1.07) | 4.20 (1.17) | 4.72 (0.89)* | 3.07 (1.23) | 4.00 (1.23)* | 2.39 (1.47) | 4.72 (0.58) |
| Utility-Value | 4.86 (0.86) | 2.78 (1.04) | 4.18 (1.21) | 4.63 (0.95)* | 3.10 (1.19) | 4.11 (1.20)* | 2.34 (1.49) | 4.72 (0.60) |

*Note.* Correlations reported below the diagonal are from the control group while correlations above the diagonal are from the intervention group. Marks of significance on the descriptives indicate that control and intervention means were significantly different.
* $p < .05$; ** $p < .005$.

Table 3

*Moderating Role of Demographic Variables*

| | Estimate (Posterior *SD*), two-tailed *p* | | | |
|---|---|---|---|---|
| | Expectancies | Costs | Relevance | Grades |
| Generation Status as the Moderator | | | | |
| Intervention | -0.115 (0.056), $p = .042$ | 0.114 (0.069), $p = .096$ | 0.102 (0.069), $p = .138$ | -0.093 (0.093), $p = .316$ |
| FG status | -0.042 (0.064), $p = .512$ | 0.187 (0.081), $p = .016$ | -0.032 (0.079), $p = .664$ | -0.192 (0.113), $p = .088$ |
| Intervention X FG | 0.031 (0.077), $p = .700$ | -0.150 (0.097), $p = .114$ | 0.054 (0.095), $p = .562$ | 0.118 (0.133), $p = .378$ |
| URM Status as the Moderator | | | | |
| Intervention | -0.068 (0.041), $p = .094$ | 0.021 (0.052), $p = .680$ | 0.143 (0.051), $p = .006$ | -0.013 (0.077), $p = .870$ |
| URM status | 0.122 (0.070), $p = .098$ | 0.115 (0.085), $p = .186$ | 0.164 (0.086), $p = .066$ | -0.347 (0.123), $p = .006$ |
| Intervention X URM | -0.104 (0.080), $p = .200$ | 0.031 (0.098), $p = .764$ | -0.040 (0.098), $p = .678$ | -0.044 (0.143), $p = .756$ |

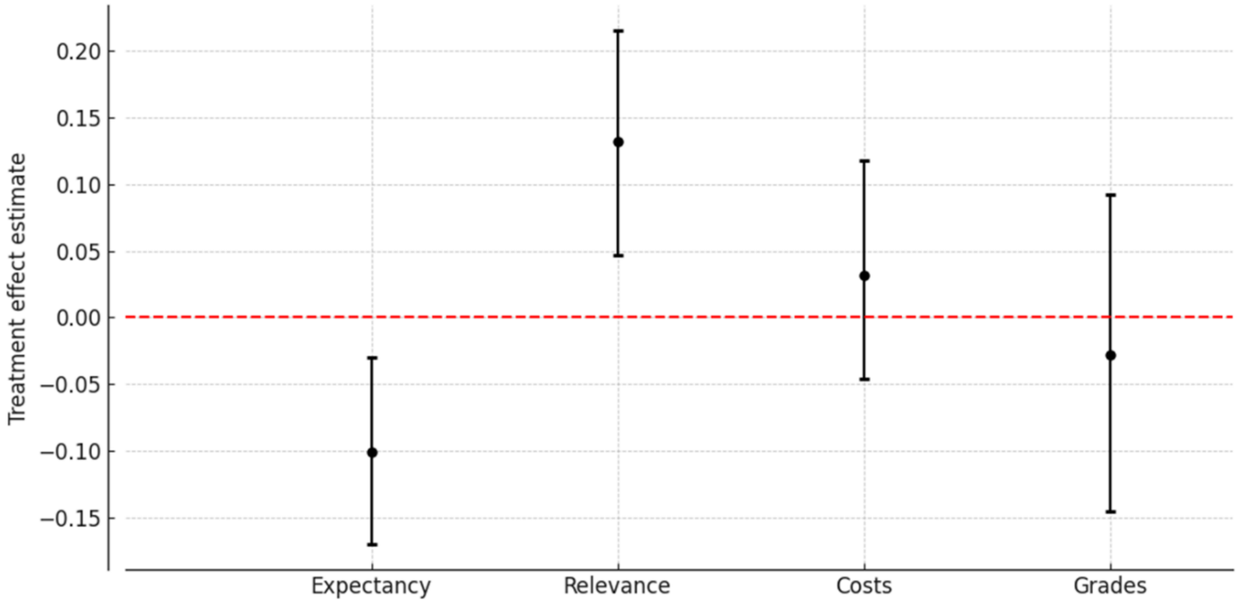
*Note.* All models also included pre-intervention motivation scores, generation status, URM status, student gender, and student high school GPA as covariates at both the student and instructor levels for both motivation and grades. Coefficients for these covariates were excluded from the table for the sake of parsimony.

Table 4

*Moderating Role of Perceived Teacher Support*

| | Estimate (Posterior *SD*), two-tailed *p* | | | |
|---|---|---|---|---|
| | Expectancies | Costs | Relevance | Grades |
| Intervention | -0.095 (0.041), *p* = .028 | 0.041 (0.047), *p* = .412 | 0.133 (0.043), *p* = .002 | -0.037 (0.073), *p* = .590 |
| Instructor Support | 0.046 (0.024), *p* = .064 | 0.025 (0.067), *p* = 0.580 | 0.036 (0.481), *p* = .736 | 0.068 (0.062), *p* = .282 |
| Intervention X Instructor Support | -0.069 (0.041), *p* = .084 | 0.006 (0.049), *p* = .920 | -0.114 (0.043), *p* = .008 | -0.035 (0.059), *p* = .492 |

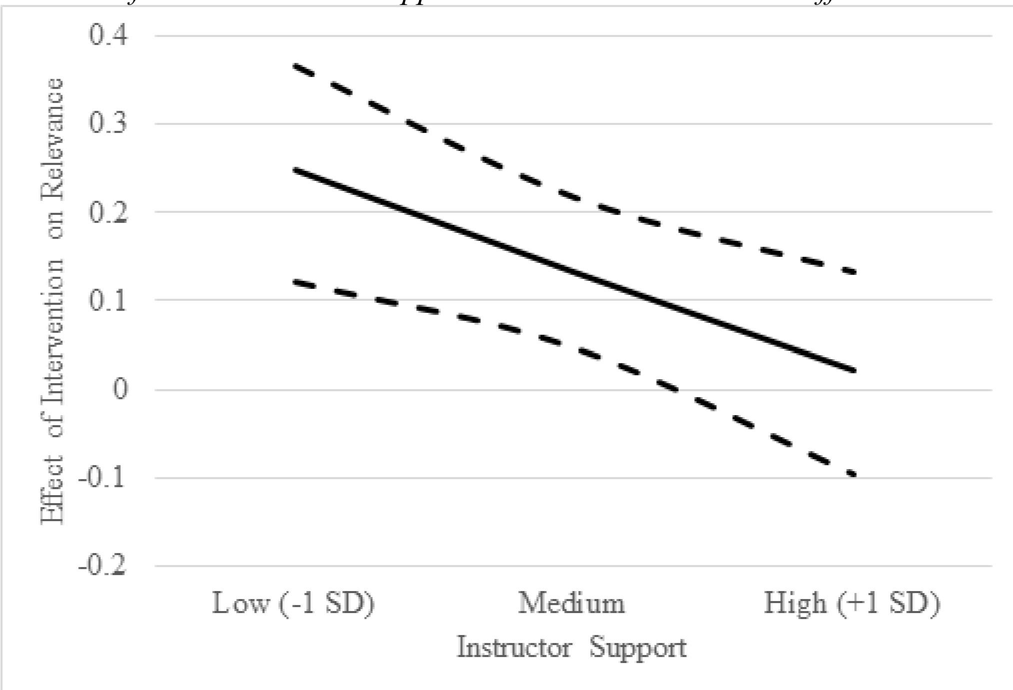
Figure 1.
*The Effect of the Utility Value Intervention on Expectancy, Relevance, Costs, and Grades.*




*Note.* Credible intervals that do not include 0 (indicated by the dotted horizontal line) represent significant effects.

Figure 2

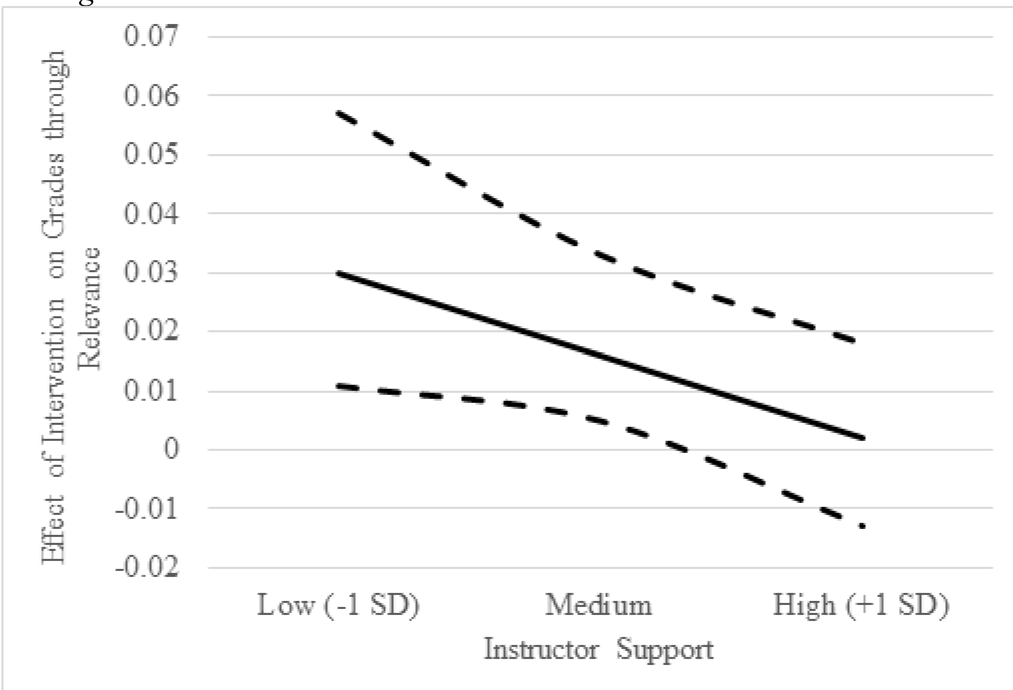
*Relation of Instructor Value-Supportiveness with Intervention Effect on Relevance.*




*Note.* The solid line represents the estimated effect of the intervention, while the dotted line identifies 95% credible intervals around the effect.

Figure 3

*Relation of Instructor Value-Supportiveness with Indirect Effects of the Intervention on Grades Through Relevance.*




*Note.* The solid line represents the estimated indirect effect of the intervention through motivation, while the dotted line identifies 95% credible intervals around the effect.