Teaching Strategies and Value for STEM Courses

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Abstract

Expectancy-value theory has been used to investigate reasons why students have low achievement and low interest in science, technology, engineering, and mathematics (STEM) courses. The purpose of this study was to investigate the relationship between self-efficacy, perceived teaching practices, and subjective task value in gateway STEM courses. Results demonstrated that self-efficacy influenced perception of teaching practices and subjective task value, and perceived teaching practices influenced subjective task value. Results and implications for teaching practices are discussed.

Introduction

Because of increased interest in retaining students in science, technology, engineering, and mathematics (STEM) fields, the present study sought to understand how instructors' teaching strategies and student self-efficacy act to influence value for STEM courses. Expectancy-value theory is used as a motivation framework, and is combined with holistic educational theory to understand students' subjective task value for STEM courses.

Background

Retention and persistence in STEM courses and majors have become increasingly important. Social policy interests, national interests, student development outcomes, and equity in education are all compelling reasons to focus efforts in this area. Of particular note are disparities in the students who choose STEM majors and careers versus those who do not. Specifically, women and students of color have historically entered these fields at much lower rates for myriad reasons. University professors, administrators, and researchers face increasing pressure to find solutions that will help attract, retain, and increase the success of students in STEM-related fields.

One theoretical frame that has been mobilized to understand this area with great frequency is expectancy-value theory. This motivation theory was originally developed in the context of understanding why women valued mathematics courses less and tended to have lower achievement in math. Both achievement gaps, as well as interest and persistence gaps, have been examined through this theoretical framework since its initial development (Eccles, 2005b). There are problems with the level at which students achieve in STEM fields, the level of interest they have in those areas of study, and the rate at which they persist in those fields. In math achievement, Watt, Eccles, and Durik (2006) found that boys and girls had similar expectancy for success, but different subjective task value. Thus, while they achieved at similar levels, they did not select math courses at the same level or persist in math to the same degree. This is consistent with the traditional understanding in expectancy-value theory: Students with a high expectation for success (or self-efficacy) will achieve at higher rates, while students with a high subjective task value for the subject will be more interested and more likely to persist in the field.

In this line of research, Acee and Weinstein (2010) found that value-reappraisal interventions could increase students' value for statistics courses and lead to increased persistence in statistics. Lawanto, Santoso, and Liu (2012) found that expectancy for success was related to achievement in an engineering course, but was also related to value for subsequent tasks. In qualitative work, Watt (2005) found that utility value strongly predicted choice of math courses in college among a high-school sample. Conversely, Matusovich, Streveler, and Miller (2010) found that engineering students reported attainment value as strongly associated with their choice of courses and career field. Eccles (2005a) has described a relationship between self-efficacy (expectancy) and value in predicting participation and interest for STEM related fields, suggesting students will need to increase in both subjective task value and expectancy for success (self-efficacy) in order to be more likely to choose those careers.

Yet, there is evidence that self-efficacy may influence perceptions of the classroom environment. For example, Selkirk, Bouchey, and Eccles (2011) found that students with high value but low self-efficacy for math seemed to perceive tests differently, with those students reporting the most anxiety about assessments. Previous research has also made clear that classroom instructional practices can influence expectancy-value motivation. Anderman and Young (1994) found that ability-focused versus process-focused teaching had marked effects on both expectancy and value, with ability-focused teaching leading to decreases in expectancy and value.

Ideally, the classroom environment would promote both expectancy for success and subjective task value. Previous qualitative work has suggested that holistic teaching strategies may lead to such increases (Montgomery, Strunk, Steele, & Bridges, 2012). In this type of classroom, learning extends beyond the traditional model of thinking, analyzing, and remembering (referred to in the holistic model as 'cognitive learning'). It also includes affective learning, which may include group work, reflective tasks, social learning, and other emotional tasks. Further, the holistic teaching model includes psychomotor learning, which may include hands-on learning tasks, practical learning, and learning with the body. Finally, it includes intuitive learning, which may include but is not limited to creativity and innovation. Based on the prior qualitative work in other areas of coursework, it was thought that these strategies may be related to students' subjective task value for STEM courses

Because previous research has suggested that students at various levels of self-efficacy (or expectancy) may perceive teaching practices differently (e.g., Selkirk, Bouchey, & Eccles, 2011), it was thought that self-efficacy might influence students' perception of holistic-oriented teaching practices as well. As a result, in the present study, the hypothesis was that self-efficacy would influence students' perception of teaching practices, which in turn would influence their subjective task value for STEM courses. However, previous research has also suggested that expectancy (self-efficacy) may directly influence value (Lawanto, Santoso, & Liu, 2012), so it was also hypothesized that self-efficacy would directly influence subjective task value for STEM courses.

Method

Participants

Participants for the present study were volunteer undergraduate students from a large Midwestern university enrolled in gateway STEM courses (1000 or 2000 level courses in the sciences, technology, engineering, or mathematics) during the Fall semester of 2012. The courses were selected at random, and instructors were asked for consent to collect data during

the regularly scheduled class session. A total of 354 participants completed the survey, including 88 freshman, 88 sophomores, 117 juniors, 57 seniors, three who marked 'other' for their college classification, and one who did not respond to the question regarding classification. The mean age of the sample was 20.59 (SD = 3.74).

Materials

The materials included a measure of self-efficacy derived from the Motivated Strategies for Learning Questionnaire (MSLQ) that was nine questions in length and had shown good reliability in previous studies, with alpha coefficients exceeding .85 (Pintrich & DeGroot, 1990). The MSLQ has been used in previous work to assess expectancy (Lawanto, Santoso, & Liu, 2012), but in this study was modified by the inclusion of the phrase in this class. Also included was a measure for subjective task value that measured intrinsic value and utility value. This measure was adapted from previous work and written to ask participants to reflect on the value of this course (Eccles & Wigfield, 1995; Wigfield & Eccles, 2000). Finally, single-item measures were included for classroom environment including students' perception of the students in the class working together to learn, opportunities for creativity, and opportunities for hands-on learning.

Procedure

A random sample of classes was obtained from institutional records. Instructors were emailed an invitation for their class to participate in the research. Approximately 20% of those contacted agreed to have a researcher visit their class. A researcher visited the class on a single pre-arranged date during the regularly scheduled class period, explained the purposes of the research, and distributed the survey, which included the informed consent information. The researcher remained in the room and collected all packets before leaving. All participants were treated in compliance with APA ethical standards and the university Institutional Review Board approved these procedures.

Results

Path analysis was used to analyze the data. A path model was created based upon the research hypotheses: Self-efficacy was hypothesized to influence perception of classroom teaching practices, and directly influence subjective task value. Further, perception of classroom teaching practices was hypothesized to influence subjective task value. The path model is found in Figure 1. In general, the model appeared to work relatively well given that there were only three nonsignificant paths. For intrinsic value, neither opportunities to work together ($t = 1.046$, $p = .296$) nor opportunities for creativity ($t = .041$, $p = .967$) were significant predictors. For utility value, opportunities for hands on learning ($t = 1.939$, $p = .053$) was not a significant predictor. All standardized path coefficients are provided in Figure 1. Path Model with Standardized Coefficients.

The results of the path analysis demonstrated that self-efficacy directly influenced both intrinsic and utility value, and also had an indirect influence on both intrinsic (.033) and utility (.049) value through perceived classroom teaching practices. Additionally, it is worth noting the negative path between opportunities for creativity and utility value. That is, students who perceived the class as offering more opportunities for creativity saw it as less useful for their career and everyday life. Further, students with higher self-efficacy were more likely to perceive the class as offering those creative opportunities, creating an indirect effect. However, students with higher self-efficacy were more likely to perceive students as working together to learn, and students who perceived that students were working together to learn saw the class as more useful for their everyday life and future career. The same is true of hands-on learning and intrinsic value. Students higher in self-efficacy perceived more opportunities for hands-on learning, and students who perceived more opportunities for hands-on learning were more likely to perceive the class as enjoyable and interesting. No fit indices were calculated, as is typical in the case of path analyses (Pedhazur, 1997).

Finally, in order to establish if the relationship between self-efficacy and perceived teaching strategies was placed in the model in the correct position, the model was also tested with perceived teaching practices predicting self-efficacy, and self-efficacy predicting subjective task value. This was done because the relationship between self-efficacy and perceived teaching strategies is still exploratory, so it was necessary to ensure the directionality was correctly established in the hypothesized model. This alternative model was clearly not a fit, as there were no significant paths between perceived teaching practices and self-efficacy,

including students working together, opportunities for creativity, and opportunities for hands-on learning. This suggested the hypothesized model was empirically superior.

Discussion

The results primarily supported the hypotheses. Self-efficacy, in general, was positively associated with students' perceptions of a supportive classroom environment in terms of holistic teaching strategies. Across the board, students with higher self-efficacy tended to rate their classroom as encouraging more social, creative, and hands-on learning experiences than did those with lower self-efficacy. This may suggest that students with lower self-efficacy for STEM courses generally perceive their courses as offering less diverse learning opportunities. Further, students with higher self-efficacy tended to find the STEM courses more valuable, both in terms of utility value and intrinsic value. This suggests that students who expect to do well in STEM courses also tend to find the courses enjoyable, and believe the course is useful for them.

Holistic teaching strategies also influenced subjective task value directly, but in some unexpected ways. Students who perceived their class as offering more opportunities to work together had higher utility value, but not higher intrinsic value. This finding is counterintuitive because group work is associated with the value of the course for future career and daily life, but not for enjoyment of the class. Prior work has suggested students enjoy classes that offer social learning versus ones that do not (Montgomery, Strunk, Steele, & Bridges, 2012). Students who perceived their classes as offering more opportunities for hands-on learning had higher intrinsic value for the course, but not higher utility value. Finally, opportunities for creative learning were not associated with intrinsic value, but were associated with lower utility value. Students who perceived their classes as offering more opportunities for creativity found those courses to be less useful for future career and daily life. This finding is particularly curious given the prior literature in this area, and leads to questions about the definition of the construct 'creativity'.

It is possible that given a question about 'creativity' in a STEM course students perceived it as having negative connotations. For example, in an engineering course, it may be that 'innovation', which is synonymous with creativity, would have a more positive connotation. Creativity may not have a 'scientific' enough connotation to bring to mind the image of a constructive classroom environment, and may instead conjure images of odd classroom experiences. However, further research is needed to interrogate the nature of creative or innovative learning experiences in STEM courses and their relationship to subjective task value.

Conclusions

The present study offers several insights for practice in the area of STEM education. First, the results demonstrate that teaching strategies alone are not sufficient to explain variations in students' subjective task value for STEM courses. Self-efficacy plays a major role. Thus, while holistic teaching strategies may be useful in increasing students' value for STEM courses, it may also be necessary to find ways to increase students' competence and self-efficacy in the field.

Further, instructors in gateway courses can directly monitor student's self-efficacy and interest in their courses to adjust their instruction and methods. Because of the interrelationships between self-efficacy, teaching strategies, and subjective task value, it may

be necessary to make dynamic adjustments in instruction based on students' motivation toward STEM education. This may be particularly true in situations where students have low self-efficacy for STEM and low value for the field.

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