

Article

Self-Regulated Learning and Achievement Emotions in an Engineering Emergency Management Module

Mihwa Park ^{1,*} , Changwon Son ²  and Sarah M. Fadillah ¹ 

¹ Department of Curriculum and Instruction, College of Education, Texas Tech University, Lubbock, TX 79409, USA; sfadilla@ttu.edu

² Department of Industrial Engineering, College of Engineering, Texas Tech University, Lubbock, TX 79409, USA; changwon.son@ttu.edu

* Correspondence: mihwa.park@ttu.edu

Abstract

This study examined engineering students' intrapersonal factors, self-regulated learning (SRL) and achievement emotions, and their prior emergency, disaster, and crisis management (EDCM) knowledge, within a three-week EDCM module embedded in an engineering course. We collected data at three points during the implementation of the EDCM module ($N = 53$). First, before the module began, students completed a demographic questionnaire, the SRL motivational orientation questionnaire, and an EDCM knowledge pretest. Second, during module implementation, students completed the SRL learning strategy questionnaire. Third, after the module was completed, students completed the achievement emotion questionnaire. We included 53 students' data and analyzed it using non-parametric statistics. Results showed no significant gender differences in learning strategies or achievement emotions; however, male students' motivation was significantly higher than that of female students. In addition, significant differences by race were found in motivational orientation, learning strategies, achievement emotions, and prior EDCM knowledge. Motivational orientation was positively associated with positive emotions, particularly enjoyment and pride, and negatively associated with negative emotions. Learning strategies, meanwhile, were primarily associated with positive emotions. Prior EDCM knowledge showed limited associations with intrapersonal factors. These findings highlight the importance of redesigning EDCM instruction in engineering education to be both effective and more responsive.

Keywords: achievement emotions; disaster education; emergency management; self-regulated learning



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1. Introduction

The frequency, severity, and economic impacts of emergencies, disasters, and crises (EDCs) have increased over recent decades. In the United States, the National Centers for Environmental Information (NCEI) documents hundreds of weather-related billion-dollar disasters since 1980 and cumulative damages measured in the trillions of U.S. dollars ([National Centers for Environmental Information \[NCEI\], n.d.](https://www.ncei.noaa.gov/data/monitoring-network/monitoring-network-reports/national-centers-for-environmental-information-ncei-n.d.)). Beyond weather-related hazards, public health crises such as the COVID-19 pandemic have caused unprecedented and widespread disruption across communities and industries. These increasing EDCs underscore the need for professionals who can plan for and coordinate complex and high-consequence events.

Engineers and engineering organizations play critical roles in preparing for emergencies, responding to incidents, and recovering damages through roles that include

infrastructure resilience, system safety, risk assessment, operational continuity, and coordination with public agencies. More than 80% of engineering manager positions require an engineering degree (U.S. Bureau of Labor Statistics, 2023); however, formal emergency management education is not routinely embedded in most engineering programs, and relatively few institutions offer dedicated emergency management programs (Federal Emergency Management Agency [FEMA], n.d.). Further, national and societal calls for action also emphasize access and equity in science and engineering education, particularly to prepare for societal challenges that disproportionately affect marginalized communities (National Science Board, 2020).

To address this curricular gap in college-level engineering education, we previously conducted a needs-analysis study with engineering students, faculty, and public safety professionals with 32 participants in total (Park et al., 2025). During focus group interviews with the three groups, we asked questions about the importance of skills and knowledge related to emergencies, disasters, and crisis management (EDCM) standards and guidelines; about existing assets, such as prior knowledge and experience related to EDCM standards and guidelines; and about instructional needs, with a focus on identifying specific learning elements and teaching methods that could enhance engineering students' EDCM-related skills and knowledge.

The needs-analysis study identified six key learning elements to be incorporated into the design of an EDCM learning module: basic drills, emergency actions, the Incident Command System, engineering knowledge, psychological aspects, and financial aspects (Park et al., 2025). Accordingly, we intentionally integrated these elements into the EDCM module and implemented a three-week instructional unit that introduced engineering students to EDCM standards and guidelines, foundational concepts, and professional practices aligned with the National Incident Management System (FEMA, 2017).

The module introduces foundational EDCM terms, concepts, and principles while integrating authentic learning experiences (e.g., scenario-based computer simulations, augmented reality, and computer games). However, prior research suggests that simply providing content-rich instruction and instructional technologies does not guarantee students' engagement in learning activities or meaningful learning of the material (Clark et al., 2021; Park et al., 2017; Ross et al., 2010). Learning EDCM is cognitively and emotionally demanding because it requires students to weigh multiple considerations—such as safety, cost, and equity—beyond conceptual content, and it often involves situations with no single correct solution. This unique context highlights the importance of intrapersonal factors in shaping how students engage in and learn from EDCM instruction. Intrapersonal factors are especially relevant to this study, given that engineering students enter the class with varying levels of prior knowledge and experience in EDCM. Prior EDCM knowledge may influence students' motivation, interest, emotions related to learning EDCM, and the learning strategies they use. Therefore, understanding how students' intrapersonal factors relate to their prior EDCM knowledge is necessary for explaining why the same instructional experiences may lead to different learning outcomes.

For these reasons, this study investigated the relationships among engineering students' self-regulated learning (SRL) and achievement emotions, and prior EDCM knowledge. SRL and achievement emotions influence how students approach, experience, and persist in EDCM learning activities. Findings from this study can inform the design of EDCM instruction that is not only aligned with standards and guidelines, but also responsive to how engineering students learn in and experience this complex, high-consequence domain.

2. Self-Regulated Learning and Achievement Emotions

Effects of educational interventions can differ not only because of their content, types of learning activities, and delivery modes, but also because of the intrapersonal factors students bring to and develop within the learning context (Huerta et al., 2021). Intrapersonal factors including self-regulated learning (SRL) (Martin et al., 2022; Zimmerman, 2000) and achievement emotion (Pekrun et al., 2002; Pekrun, 2006) are widely recognized as central to learning and academic performance. When learners recognize their strengths and limitations, actively monitor progress toward goals, and reflect on learning strategy effectiveness, they tend to sustain motivation and improve learning outcomes (Schunk & Zimmerman, 1998). Such students are characterized as self-regulated learners (Zimmerman, 2002). Recently, Allemand et al. (2026) conceptualized SRL as a self-directed process through which learners work toward learning goals, whether those goals are self-generated or externally assigned. Throughout this process, learners monitor their progress and adjust their cognitive, motivational, and behavioral strategies to achieve their learning goals.

SRL is often framed as a foundational competency for lifelong learning and has been examined through various theoretical frameworks (Panadero, 2017; Pintrich, 2000; Zimmerman, 2000). Engineering education is no exception, as it emphasizes SRL as a critical component in supporting students' academic performance (Martin et al., 2022; Zheng et al., 2023). Engineering students and practicing engineers are expected to integrate relevant knowledge and skills to solve complex engineering problems, which often require iterative refinement (Zheng et al., 2023). Because engineering problems are inherently tied to societal and economic issues and directly affect human life, engineering problem solving requires not only cognitive competence but also empathetic competence to develop effective and human-centered solutions that benefit society at large.

Pintrich and De Groot (1990) identified two primary components of SRL for successful learning: motivational orientations and learning strategies. Building on this model, Pintrich and colleagues developed the Motivated Strategies for Learning Questionnaire (MSLQ) to assess college students' motivational orientations and use of different learning strategies (Pintrich et al., 1991). Motivational orientations encompass value, expectancy, and affective components. Learning strategies incorporate cognitive, metacognitive, and resource-management strategies. MSLQ is the most used instrument in SRL measurement (Honick & Broadbent, 2016), and previous studies have provided evidence supporting its validity in measuring learners' SRL in higher education (Magno, 2011). Using MSLQ, studies found that student motivation and learning strategies are critical in promoting students' learning achievement. For example, Hieb et al. (2015) found that internal goal orientation and factors related to learning strategy were significant predictors of learning achievement in an engineering introductory course. Martin et al. (2022) used a modified MSLQ and found that SRL was linked to academic success and failure in civil engineering students; students who scored lower in SRL tended to earn lower GPAs.

In parallel, affective variables also play an important role in sustaining cognitive engagement during difficult tasks, which highlights the importance of helping students maintain a balance between self-regulation and emotion rather than focusing solely on performance outcomes (Panaoura, 2025). Emotions have powerful influences on an individual's cognitive processes, behaviors, and motivations (Coan & Allen, 2007; Damasio, 1999; Lazarus, 1984). Within educational research, control-value theory offers a comprehensive framework for understanding the structure of emotions and their relation to individuals' control and value appraisals, particularly in classroom settings (Pekrun, 2006; Pekrun & Perry, 2014). According to control-value theory, students' perceptions of control over their learning and the value they assign to academic activities shape their achievement emotions,

which in turn influence engagement and academic performance (Pekrun, 2006; Pekrun et al., 2011; Pekrun & Perry, 2014).

Achievement emotions are defined as emotions tied directly to achievement-related activities and outcomes, which encompass momentary occurrences in a given situation and an individual's habitual and recurring emotions (Pekrun, 2006). These emotions are associated not only with learning outcomes such as success and failure, but also with academic tasks and activities, including studying, doing homework, and engaging in learning tasks. Achievement emotions are classified by valence (positive vs. negative) and activation (activating vs. deactivating). These distinctions are theoretically important because emotions with the same valence may have different effects on learning (Pekrun & Linnenbrink-Garcia, 2012). For example, enjoyment and pride are generally characterized as positive activating emotions that promote persistence and sustained engagement, whereas boredom and hopelessness are negative deactivating emotions that tend to disengage in learning. By contrast, some negative emotions, such as anger and anxiety, are activating in nature and may influence students' effort and persistence in learning (Pekrun et al., 2011). Therefore, in educational contexts, the effect of emotions on learning cannot be understood solely in terms of whether they are positive or negative; their activating or deactivating qualities are also critical for explaining their influence on students' learning processes and outcomes.

Although SRL frameworks incorporate affective elements such as test anxiety and confidence in course success, the broader taxonomy of achievement emotions has been underexamined in SRL research. Motivation and the use of learning strategies can shape students' emotional experiences, for example by increasing perceived competence, while emotions can in turn facilitate or hinder the use of learning strategies. Nonetheless, the associations between achievement emotions and SRL, as well as their relationships with students' prior knowledge in EDCM, had not been investigated at the time this study was conducted. A better understanding of these relationships could help make the EDCM module more effective by accounting for students' intrapersonal factors and prior knowledge in its design. As mentioned earlier, EDCM content can be personally and socially salient, often connecting to students' experiences as community members. As such, EDCM teaching and learning should aim not only to support knowledge development and management skill gain, but also to recognize students' emotions and learning processes. Therefore, examining SRL, achievement emotions, and prior knowledge together in EDCM education is necessary to inform the design of effective and more responsive EDCM instruction.

3. Study Purpose and Research Questions

This exploratory study examines students' motivational orientations and learning strategies as components of SRL, and students' achievement emotions experienced during module learning activities. Understanding how these constructs are related, and whether their patterns vary across demographic groups, may inform future directions for refining the EDCM module and its assessments.

The research addresses three research questions. (1) To what extent do SRL components and achievement emotions vary by participating students' demographic characteristics (e.g., gender and race)? (2) How are SRL components (motivational orientations and learning strategies) related to achievement emotions among participating students in the EDCM module? (3) How are SRL components and achievement emotions associated with participating students' prior EDCM knowledge?

4. Method

4.1. Instructional Context and Module Design

The EDCM module was implemented in Spring 2025 in an Advanced Systems Safety Engineering course at a large public Hispanic-Serving Institution in the United States. Hispanic-Serving Institutions are colleges and universities where Hispanic students make up at least 25% of the full-time undergraduate population.

The module expanded existing course coverage from a single lecture to a three-week sequence (two class meetings per week; six total class meetings). The module was designed to help students improve competencies in basic emergency preparedness and response, emergency communication, incident action planning, incident command, and coordination consistent with the national guidelines such as the National Incident Management System (NIMS) (FEMA, 2017).

The module comprised three instructional strands: (a) fundamentals of EDCM, (b) pre-incident processes, and (c) post-incident processes. As shown in Table 1, the instructional activities included lectures, in-class exercises, homework assignments, and an exam aligned with module learning activities.

Table 1. Instruction activities of the 3-week module for EDCM.

Category	Specific Topics or Activities
Lecture	- Fundamentals of EDCM: Core terms and definitions, major disasters in history, common attributes of a disaster, hazards and vulnerability, and fundamental disaster management principles. - Pre-incident processes of EDCM: Preparedness, emergency planning, planning approaches, and emergency operations plan. - Post-incident processes of EDCM: Resource management, information and communication, financial aid, and command and coordination during incidents.
In-class exercise	- Listing a personal disaster supplies kit - Discussion on the roles of vulnerability in a disaster
Homework	“Build your own emergency plan”: students were asked to write their own emergency plan for a tornado incident based on the historic Lubbock Tornado in 1970. Students were asked to identify escape routes, sources of emergency information, special needs, animal care, financial management, and sheltering.
Optional project	Gamified disaster simulation: As an optional individual project, students completed a simulation-based planning task using Stop Disasters game (https://www.stopdisastersgame.org/game/ (accessed on 21 April 2025), developed by the United Nations Office for Disaster Risk Reduction (UNDRR, n.d.). Students used module concepts to develop and test disaster plans against simulated hazard scenarios, with the goal of connecting planning principles to dynamic decision-making.
Exam	Students’ knowledge gain was assessed using various question types, including true/false, multiple-choice, short-answer, and essay questions.

4.2. Measures

Three measures were employed: (1) a pre-EDCM knowledge test, (2) a modified Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991), and (3) a modified Achievement Emotions Questionnaire-Mathematics (AEQ-M; Pekrun et al., 2005). The pre-EDCM knowledge test was developed to assess students’ baseline knowledge of EDCM and consisted of 12 multiple-choice items administered prior to the module. The instrument was developed by the course instructor, who has expertise in EDCM and holds a PhD in a related field. The test content aligned with the core topics addressed in the module,

including fundamental emergency management practices, emergency communication, and Incident Command System concepts.

To examine students' SRL, we adapted the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991). Specifically, we removed redundant items from the original MSLQ after consulting with researchers to confirm item overlap. We also changed the response format from a seven-point to a five-point Likert scale and excluded items specific to test anxiety before administering the questionnaire to students. The adapted MSLQ targeted two SRL components: motivational orientations and learning strategies. Motivational orientation scales were administered prior to the module to capture student motivation, whereas learning strategy scales were administered mid-module to assess their learning strategies enacted during the module. The original MSLQ consisted of 81 items, and the modified version included 61 items. Cronbach alpha for the modified MSLQ was 0.832, which indicates good internal consistency reliability for use in the study.

Achievement emotions were measured after completion of the EDCM module. We adapted the Achievement Emotions Questionnaire–Mathematics (AEQ-M; Pekrun et al., 2005). The AEQ-M assesses students' achievement emotions in mathematics and includes 60 items measuring seven discrete emotions: enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom. The instrument consists of three subscales corresponding to different pedagogical situations: mathematics class-related, mathematics learning-related, and mathematics test-related experiences. Within each subscale, items were designed to assess these emotions. The full version of the AEQ-M is available in Pekrun et al. (2005). Because the AEQ-M was originally developed for a mathematics context, we replaced all references to mathematics with references to the EDCM module in the engineering course context. For each item, participants responded using a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The adapted AEQ-M demonstrated high internal consistency reliability, with a Cronbach alpha coefficient of 0.894.

For all measures, higher scores indicate stronger endorsement of the corresponding construct (motivation/learning strategy use/emotion intensity).

4.3. Participants

Seventy-three students were enrolled in the course. Of these, 53 completed all study measures—the pre-EDCM knowledge test, the adapted MSLQ, and the adapted AEQ-M—and were included in the analyses. Participants were also asked to report demographic information, including gender and race, on a voluntary basis. The original items asking about gender and race are presented below.

What is your gender?

- Male;
- Female;
- Prefer not to say;

Which best describes your race? Please select all that apply.

- Hispanic or Latino;
- Black or African American;
- White;
- Asian or Asian American;
- Native American or Alaska Native;
- Native Hawaiian or Other Pacific Islander;
- Two or more races;
- Prefer not to say;
- Other (please specify:_____).

One of the 53 students did not report his/her race; therefore, the student was excluded only from analyses involving race. For analyses in which race was not included as a variable, the student's data, including measures and gender, were retained. Among these 53 students, 13 identified as female and 40 as male; eight identified as White but not Hispanic or Latino, 23 as Asian or Asian American, seven as Black or African American, 14 as Hispanic or Latino but not any other race, and one as unknown. All students were industrial engineering majors. We note that some students selected multiple options for the race item. However, these students were excluded from the analysis not because of their race, but because they did not complete all measures and skipped at least one measure.

4.4. Procedure

We collected data at three points during implementation of the EDCM module. First, before the module began, students completed a demographic questionnaire, the SRL motivational orientation items, and the EDCM knowledge pretest. Second, during module implementation, specifically two weeks after the module began, students completed the SRL learning strategy items. Third, after the module was completed, students completed the adapted AEQ-M.

4.5. Data Analysis

Missing data was small (approximately 1.9% per measure). Consistent with guidance that mean substitution is acceptable when missingness is low (e.g., <5%), item-level mean replacement was used for missing responses (Hair et al., 2014). Composite variables were computed for motivation, learning strategies, and each emotion scale. To address Research Question 1, we used nonparametric statistical analyses because of the small and unequal subgroup sizes. Specifically, Mann–Whitney U tests were used to examine differences in SRL and achievement emotions between gender groups. Kruskal–Wallis one-way analyses of variance were used to examine differences in SRL and achievement emotions across racial groups. When omnibus tests were statistically significant, Dunn's post hoc tests were conducted to identify pairwise group differences. To address Research Questions 2 and 3, Pearson correlation analyses examined relationships among prior EDCM knowledge (pre-test), SRL variables, and achievement emotions. Statistical significance was evaluated at $\alpha = 0.05$.

5. Results

5.1. Variation in SRL and Achievement Emotions by Demographics

The Mann–Whitney U test indicated that male students reported significantly higher motivation scores than female students ($Z = -2.09, p < 0.05$; Table 2). However, no statistically significant gender differences were found in learning strategies or achievement emotions.

In terms of differences between racial sub-groups, the findings indicated statistically significant differences in motivational orientation, learning strategies, and both positive and negative achievement emotions. Figure 1 presents box-and-whisker plots for each construct by race.

Specifically, the Kruskal–Wallis analysis results revealed statistically significant racial group differences in motivational orientation, $\chi^2(2) = 13.48, p < 0.05$; learning strategies, $\chi^2(3) = 8.391, p < 0.05$; positive emotions, $\chi^2(3) = 24.05, p < 0.05$; and negative emotions, $\chi^2(3) = 10.45, p < 0.05$.

Dunn's post hoc tests were conducted to identify which racial groups differed statistically on each construct. For motivation, Asian or Asian American students reported statistically significantly higher scores than Hispanic or Latino students ($Z = -3.04, p < 0.05$) and White students ($Z = -2.04, p < 0.05$). Similarly, Black or African American students

reported statistically significantly higher motivation scores than Hispanic or Latino students ($Z = -2.77, p < 0.05$) and White students ($Z = 2.02, p < 0.05$). For learning strategies, Asian or Asian American students reported statistically significantly higher scores than Hispanic or Latino students ($Z = -2.86, p < 0.05$). No other statistically significant differences were found across racial groups in the SRL components. Although it was not statistically significant, participating Hispanic or Latino students had the lowest mean scores across both SRL.

Table 2. Motivational orientation, learning strategy, and achievement emotion by gender.

Variable	Gender	N	Mean	Median	SD	Mann–Whitney U Test	
						Z	p
Motivation	Male	40	17.08	17.10	1.10	−2.09 *	0.04
	Female	13	16.41	16.20	0.89		
Learning Strategy	Male	40	15.92	16.06	2.02	−0.58	0.56
	Female	13	16.38	16.11	1.19		
Positive Emotion	Male	40	10.52	10.25	2.06	−0.18	0.86
	Female	13	10.26	10.58	1.72		
Negative Emotion	Male	40	7.56	6.84	2.44	−1.46	0.14
	Female	13	8.41	8.00	2.45		

Note. * $p < 0.05$.

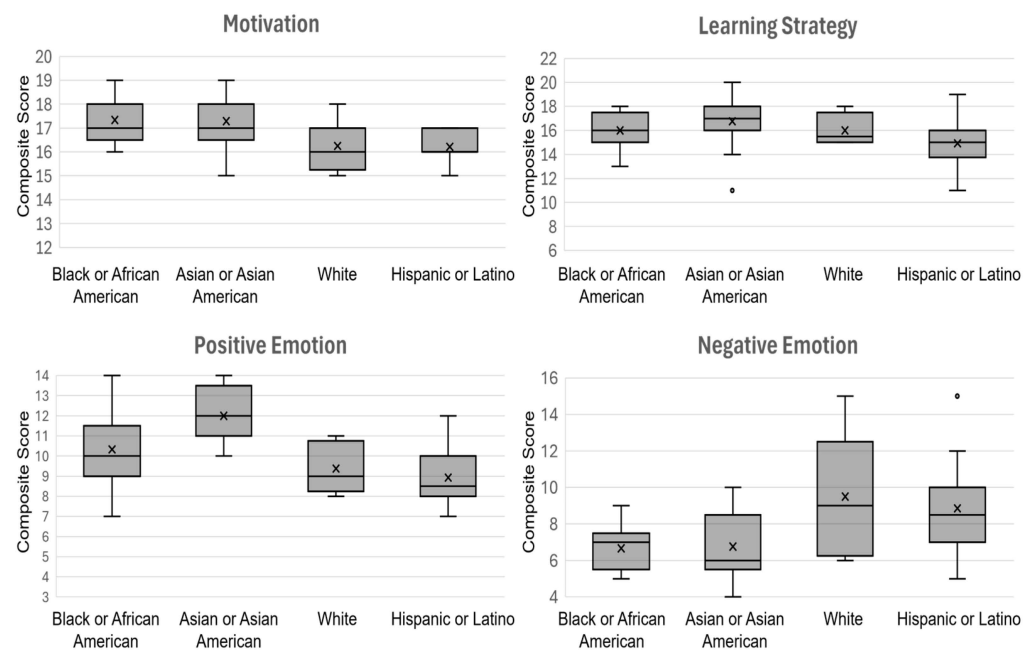


Figure 1. Motivational orientation, learning strategy, and achievement emotions by race.

With respect to achievement emotions, Asian or Asian American students reported statistically significantly higher positive achievement emotions and significantly lower negative emotions than both White students (positive emotion: $Z = -3.37, p < 0.05$; negative emotion: $Z = 2.21, p < 0.05$) and Hispanic or Latino students (positive emotion: $Z = -4.48, p < 0.05$; negative emotion: $Z = 2.59, p < 0.05$). Hispanic or Latino students reported statistically significantly higher negative emotions than Black or African American students ($Z = 2.11, p < 0.05$).

When specific emotions were examined, White students reported statistically significantly higher boredom than Asian or Asian American students ($Z = 2.94, p < 0.05$) and

Black or African American students ($Z = -2.14, p < 0.05$). White students also reported statistically significantly higher hopelessness than Black or African American students ($Z = -1.96, p < 0.05$). Similarly, Hispanic or Latino students reported statistically significantly higher hopelessness than both Asian or Asian American ($Z = 2.00, p < 0.05$) and Black or African American students ($Z = 2.20, p < 0.05$). Differences in the other types of negative emotions, shame, anxiety, and anger, were not statistically significant.

Overall, these findings show that Asian or Asian American participating students experienced more positive and less negative achievement emotions in EDCM learning within the study context, relative to participating White students and participating Hispanic and Latino students. By contrast, White students and Hispanic or Latino students reported more negative achievement emotions, particularly hopelessness, compared with Black or African American students within the sample of students.

5.2. Variation in Prior EDCM Knowledge by Demographics

The variation in prior EDCM knowledge was examined by gender and race. While the Mann–Whitney U test showed no significant statistical difference in prior knowledge between gender, $Z = -0.30, p > 0.05$, the Kruskal–Wallis test result showed that prior EDCM knowledge differed statistically significantly across racial groups, $\chi^2(3) = 8.01, p < 0.05$. Figure 2 shows the variation in EDCM knowledge across racial groups.

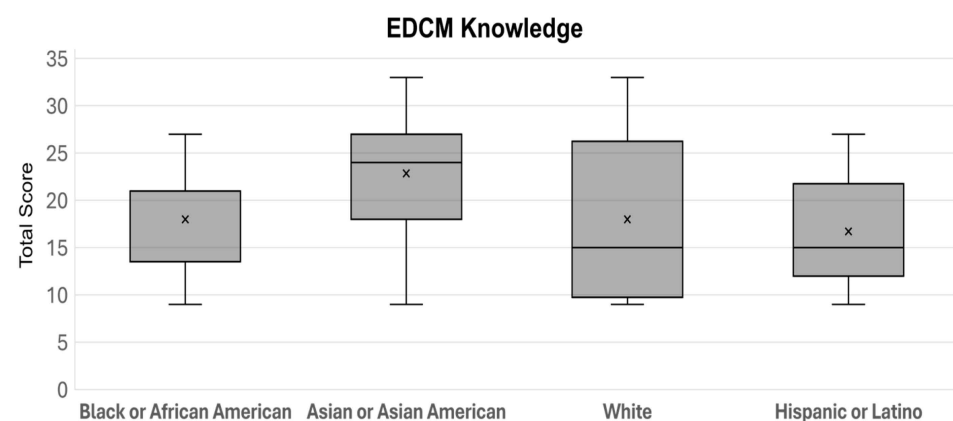


Figure 2. Prior EDCM Knowledge by race.

Therefore, a Dunn's post hoc test was conducted to examine racial group differences in prior EDCM knowledge. The results showed that Asian and Asian American students had statistically significantly higher prior EDCM knowledge than Hispanic or Latino students ($Z = -2.55, p < 0.05$). No other statistically significant group differences were found.

We note that the subgroup findings should be interpreted with caution because the participants were recruited from a single course at one institution and the demographic subgroup sizes were small and uneven. Therefore, our subgroup findings should not be interpreted as evidence of either the absence of demographic differences or definitive demographic differences in the broader population. Rather, the results should be viewed as preliminary indicators that may guide future instructional design, recruitment strategies, and confirmatory research.

5.3. Relationships Between Prior EDCM Knowledge, SRL and Achievement Emotions

Table 3 presents the Pearson correlations among prior EDCM knowledge scores (pretest), SRL components (motivational orientation and learning strategies), and achievement emotions.

Table 3. Pearson correlations among pre-test, SRL components, and achievement emotions.

	1	2	3	4	5	6	7	8	9	10	11	12
Pre-test (1)	1.000											
Motivational Orientation (2)	0.211	1.000										
Learning Strategy (3)	0.091	0.260	1.000									
Enjoyment (4)	0.291 *	0.602 *	0.459 *	1.000								
Pride (5)	0.143	0.507 *	0.443 *	0.788 *	1.000							
Anger (6)	−0.240	−0.353 *	0.136	−0.425 *	−0.279 *	1.000						
Anxiety (7)	−0.120	−0.297 *	0.219	−0.258	−0.258	0.713 *	1.000					
Shame (8)	0.003	−0.248	0.053	−0.226	−0.125	0.677 *	0.735 *	1.000				
Hopelessness (9)	−0.141	−0.430 *	0.017	−0.434 *	−0.306 *	0.742 *	0.770 *	0.665 *	1.000			
Boredom (10)	−0.119	−0.456 *	−0.201	−0.648 *	−0.343 *	0.519 *	0.291 *	0.301 *	0.441 *	1.000		
Positive Emotion (11)	0.252	0.598 *	0.477 *	0.974 *	0.907 *	−0.393 *	−0.271 *	−0.200	−0.409 *	−0.570 *	1.000	
Negative Emotion (12)	−0.157	−0.440 *	0.067	−0.474 *	−0.329 *	0.869 *	0.884 *	0.787 *	0.932 *	0.576 *	−0.446 *	1.000

Note. $N = 53$. * $p < 0.05$.

Motivational orientation was positively and significantly correlated with overall positive emotions ($r = 0.598$, $p < 0.05$), enjoyment ($r = 0.602$, $p < 0.05$), and pride ($r = 0.507$, $p < 0.05$). These findings indicate that students with higher motivational orientation tend to report more positive emotions, particularly enjoyment and pride, in EDCM learning. In addition, motivational orientation was negatively and significantly correlated with overall negative emotions ($r = -0.440$, $p < 0.05$) and with four of the five specific negative emotions: anger, anxiety, hopelessness, and boredom. Shame was also negatively correlated with motivational orientation, although this association was not statistically significant. Overall, these findings suggest that students with higher motivational orientation tend to report lower levels of negative emotions, including negative activating emotions, such as anger and anxiety, and negative deactivating emotions, such as hopelessness and boredom.

Learning strategies were also positively and significantly correlated with overall positive emotions ($r = 0.477$, $p < 0.05$), enjoyment ($r = 0.459$, $p < 0.05$) and pride ($r = 0.443$, $p < 0.05$). In contrast, learning strategies were not significantly related to overall negative emotions, and its correlation coefficient was very weak ($r = 0.067$, $p > 0.05$). Interestingly, learning strategies showed a mixed pattern of associations with specific negative emotions, including positive associations with anger and anxiety and a negative association with boredom. However, because these associations were not statistically significant, their interpretation should be limited to this specific sample. Among these participants, students' use of learning strategies may have associated with certain activating negative emotions, such as anger and anxiety, while also being associated with lower levels of boredom. In other words, students who experienced anger and anxiety during EDCM learning may have reported greater use of learning strategies, whereas students who felt bored may have reported less frequent use of learning strategies. However, these relationships were weak and should be interpreted with caution.

In terms of the relationship between prior EDCM knowledge and intrapersonal factors, students' prior EDCM knowledge was not significantly correlated with motivational orientation, learning strategies, or overall positive and negative emotions, and these correlations were weak (see Table 3). The only statistically significant association was with enjoyment; however, this relationship was also weak ($r = 0.291$, $p < 0.05$). These findings imply that prior EDCM knowledge may not be related to students' intrapersonal characteristics in the EDCM learning context.

6. Discussion

EDCM is highly relevant to everyday life, particularly when individuals face unavoidable and disastrous situations. EDCM knowledge and skills have important implications at the personal, societal, institutional, and global levels. In engineering education, formal EDCM instruction has often been lacking in preparing future engineers to anticipate emergencies and disasters, respond to incidents, and recover from the damage they cause. In addition, EDCM has often been taught with a focus on memorizing terminology and standard guidelines regardless of students' characteristics or backgrounds. This study explored the relationships among participating engineering students' intrapersonal factors, prior EDCM knowledge, and demographic characteristics, including gender and race, to inform the design of a more responsive and effective EDCM learning module. Specifically, the study explored variations in students' SRL, achievement emotions, and prior EDCM knowledge across demographic groups, as well as the relationships among prior EDCM knowledge, SRL, and achievement emotions in the EDCM learning context. The findings revealed several important patterns across these variables. First, we found a statistically significant gender difference in motivational orientation, but no statistically significant gender differences in learning strategies, achievement emotions, or prior EDCM knowledge. In contrast, there were statistically significant differences across racial groups in SRL components, positive and negative emotions, and prior EDCM knowledge. Second, motivational orientation was positively and statistically significantly related to positive achievement emotions and negatively and statistically significantly related to negative achievement emotions, whereas learning strategies were statistically significantly associated only with positive emotions, not negative emotions. Third, prior EDCM knowledge showed only limited associations with students' intrapersonal factors.

The statistically significant difference between male and female students in motivational orientation aligns with Jones et al. (2010). Jones et al. found that male engineering students showed higher levels of motivational constructs than female students. Engineering has traditionally been regarded as a masculine field and culture (Faulkner, 2000; Seron et al., 2018). The higher motivational orientation reported by male students is consistent with previous studies that have discussed the masculine culture of engineering. We recommend that EDCM instructors support female students' motivation in learning EDCM, for example, by connecting EDCM more closely to students' everyday lives and providing real-world examples of emergency and disaster contexts to promote their motivation in learning EDCM. The absence of statistically significant gender differences in the other domains implies that male and female students may have experienced the EDCM module in broadly similar ways with respect to learning strategies and achievement emotions. Although we used non-parametric statistics to analyze the data, this result should be interpreted cautiously because the sample size was small and the gender distribution was uneven. We also note that the absence of statistically significant gender differences in learning strategies, achievement emotions, and prior knowledge does not necessarily indicate the absence of gendered experiences within the EDCM learning context. Rather, it implies that such differences were not detected in our data set.

Findings showed that using the collected data for the study, the racial group differences in SRL, achievement emotions, and prior EDCM knowledge were statistically significant. Participating Hispanic or Latino students reported the lowest mean scores across the SRL components. In contrast, participating Asian or Asian American students reported higher SRL—motivational orientation and learning strategies—as well as higher positive emotions and lower negative emotions than students in other racial groups. These patterns could imply that participating students may not have engaged with the EDCM learning module with equivalent academic preparation, motivation, or emotional experiences related to

learning. We note that these differences should not be interpreted as being attributable to participant students' race itself. Rather, they may reflect contextual and cultural differences that shape participant students' opportunities to develop prior knowledge and intrapersonal factors. For example, some students may have had prior exposure to EDCM-related events or topics through personal experiences with EDCs, media, volunteering, or institutional contexts. They may also have developed higher self-efficacy in learning and applying new skills through successful educational experiences and recognition from peers, teachers, and family as successful students or future engineers. Students from certain racial groups may have experienced higher family expectations for academic success. [Turingan and Yang \(2009\)](#) explained differences in these intrapersonal factors as resulting from multiple factors, such as social expectations, values, and beliefs related to education and academic success.

The findings from the adapted AEQ-M data showed that participating White and Hispanic or Latino students tended to report higher negative emotions, and participating White students reported higher boredom. Achievement emotions are closely tied to engagement, especially when they are deactivating emotions such as boredom. Therefore, when redesigning the module, it is important to address not only general negative emotions but also deactivating negative emotions by incorporating more engaging and appropriately challenging learning activities. Therefore, we plan to include a scenario-based group activity in which students work collaboratively to solve EDC incidents.

We note that this study should be interpreted as exploratory rather than as a confirmatory test of demographic subgroup differences. As we explained before, the purpose of the study was to identify patterns in students' SRL, achievement emotions, and prior EDCM knowledge that could inform future refinement of the EDCM module and its assessments. This purpose is consistent with exploratory research, which is intended to identify patterns, describe emerging relationships, and provide the groundwork for future hypothesis-driven confirmatory research. As such, our demographic subgroup analyses results should be interpreted as preliminary patterns within the specific groups of students drawn from a single course at one institution. Therefore, the findings may not generalize to other engineering majors, institutions, or instructional contexts.

Correlation analyses also revealed several important patterns. Students with higher motivations tended to report greater positive emotions and lower negative emotions. This pattern implies that motivation may serve as a supporting factor in students' positive learning experiences. This pattern aligns with SRL theory, which emphasizes motivational orientation as a driver of engagement and persistence ([Pintrich & De Groot, 1990](#); [Zimmerman, 2002](#)), and with control-value theory, which posits that higher perceived control and value such as activating positive emotions are related to higher motivation ([Pekrun, 2006](#); [Pekrun & Linnenbrink-Garcia, 2012](#)).

By contrast, learning strategies showed a somewhat different pattern. Although learning strategies were positively associated with positive emotions, they were not statistically significantly related to overall negative emotions. We also found a complex relationship between learning strategies and specific types of negative emotions among participant students, although these associations were not statistically significant. Specifically, our findings showed that learning strategies may co-occur with activating negative emotions such as anger and anxiety in learning, implying that students who encounter challenges and are concerned about their performance may increase their effort and strategy use in response to overcome challenging situations and these negative emotions. This nuance aligns with the idea that some negative emotions, especially activating negative emotions (e.g., anxiety and anger), can trigger students' use of learning strategies rather than being purely detrimental ([Pekrun et al., 2011](#)). For example, activating negative emotions such as anxiety may co-occur with increased effort, planning, and monitoring. The negative

relationship between boredom and learning strategies, although weak and nonsignificant, may suggest that deactivating emotions are detrimental to student engagement in learning. Because these findings were not statistically significant, they should not be overinterpreted; however, they do point to the possibility that not all negative emotions function in the same way in relation to SRL.

As mentioned previously, prior EDCM knowledge was only weakly related to participant students' intrapersonal factors. This finding implies that students with higher EDCM knowledge did not necessarily have stronger motivation, greater use of learning strategies, or higher positive emotions during the module. Therefore, one lesson for redesigning the module is that students' emotions and SRL may be shaped more by how they experience the learning environment, including the module design itself, than by what they already know about EDCM.

These findings have several instructional implications. First, we emphasize that EDCM learning environments should support students' motivation, especially for female students, and positive emotions, as these factors were closely linked to one another. For example, an EDCM module should include cases relevant to students' lives, provide challenges that students can solve, and foster confidence by offering hands-on opportunities for success in order to promote enjoyment and pride. Second, instructors should be more attentive to the possibility that students may experience the same instructional environment differently, as we found racial group differences across several constructs. This calls for more equitable and responsive pedagogy that recognizes differences in emotional experiences, motivational orientations, and learning strategies. Third, students' prior EDCM knowledge was related to enjoyment. Because enjoyment is consistently associated with engagement and persistence (Pekrun & Linnenbrink-Garcia, 2012), this relationship indicates a possible lever for equity-oriented redesign: providing early instructional supports that build competence for students with lower prior knowledge. Taken together, these findings suggest the need to support students through motivational scaffolds, such as progress-oriented feedback, and emotional support, such as validating students' negative emotions related to learning. For example, instructors can acknowledge that feeling anxious or frustrated is normal in learning contexts. In addition, we recommend providing more engaging, real-life EDC event-based learning activities in which students can design solutions and demonstrate how to manage incidents.

We note several study limitations. As previously noted, although the participants were appropriate for exploratory study, they were drawn from a single institution and a single course. In addition, the demographic subgroup sizes were small and uneven, which may limit generalizability and reduce statistical power. Although nonparametric tests were appropriate for addressing non-normality and small subgroup distributions, these methods did not fully overcome limitations, including the loss of statistical power, due to small and unequal subgroups. For this reason, we again note that the subgroup findings should be interpreted as exploratory and hypothesis-generating rather than confirmatory. We also note that the pretest was not statistically validated; however, its content was reviewed by experts who have taught EDCM concepts for multiple years and who hold PhDs in related areas. Some of the correlations, particularly those involving specific negative emotions and learning strategies, were weak and not statistically significant; these patterns should therefore be viewed as exploratory rather than conclusive. We plan to redesign the EDCM module by considering our findings, reimplement it, and incorporate pre- and post-knowledge measures to examine learning gains resulting from the instructional intervention. We did not interview students to better understand their experiences in EDCM and the EDCM module, or their achievement emotions and SRL. Such qualitative

work would help clarify how SRL and emotions influence student learning and how these factors relate to one another.

We recommend future research that investigates students' prior experiences with EDCs and their perceptions of those experiences and EDCs, alongside students' knowledge of EDCM and relevant intrapersonal factors. This could be done through student interviews or surveys designed to examine students' prior experiences and perceptions related to EDCs. Further, people with special needs and veterans are also underrepresented populations in engineering education. Therefore, future studies focusing specifically on these groups of students could provide valuable insights into EDCM education. Because these populations may represent a relatively small group of students, qualitative approaches, such as interviews, may be particularly useful for capturing their experiences and perspectives.

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