Board 334: Motivation Loss in Math: Contributing Factors and Consequences

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Abstract

Sustaining student motivation in STEM education is crucial for reducing dropout rates. Prior research shows a decline in motivation among students in general, with greater declines for students identifying as Black, Latine, Native American, and/or first-generation (i.e., marginalized). The present study seeks to understand the dynamics of motivation loss—its antecedents and consequences—among marginalized versus non-marginalized students in introductory STEM courses. We tested changes in student motivation over time, its relationship to academic achievement, differential rates of change based on marginalized student status, and whether these differential rates could be explained by students' perceived treatment by instructors. Participants were 1,231 students enrolled in introductory math courses across 13 community colleges in the Southeastern United States. Motivation was assessed four times during a semester using expectancy, value, and cost indicators, and students' perceptions of treatment by their instructors were assessed once at the semester's start. Results of the latent growth curve models suggested that positive motivation beliefs (i.e., expectancies and values) significantly declined while negative motivation beliefs (i.e., costs) significantly increased over time. These changes in motivation beliefs significantly predicted lower math achievement. Further, Black, Latine, and Native American students showed more pronounced declines in expectancies compared to White and Asian students. Additionally, first-generation students reported more pronounced increases in cost relative to continuing-generation students. Finally, for Black, Latine, and Native American students, but not White or Asian students, perceptions of fair treatment by instructors predicted a slower decline in math expectancies. Overall, results suggested that motivation loss, which was more severe among marginalized students, had negative consequences for students' achievement. Further, our study highlights the potentially protective role of fair and respectful treatment in academic contexts for Black, Latine, and Native American students. Results imply that creating more perceptibly supportive learning contexts may prevent motivation loss and improve achievement, particularly among marginalized groups.

Introduction

The pursuit of excellence in science, technology, engineering, and mathematics (STEM) requires students' sustained enthusiasm and commitment. However, the high rate of dropouts and transitions to other majors implies that students struggle with maintaining motivation in STEM disciplines. Indeed, longitudinal research suggests that motivation tends to decline over time in STEM fields, particularly in introductory courses that serve as gateways to graduation. This decline in motivation can, in turn, result in decreased academic performance and hindered progress toward degree attainment [1]-[2]. This motivation loss may be even more substantial for Black, Latine, Native American, and first-generation students (i.e., marginalized students). Despite starting STEM majors with similar or higher levels of interest compared to non-marginalized students [2], these specific student groups tend to experience higher rates of dropout from STEM majors [3]-[4]. This disparity underscores the importance of understanding the unique challenges faced by marginalized students in sustaining their motivation within STEM disciplines.

The learning context within STEM education could play a crucial role in understanding the nature of motivation loss, particularly for students from marginalized groups. These contextual factors extend beyond the traditional pedagogical methods and curriculum structures and encompass sociocultural contributors such as experiences with stereotypes, exclusion, unfair treatment, and belonging uncertainty. Indeed, research suggests that higher perceptions of stereotype threat (i.e., worries about being judged negatively based on stereotypes [5]) among Black, Latine, and Native American students predicted faster declines in motivation for science across four years of college [6]. This finding implies that students' perceptions of how they would be treated in the learning context could have long-term and chronic effects on their motivation, which could in turn influence their achievement and persistence outcomes.

To better understand the nature of motivation loss in STEM and its consequences, we grounded our study in the expectancy-value-cost motivational framework [7]-[8]. This theory posits that for students to experience motivation, they need to maintain optimal levels of expectations of success (i.e., expectancy), recognize values for the task/domain (i.e., value), and perceive limited drawbacks associated with engaging in the task/domain (i.e., cost). These beliefs, in turn, are predictive of achievement outcomes and influence persistence decisions. We measured motivation four times across a semester using these three indicators to better understand the differential nature of motivation loss among marginalized and non-marginalized students. Additionally, we examined perceptions of treatment by instructors as a key contextual factor that could contribute to the differential rate of motivation loss in students from marginalized versus non-marginalized groups. Specifically, we addressed the following research questions:

1. How does motivation change over time in an introductory math course?
2. Does the change in motivation predict math achievement?
3. Do students from various demographic groups experience varying rates of motivation change?
4. Can the differential rates in motivational change among different demographic groups be explained by perceptions of the learning context?

Methods

We collected data as part of a larger study (NSF HRD#2000507) aimed at examining the effects of a motivation-supporting intervention on students' math outcomes. To eliminate the confounding effects of the intervention on students' motivational change, we limited our sample to students in the control condition (N = 1,231). Students were recruited from 13 community colleges in the Southeast U.S. and were 64.1% female, 40.3% first-generation, and 32.3% Black, Latine, or Native American. These students were enrolled in one of four introductory math courses (college algebra, introductory statistics, finite math, and math for general studies). Using the measure created by Kosovich and colleagues [9], we measured students' motivation beliefs (expectancies, values, costs) at weeks 1, 3, 5, and 14 of the semester. During week 1, we assessed how fairly and respectfully students perceived they were treated by their instructors, to measure students' baseline perceptions of their learning context [10]. See Table 1 for details on our scales. After week 15, institutions provided students' math grades. Our analyses controlled for clustering effects of students in the same course.

Table 1. Sample Expectancy-Value-Cost and Perceptions of Fair Treatment Items and Reliabilities

Motivation Construct	# Items	Sample Item	Reliability
Expectancy [9]	3	"I believe I can be successful in math."	$\alpha_1 = .89$, $\alpha_2 = .86$, $\alpha_3 = .88$, $\alpha_4 = .91$
Value [9]	4	"What I learn in my math classes will be useful in the future."	$\alpha_1 = .86$, $\alpha_2 = .75$, $\alpha_3 = .80$, $\alpha_4 = .90$
Cost [9]	5	"I'm unable to put in the time needed to do well in math."	$\alpha_1 = .85$, $\alpha_2 = .75$, $\alpha_3 = .74$, $\alpha_4 = .87$
Perceptions of Treatment by Instructors [10]	2	"I am treated fairly by teachers and other faculty/staff at my school."	$r_1 = 0.65$

Note: Subscripts on Cronbach's alpha reliabilities indicate timepoint. A subset of 2 items from each scale were used for timepoints 2 and 3.

Results and Discussion

We conducted latent growth curve models [11] to examine change in motivational beliefs. To this end, we examined the intercepts (initial levels of motivation) and slopes (rates of change in motivation) for each motivation variable. We set the linear slope of motivation variables to 0, 0.15, 0.31, and 1.00 to match the time intervals between measurements (i.e., assessments at weeks 1, 3, 5, and 14). After calculating the intercepts and slopes, we then explored whether these parameters predict math achievement and can be predicted by demographic and learning context variables. Data was analyzed using Mplus version 8.6 [12]. Results for each research question is discussed below.

How Does Motivation Change Over Time in an Introductory Math Course?

Analyses of the intercepts indicated that students started their introductory math courses with relatively high (and significantly different than zero) expectancies ($M_{intercept} = 4.79$, $p < .001$) and values ($M_{intercept} = 3.27$, $p < .001$), and relatively low (and significantly different than zero) perceived costs ($M_{intercept} = 2.93$, $p < .001$). However, results of the linear slopes suggested that over the course of the semester, expectancies and values significantly declined ($M_{slope} = -.24$, $p < .001$ for expectancies; $M_{slope} = -.33$, $p < .001$ for values) and costs significantly increased ($M_{slope} = .25$, $p < .001$). These results provide evidence that students suffer a significant motivation loss in these introductory math courses.

Does the Change in Motivation Predict Math Achievement?

Results also indicated that the decline in expectancies and values and the increase in costs *significantly predicted math achievement* ($b = 1.11$, $p < .001$ for expectancies; $b = .95$, $p < .001$ for values; $b = -1.16$, $p < .042$ for costs). Therefore, motivation loss has practical consequences for students' achievement—and potentially for degree attainment—in introductory math courses.

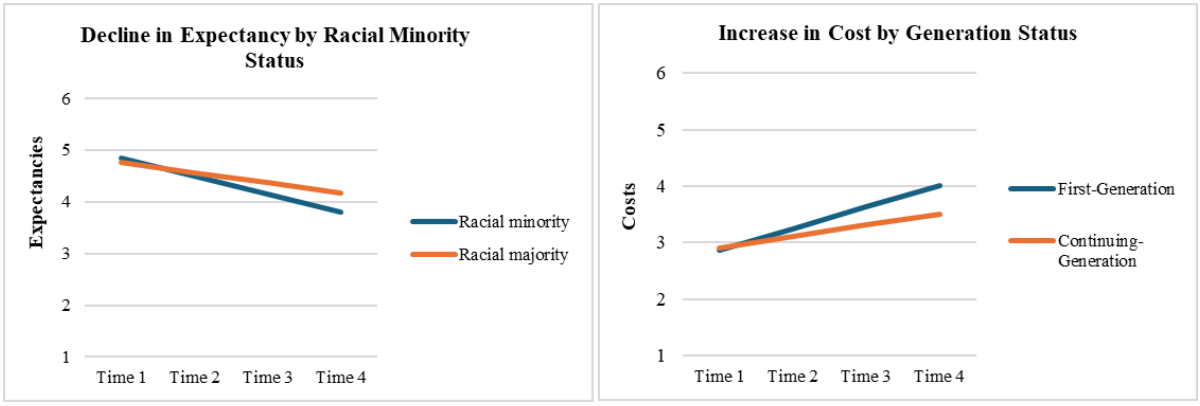
Do Students from Various Demographic Groups Experience Varying Rates of Motivation Change?

We regressed the intercepts and slopes of motivation beliefs on students' racial minority status (Black, Latine, and Native American vs. White and Asian) and generation status. Results indicated that Black, Latine, and Native American students had similarly high initial levels (as measured by intercepts) of expectancies for success (b = .09, p = .112) and values (b = .14, p = .126), though higher levels of cost (b = .16, p = .010), compared to White and Asian students. First-generation and continuing-generation students also had similar initial levels of motivational beliefs (expectancies, b = -.04, p = .400; values, b = .09, p = .231; costs, b = -.08, p = .127). This finding was consistent with past research that suggests marginalized students tend to start STEM majors with similar levels of motivation as their non-marginalized peers [2]. However, the higher initial costs for Black, Latine, and Native American students may indicate that these students may have more barriers to their motivation to overcome in the beginning of their math course.

Although marginalized and non-marginalized students demonstrated similar levels of initial motivation, they showed differential levels of change in some of these beliefs. The results of linear slopes suggested that expectancies declined more rapidly for Black, Latine, and Native American students compared to White and Asian students (b = -.19, p = .028), but that the rates of change in values and costs did not significantly differ between these groups (b = -.09, p = .162 for values; b = .03, p = .757 for costs). Additionally, for first-generation students, costs increased more steeply (b = .16, p = .033) compared to continuing-generation students, but the rates of change in expectancies and values did not significantly differ between first-generation and continuing-generation groups (b = -.10, p = .196 for expectancies; b = -.10, p = .188 for values). See Figure 1 for a graphical representation of the significant results.

The equal initial motivation between marginalized and non-marginalized students but more substantial loss in some of the motivation beliefs among students of marginalized groups hinted at the existence of factors that could be differentially impacting students of marginalized groups.

Figure 1. Differential Rates of Change in Expectancies, Values, and Costs by URM Status and Generation Status



Note. These graphs represent the linear slopes for expectancies and costs, suggesting that expectancies decrease more steeply for racial minority students (Black, Latine, Native-American) and costs increase more rapidly for first-generation students.

Can the Differential Rates in Motivational Change Among Different Demographic Groups be Explained by Perceptions of the Learning Context?

We explored one contextual factor (i.e., perceptions of fair and respectful treatment by instructors) as a predictor of the differential rate of motivational loss between marginalized and non-marginalized students. Given the findings presented in the previous section, we tested whether this contextual variable predicted differential rates of change in expectancies between the Black, Latine, and Native American group versus the White and Asian group, as well as differential rates of change in costs between the first-generation group and the continuing-generation group. We found that perceptions of fair and respectful treatment by instructors negatively predicted the decrease in expectancies for Black, Latine, and Native American students (b = -.35, p = .015) but not for White and Asian students (b = -.09, p = .223). This finding suggested that having the opportunity to learn in an inclusive context where students perceived that they were treated fairly and respectfully by their instructors protected racial minority students' expectations for success from declining rapidly. When examining generation status, we found that perceptions of fair and respectful treatment by instructors did not significantly predict the increase in costs for either first-generation students (b = .06, p = .533) or continuing-generation students (b = -.02, p = .830).

Conclusion

Our study takes a comprehensive approach by not only examining the nature and consequences of motivation loss among all students but also testing the contextual factors that contribute to the inequities in motivation loss and achievement. We found that although motivation declined for all students on average, for students of marginalized groups, including Black, Latine, Native American, and first-generation students, these beliefs declined more steeply. This is especially disconcerting given that steeper declines in motivation were associated with lower levels of math achievement. On a more hopeful note, the steeper decline in motivation, particularly among

Black, Latine, and Native American students, was attenuated by students' perceptions of fair and respectful treatment relayed by their instructors. This suggests that improving the context through the provision of inclusivity, autonomy, and respect to students could support racial minority students' motivation and achievement and reduce equity gaps. Through this research, we aspire to contribute valuable insights that can inform interventions and educational policies aimed at improving outcomes for students of marginalized groups.

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