ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #38255

Improving Community College Students' STEM Motivation and Achievement by Implementing Utility-Value Interventions

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Introduction

Students from underserved populations (e.g., first-generation college students, racially marginalized students) face substantial barriers to degree completion in introductory science, technology, engineering, and math (STEM) courses [1], [2]. To remedy this equity problem, a variety of interventions have been designed to improve the achievement and persistence of historically underserved students in STEM disciplines. For example, utility-value interventions increase students' math interest and achievement in four-year colleges [3], [4] and are particularly effective for first-generation and racially marginalized students [5]. However, more research is needed on the efficacy of utility-value interventions at two-year colleges, which enroll a majority of first-generation students. Additionally, the psychological processes through which these interventions impact STEM achievement and retention need to be further explored.

Utility-value interventions are designed to enhance students' perceptions of the usefulness of a learning task (i.e., increase student perceptions of course utility value) [4], [6], [7], [8], with the aim of improving their motivation, performance, and persistence in courses. The basic notion behind utility-value interventions is that helping students draw connections between course content and their daily lives will increase students' perceived utility for the course. For instance, several intervention studies enhanced students' perceived utility value for their course by asking them to write about ways they might apply course concepts in real-world settings [7], [8]. Results of these interventions suggested that engaging in these writing activities enhanced students' interest and academic performance in the course. Therefore, finding one's coursework relevant to one's life may serve as a psychological mechanism through which the intervention improves academic outcomes.

Additionally, these utility-value interventions were particularly beneficial for students who reported lower competence beliefs [7], [8], [9]. Given that first-generation students typically report lower perceived preparedness for college [10] and therefore might express more doubts about their academic competence, the utility-value interventions may prove particularly effective for this student population. To test these possibilities, we addressed the following research questions: (1) Does the utility-value intervention improve students' math achievement at two-year colleges? (2) Does perceived math relevance serve as a psychological mechanism for the effects of the utility-value intervention on math achievement? (3) Does the utility-value intervention particularly benefit first-generation students?

Methods

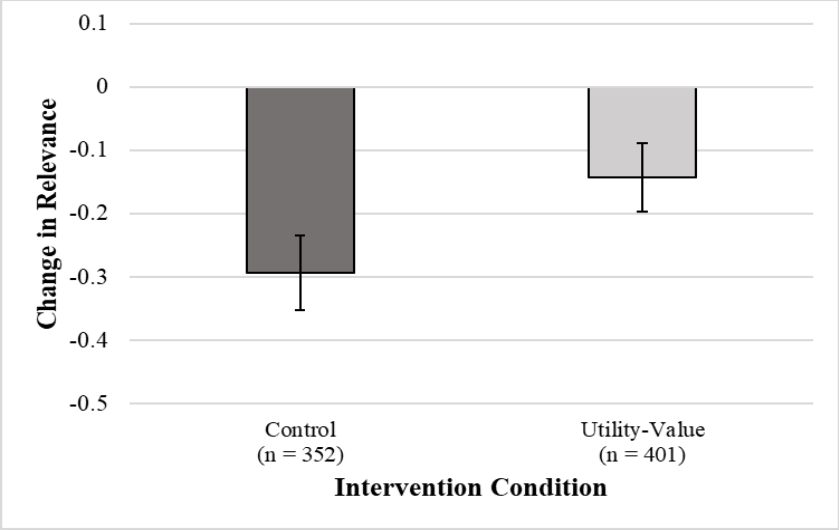
Participants were 1,318 students enrolled in introductory math courses across three community colleges in the Southeast United States. Students were randomly assigned to either the utility-value intervention condition (N = 732) or the control condition (N = 586). Participants were 71.3% female, 55.2% first-generation, 51.9% White, 26.4% African-American, 8.1% multi-racial, 6.1% Hispanic/Latinx, and 3.2% Asian, with the remainder selecting other races or declining to answer. Over the course of the semester, participants were asked to complete four online activities

on the Qualtrics survey platform, occurring at weeks one (Time 1), three (Time 2), four (Time 3), and twelve (Time 4) in the semester. The first and fourth activities were baseline and end-of-semester surveys to gauge student motivation, respectively, while the second and third activities contained the intervention materials. Students in the control condition were asked to summarize concepts they had learned recently in their math course (Activities 2 and 3). Students in the intervention condition were asked to read quotes from previous students about how math was important to their lives and rank these quotes based on how relevant they found them (Activity 2), then to write about how they could use math in real-world scenarios (Activity 3). We measured students' perceived math relevance pre- and post-intervention using two items constructed by Hulleman and colleagues [4]. Students' math course grades were obtained from administrative records at the end of the semester.

Results

We performed path analyses to investigate the direct and indirect effects of the intervention on math grades. Results revealed that the direct effect of the intervention on math grades was not statistically significant (b = -.12, β = -.04, 95% CI [-.32, .09]). However, after controlling for Time 1 perceived relevance (measured pre-intervention), the direct effect of the intervention on Time 3 perceived relevance (measured post-intervention) was significant (b = .16, β = .06, 95% CI [.02, .29]). That is, the utility-value intervention impacted students' change in perceived relevance over time. Although students in both conditions experienced decreases in relevance over time, students in the utility-value condition reported smaller decreases in relevance (M = -.23, SD = 1.24, d = -.19) compared to those in the control condition (M = -.32, SD = 1.28, d = -.25; see Figure 1). Additionally, after controlling for Time 1 relevance, the direct effect of Time 3 relevance on math grades was significant such that students who found math more relevant after the intervention received higher grades (b = .18, β = .15, 95% CI [.06, .30]). Further, the indirect effect of condition on grades through relevance was significant (b = .03, β = .01, 95% CI [.004, .07]).

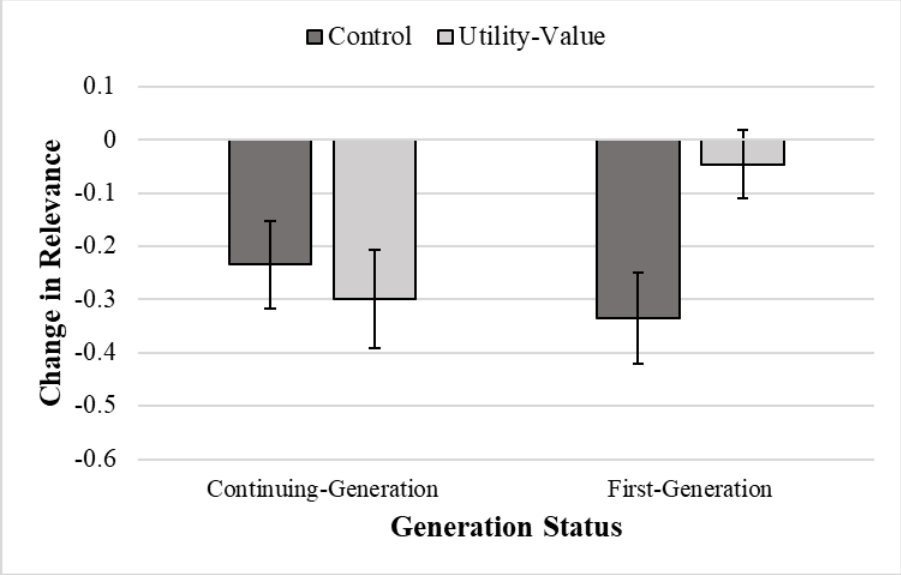
Figure 1
Change in Relevance by Condition



Note: n = sample size. Change in Relevance was calculated by subtracting Time 1 Relevance from Time 3 Relevance; error bars represent +/- 1 standard error.

We also examined the role of generation status in moderating the effects of the intervention on perceived math relevance and grades. Results suggested that after controlling for Time 1 relevance, the effect of the interaction of intervention by generation status on Time 3 relevance was significant (b = .48, β = .18, 95% CI [.20, .75]). Simple slope results revealed that the positive effect of the intervention on relevance was significant for first-generation students (b = .37, p < .001, 95% CI [.20, .54]) but not for continuing-generation students (b = -.11, p = .307, 95% CI [-.31, .10]). For first-generation students in the control condition, perceived math relevance decreased significantly from Time 1 to Time 3 (M = -.35, SD = 1.27, d = -.28), but for first-generation students in the utility-value intervention condition, perceived math relevance remained mostly stable over time (M = -.08, SD = 1.19, d = -.07). That is, the utility-value intervention protected first-generation students' perceived math relevance from decreasing rapidly over time. This buffering effect was not observed for the continuing-generation students, who experienced similar decreases in math relevance in the control (M = -.25, SD = 1.29, d = -.19) and intervention conditions (M = -.34, SD = 1.26, d = -.27). See Figure 2.

Figure 2
Change in Relevance by Condition and Generation Status



Note: Change in Relevance was calculated by subtracting Time 1 Relevance from Time 3 Relevance; error bars represent +/- 1 standard error. Significant differences were found between the control and utility-value intervention conditions in the first-generation group.

Further, the indirect effect of intervention on grades through relevance was significantly moderated by generation status (b = .09, 95% CI [.03, .18]). That is, the strength of this indirect effect differed for first-generation and continuing-generation students. We followed up this significant interaction with simple slope tests. Results revealed that, for first-generation students the indirect effect of intervention on grades through perceived relevance was significant (b = .07, 95% CI [.02, .13]). This indirect effect was not significant for continuing-generation students (b = -.02. 95% CI [-.07, .01]).

Discussion

Results from the present study add to the growing body of research that suggests that brief psychological interventions make a significant difference in students' learning outcomes. Consistent with prior research [6], [8], [11], our findings revealed that the theory-guided utility-value intervention is effective in improving students' motivation and achievement. Results further confirmed the theoretical expectation [3] 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' perceptions of relevance for math. Higher math relevance, in turn, improves students' math achievement in the course. Consistent with prior research that highlights the additional effectiveness of utility-value interventions for underserved students [5], we found that our intervention particularly benefited first-generation students. Results suggested that whereas perceived math relevance decreased for continuing-generation students in the control and intervention conditions alike, first-generation students in the intervention condition did not experience a significant decrease in perceived relevance. Therefore, findings suggested that our brief, classroom-based utility-value intervention could stop the downward trajectory of motivation for first-generation students and protect them from subsequent negative impacts on achievement. This finding is particularly important given the community college context in which our interventions were implemented. Serving a population of over 55% first-generation students, the community colleges in our study should prioritize instructional strategies that are conducive to the needs of this large student population. By investing in motivation-enhancing activities such as utility-value interventions, community colleges could significantly improve first-generation students' academic experiences, contribute to narrowing equity gaps, and increase institutional achievement and retention rates.

Acknowledgement

This work was supported by a National Science Foundation Level III ECR Core Research Grant (FAIN: 2000507). The content is solely the responsibility of the authors and does not represent the official views of the National Science Foundation.

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