Perceptions of Emotional Cost and Undergraduate Students' Interest in Physics

Arianna L. Black, 2021

Introduction

For many years, educators and other stakeholders have raised concerns about student persistence and retention in science, technology, engineering, and mathematics (STEM) education pathways and careers (National Science Foundation [NSF], 2019). Despite the attention being devoted to this issue, problems remain; women, in particular, are underrepresented in STEM education pathways and majors, as well as in STEM careers (NSF, 2019). Investigating factors that affect students' educational experiences and choices, particularly in undergraduate course and major selection, can be helpful, as often those decisions lead students down specific career paths. Students' academic motivation is one aspect that may help us better understand student persistence, achievement, and retention in STEM education during undergraduate studies.

Literature Review

Motivation

Student motivation is the initiation and maintenance of goal-directed activities (Schunk et al., 2014). Students' academic motivation has been associated with important educational behaviors and outcomes, including persistence, achievement, and retention (e.g., Schunk et al., 2014). Students may have a wide variety of reasons that they feel motivated (or unmotivated) toward their academic pursuits, including finding the content relevant or useful, feeling that it is personally important to reach a goal, having a particular interest in the subject matter, or finding the material too difficult or unimportant, among other reasons (e.g., Eccles & Wigfield, 2020; Hidi & Renninger, 2006).

Interest

Student interest develops in phases and ranges from interest that is merely situational and confined to a moment or context, to that which is more enduring or long term (Hidi & Renninger, 2006; Linnenbrink-Garcia et al., 2010). This longer-term form of interest is known as individual interest, and often leads students to engage with content or activities repeatedly over time (Hidi & Renninger, 2006). Student interest is an important facet for goal pursuits, as well as for academic persistence. Research has shown, however, that the environment or the context can support or inhibit students' interest (Hidi & Renninger, 2006). Given the associations between interest and persistence in a domain, student interest is an crucial outcome in its own right. Importantly, however, interest alone will not lead to goal achievement, as there are additional elements related to task engagement or goal pursuits that must be considered.

Expectancy-Value Theory of Achievement Motivation

A useful theoretical framework for understanding factors that may affect students' achievement motivation is Expectancy-Value Theory (EVT; Eccles & Wigfield, 2020). Expectancy-Value Theory suggests that an individual's motivation for achievement endeavors depends in part on whether they expect to be successful, or their expectancies for success, and how valuable the task is, or what is known as task values. Under the EVT framework, task values include how useful, relevant, interesting, or important the task is, as well as the potential associated costs of task engagement.

While students' expectancies for success have been associated with their subsequent performance and achievement, students' task values are often predictive of their choices (Eccles & Wigfield, 2020). Students may value a task because it is relevant or useful (utility value), personally important (attainment value), or because the task is worth engaging in for its own sake

(intrinsic or interest value) (Eccles & Wigfield, 2020). The fact that task values predict student choices has important implications for decisions that are likely to be made during a students' undergraduate educational career, like course-taking and major selection. Yet, little is known about the development of students' motivation during this time period, despite its importance (Robinson et al., 2019).

Costs: Negative Aspects of Task Engagement

Although students may be motivated to reach their goals because they are interested or find the goal important or useful, this is not always the case. There are also negative aspects associated with goal pursuit, which EVT accounts for by including costs as a task value consideration in the theoretical framework. Costs are the perceived negative consequences of task-engagement (Eccles & Wigfield, 2020; Flake et al., 2015). Costs are multifaceted and include effort costs, loss of valued alternative(s), and emotional or psychological cost (Eccles & Wigfield, 2020; Flake et al., 2015). Effort costs, further separated into task effort and outside effort, account for the consideration learners make for whether the task is worth engaging in based on the amount of effort required for completion or other responsibilities that keep students from exerting effort in the target area, respectively (Flake et al., 2015). Loss of valued alternatives acknowledges that when learners engage in any activity they are, by default, foregoing the opportunity to engage in other activities (Eccles & Wigfield, 2020). Finally, costs also include emotional or psychological costs, such as how stressful or anxiety-inducing pursuing a goal is, or the anticipated social costs of failure (Eccles & Wigfield, 2020; Flake et al., 2015).

Emotional cost, in particular, has been found to be negatively associated with students' interest (e.g., Flake et al., 2015), and other studies have found that students' perceptions of cost

in STEM courses typically increase over time (e.g., Robinson et al., 2019). As such, it can be helpful to understand how students perceive their STEM courses and how an important motivational factor, cost, is related to students' interest in physics.

Current study: Goals and Research Questions

Due to the relations between task values, specifically, costs, and student interest and persistence, the goal of the current study were to identify the relationship between students' perceptions of emotional cost in their physics course and their interest in physics as a domain. In addition, this study sought to understand whether the relationship between perceptions of emotional cost in physics class and interest in physics as a domain depended on student gender, given the underrepresentation of women in STEM domains. As such, research questions were as follows:

1. What is the association between perceptions of emotional cost in physics class and individual interest in physics?
2. Does gender moderate the relationship between perceptions of emotional cost and interest in physics?

Method

Participants

Participants in this study were students in introductory physics courses at a large, Midwestern university (n = 832). Seventy percent of participants identified as male, while 30% were female identifying. Sixty-eight percent of participants were White, 24% were Asian/Asian American, 3% were Hispanic/Latinx, 3% were more than one or other, and 2% were Black. In terms of grade-level, 49% of participants were freshmen, 37% were sophomores, 11% were juniors, and 3% were seniors.

Procedure

Data for this study came from a larger, ongoing project that assesses learning, motivation, and retention in undergraduate physics courses. Participants responded to Likert-type items, collected via online survey at the beginning and end of the spring 2017 semester.

Measures

Items assessed participants' agreement with previously validated survey measures; in particular, perceptions of emotional cost (Flake et al., 2015) and individual interest (Linnenbrink-Garcia et al., 2010). The emotional cost scale had six items, ranging from completely disagree (1) to completely agree (9), and the interest scale had eight items, ranging from strongly disagree (1) to strongly agree (7). Sample items and Cronbach's alphas are reported (Table 1). As is standard practice, survey items were modified slightly to be specific to the course and domain of physics, respectively. A higher score on emotional cost indicated greater perceptions of emotional cost in their physics course, and a higher score on interest indicated feeling a stronger individual interest in physics as a domain. Participants also self-reported gender identity and other demographic information, as described previously.

Table 1.

Cronbach's Alphas and Sample Survey Items

Scale	α	Sample Item
Interest	.96	Physics is practical for me to know.
		It is important to me to be a person who reasons using physics.
		I like physics.
		I enjoy physics.
Emotional Cost	.95	I worry too much about this physics class.
		This physics class is emotionally draining.
		This physics class makes me feel too anxious.
		This physics class is too stressful.

Analyses

The current study utilized hierarchical multiple regression analyses in SPSS v. 27 to assess the relationship between emotional cost and interest and whether gender moderated this relationship. The predictor variable (i.e., emotional cost) was centered at the mean, a common practice in regression analyses that makes coefficient values more readily interpretable (e.g., Wainer, 2000). Male was coded as zero and female was coded as one.

Results

Descriptive statistics were calculated for dependent and independent variables (Table 2). Pearson correlations among variables were also calculated (Table 3).

Table 2.

Descriptive Statistics

		Male	Female
Individual Interest	*M*	4.38	3.85
	SD	1.44	1.63
	n	588	244
Emotional Cost	*M*	5.22	5.97
	SD	1.99	2.05
	n	587	244

Table 3.

Pearson Correlations among Interest, Emotional Cost, and Gender

Variable	1	2	3
1. Individual Interest	-		
2. Emotional Cost	-.353**	-	
3. Gender	-.153**	.161**	-

Note.
**Correlation is significant at the 0.01 level (2-tailed).

Research Question One

For research question one, results of hierarchical multiple regression analysis (Table 4) revealed that the expected value of interest in physics for males was 4.32 ($p < .001$) when controlling for perceptions of emotional cost. For females, the expected value of interest was significantly lower ($B = -0.35$, $p = .002$). Holding gender constant, it is expected that a one unit increase in emotional cost would result in 0.25 unit decrease in interest in physics ($p < .001$).

Research Question Two

For research question two, results of hierarchical multiple regression analysis with the interaction term added (Table 4) revealed that the expected value of interest in physics for males was 4.33 ($p < .001$), holing emotional cost constant. The expected value of interest in physics was significantly lower for females ($B = -0.30$, $p = .006$). Holding gender constant, it is expected that a one unit increase in emotional cost would result in 0.20 unit decrease in interest in physics ($p < .001$). The interaction term between gender and emotional cost resulted in decreased interest in physics ($B = -0.18$, $p = .001$). Probing the interaction (Figure 1) revealed that for females, the perception of emotional cost in physics class impacts their interest more negatively than it does for males.

Table 4.

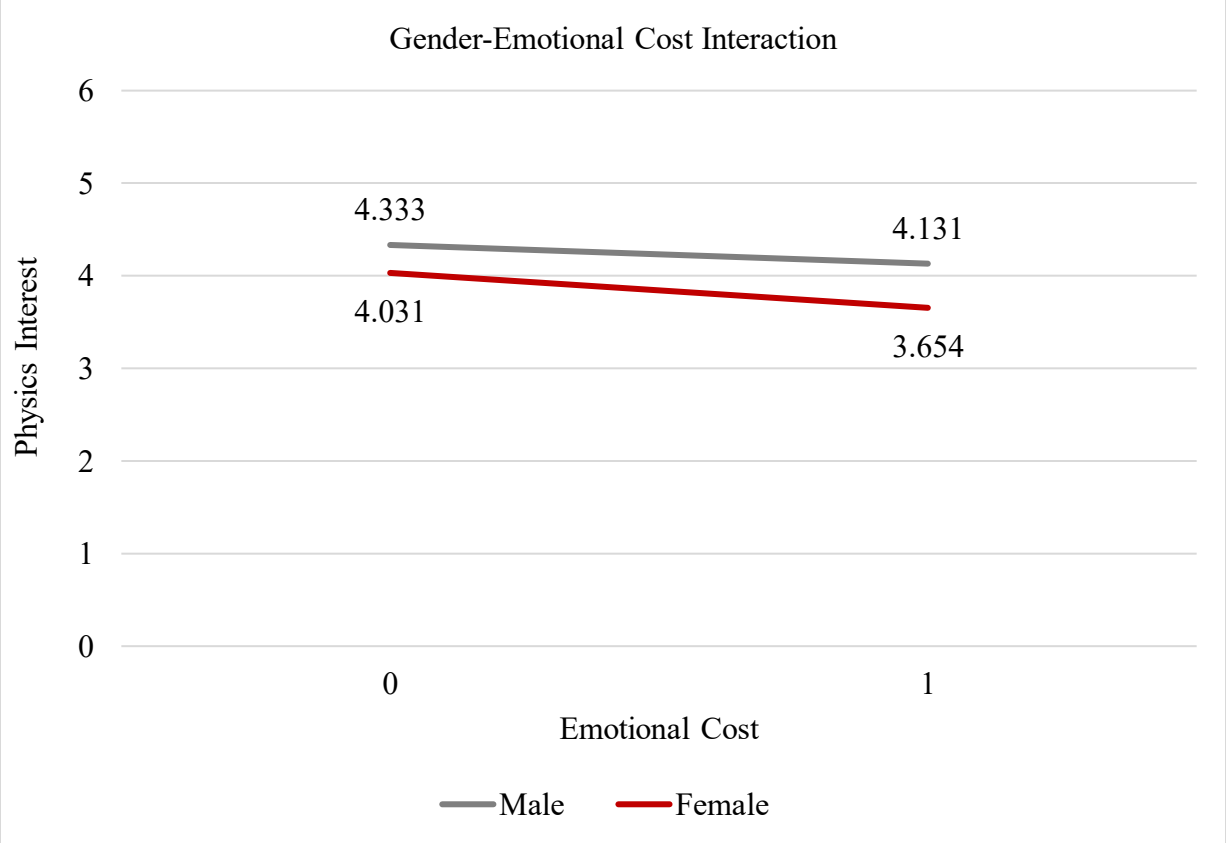
Results of Hierarchical Linear Regression Analyses Predicting Interest in Physics

Variable	B	*SE* B	*β*	95% CI		*p*
				LL	*UL*	
Step 1						
Intercept	4.32	0.06		4.20	4.43	.000
Gender	-0.35	0.11	-0.10	-0.55	-0.11	.002
Emotional Cost	-0.25	0.02	-0.34	-0.30	-0.21	.000
Step 2						
Intercept	4.33	0.06		4.21	4.45	.000
Gender	-0.30	0.11	-0.09	-0.50	-0.07	.006
Emotional Cost	-0.20	0.03	-0.27	-0.26	-0.14	.000
Gender-Emotional Cost Interaction	-0.18	0.05	-0.13	-0.28	-0.07	.001

Note.
R^2 = .138, p < .001 for step 1; R^2 Δ = .012, p < .001 for step 2.

Figure 1.

Interaction between Gender and Emotional Cost.



Discussion

Implications

This study revealed that perceptions of emotional cost were associated with decreased interest in physics, and that this relationship was dependent on student gender as well. Because student interest is related to important achievement behaviors that are relevant to problems in STEM education, such as persistence, these findings may be useful for better understanding students' educational experiences. Furthermore, these findings can also be used to support the development of interventions that are designed to promote student persistence and retention in STEM fields, particularly for underrepresented populations, such as women.

One possible type of intervention is to reduce or mitigate students' perceptions of cost (e.g., Rosenzweig et al., 2020). Cost reduction interventions in STEM fields are novel, but recent studies have shown that reducing perceptions of cost may benefit students' course outcomes (Rosenzweig et al., 2020). Furthermore, cost reduction interventions typically involve relatively few resources, both financially and in terms of time, thus making them well suited to reach the sizeable audiences that tend to be present in introductory courses at large, undergraduate institutions. For instance, in their recent study, Rosenzweig et al (2020) had students rate their agreement with different quotations from previous students' physics course experiences expressing elements of cost, including emotional cost, and how they overcame that as the semester progressed. Then, students were asked to provide their own quotations in a similar format, whereby they briefly wrote about a "costly" challenge in the course that they had overcome. Initial results showed that students in the intervention condition had significantly higher exam scores and overall course grade, particularly for students who were initially lower performing, as compared to those in the control group (Rosenzweig et al, 2020). These findings

demonstrate the ease and promise of cost reduction interventions, warranting ongoing research in this area.

Limitations

This study had a few limitations. First, the data were cross-sectional from a single timepoint, which prohibits casual determinations from being made. In other words, while emotional cost was associated with decreased interest in physics, longitudinal analyses would be necessary before making any kinds of causal conclusions that perceptions of emotional cost resulted in decreased interest in physics. In addition, beyond gender, this study did not include any other covariates/control variables. Including other demographic information, such as race, prior achievement, or generational status, could provide more nuance and rigor.

Future Directions

While previous research has suggested that student interest is related to persistence (e.g., Hidi & Renninger, 2006), additional longitudinal work that investigates this relationship is important. In addition to considering the impact on student interest, determining students' actual persistence and retention in physics courses and/or majors for this sample could provide one fruitful area for additional projects. Lastly, including other elements of cost to determine which is most impactful for STEM students is another avenue that may provide important information about how students experience their STEM education. Previous studies have demonstrated that effort cost may be particularly salient in introductory STEM undergraduate courses (Robinson et al., 2019). Furthermore, it may also be beneficial to include other components of task values besides cost (i.e., utility, intrinsic, and attainment value), as studies have shown that these task values are also related to course outcomes, including achievement and retention (Robinson et al., 2019).

Conclusion

Using theories of academic motivation, this study revealed a relationship between students' perceptions of emotional cost in their physics class and their interest in physics as a domain. These findings can help educators and other stakeholders better understand students' STEM education to more adequately promote and encourage persistence, achievement, and retention. This may be particularly important for certain populations, including, though not limited to, women, who continue to remain underrepresented in STEM education and careers.

References

Eccles, J. S. & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. Contemporary Educational Psychology, 61. https://doi.org/10.1016/j.cedpsych.2020.101859.

Flake, J. K., Ferland, M., & Flora, D. B. (2017, April 28), Trajectories of psychological cost in gatekeeper classes: Relationships with expectancy, value, and performance. Paper presented at the 2017 annual meeting of the American Educational Research Association. Retrieved September 13, 2020, from the AERA Online Paper Repository.

Flake, J. K., Barron, K. E., Hulleman, C., McCoach, B. D., Welsh, M. E. (2015). Measuring cost: The forgotten component of expectancy-value theory. *Contemporary Educational Psychology, 41,* 232 – 244. http://dx.doi.org/10.1016/j.cedpsych.2015.03.0020361-476X/

Hidi, S. & Renninger, K. A. (2006). The four-phase model of interest development. Educational Psychologist, 41(2), 111-127.

Linnenbrink-Garcia, L., Durik, A. M., Conley, A.M., Barron, K. E., Tauer, J. M., Karabenick, S. A., & Harackiewicz, J. M. (2010). Measuring situational interest in academic domains. *Educational and Psychological Measurement, 70*(4), 1 – 25. https://doi.org/10.1177/0013164409355699

National Science Foundation, National Center for Science and Engineering Statistics. (2019). Women, minorities, and persons with disabilities in science and engineering: 2019. Special Report NSF 19-304. Alexandria, VA. https://www.nsf.gov/statistics/wmpd.

Robinson, K. A., Lee, Y., Bovee, E. A., Perez, T., Walton, S. P., Briedis, D., Linnenbrink-Garcia, L. (2019). Motivation in transition: Development and roles of expectancy, task values, and costs in early college engineering. *Journal of Educational Psychology, 111, 6,* 1081 – 1102. http://dx.doi.org/10.1037/edu0000331

Rosenzweig, E. Q., Wigfield, A., & Hulleman, C. S. (2020). More useful or not so bad? Examining the effects of utility value and cost reduction interventions in college physics. Journal of Educational Psychology, 112(1), 166 – 182. http://dx.doi.org/10.1037/edu0000370.

Schunk, D. H., Meece, J. L., & Pintrich, P. (2014). *Motivation in education. Theory, research, and applications*. Englewood Cliffs, NJ: Prentice Hall.

Wainer, H. (2000). The centercept: An estimable and meaningful regression parameter. *Psychological Science, 11*(5), 434 – 436.