

Using a Self-Compassion Intervention to Increase Engineering Self-Efficacy in Women
Pursuing Engineering in Higher Education

by

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ABSTRACT

Encouraging women's pursuit and retention in higher education has been an important movement in the United States over the last several decades. While there has been considerable progress, women are still underrepresented in fields related to Science, Technology, Engineering, and Mathematics (STEM). The most significant gender gap being engineering, where women make up only 21% of all engineering majors. Lack of self-efficacy is one variable that has been implicated as a barrier for women in engineering, due to implicit and explicit biases and discrimination women experience relating to engineering in higher education. Self-compassion has been shown to be strongly correlated with self-efficacy, with explanations theorized at the level of each positive subcomponent: self-kindness, common humanity, and mindfulness. The current study investigates the effects of a self-compassion mindstate induction (SCMI) intervention on engineering self-efficacy compared to a control group. This study also explores gender and race discrimination from faculty and peers in the participants' environment to observe if this plays a role in the effect of the intervention. Women ($N=73$) majoring in engineering were recruited from a large southwestern university to participate. A multivariate analysis of covariance (MANCOVA) was conducted, revealing a significant three-way interaction for condition type (SCMI or control), discrimination scores, and engineering self-efficacy from Time 1 to Time 2 ($F(1, 69) = 6.51, p = .01$). The results of this study suggest that participants in the SCMI condition experienced a significant increase in engineering self-efficacy from Time 1 to Time 2 when controlling for discrimination in the women's environment. Self-compassion based interventions that have the potential to increase engineering self-efficacy may be

particularly helpful to women who experience more gender and race discrimination in their environment. Future work should be done to examine discrimination more directly in the context of self-compassion and engineering self-efficacy. These results show promise for using brief, accessible, cost-free, positive psychology interventions to support women pursuing engineering in higher education. This research contributes to the literature aiming to address gender disparities in engineering higher education, laying the groundwork for future interventions that support underrepresented populations in STEM.

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CHAPTER 1

INTRODUCTION

In the United States, there has been considerable progress in achieving equality and equity for women in the education and employment sectors over the last several decades. According to the Pew Research Center, women are now more likely to attend college than men (Parker, 2021). However, there is still a significant discrepancy in the proportion of women in Science, Technology, Engineering, and Mathematics (STEM) fields compared to men. The most striking gender gap within STEM higher education and employment fields is in engineering, where women make up only 21% of all engineering majors and only 15% of the workforce (AAUW, 2022; Christnacht, 2019).

Researchers and organizations are searching for ways to address the barriers women in engineering face to increase representation and create more equitability in the field. These barriers are primarily sociocultural, as there is very little to no evidence that supports biological sex differences in aptitude for STEM (Halpern et al., 2007; Spelke, 2005). These sociocultural barriers include implicit biases formed in childhood, discrimination from other professionals in the field, lack of representation and role models, as well as others (AAUW, 2015; Ceci & Williams, 2010; Michelmore & Sassler, 2016). Self-efficacy has been implicated as an important factor in motivating women to pursue and continue in engineering (Msambwa et al., 2023; Payeras et al., 2023; Falco & Summers, 2019; McPhee et al., 2013). Self-efficacy pertains to one's belief in their own abilities to accomplish their goals (Bandura, 1977). Women who report more self- efficacy in engineering are more likely to choose engineering majors and pursue engineering occupations post-graduation (Ouweneel et al., 2013; Corbu et al., 2021).

Self-efficacy has been closely linked to self-compassion and academic outcomes (Neff et al., 2005; Leppma & Darrah, 2022; Falco & Summers, 2019; Iskender, 2009; Liao et al., 2021). Self-compassion refers to treating oneself with kindness and understanding, especially in the face of hardship (Neff, 2003). Self-compassion allows individuals to be aware of their experiences without self-judgment or criticism, which could be particularly important to one's self-efficacy. Despite the moderate body of research examining self-compassion and self-efficacy, there is a gap in the research determining if inducing self-compassion will change self-efficacy in women pursuing engineering in higher education.

The purpose of this research is to determine if a self-compassion mindstate induction intervention increases engineering self-efficacy for women majoring in engineering in higher education. In addition, information regarding experiences of racial and gender discrimination in one's environment will also be considered to determine if this plays a significant role in the effect of the intervention on self-efficacy.

CHAPTER 2

BACKGROUND LITERATURE

Self-Efficacy Background Overview

The goal of the present study is to increase engineering self-efficacy in women pursuing engineering in higher education. Self-efficacy refers to one's belief in their own ability to achieve goals through the execution of necessary behaviors (Bandura, 1977).

Self-efficacy can also be defined as one's perception of their capability to manage difficulties and persevere through challenges (Bandura, 1977; Caprara et al., 2012). Self-efficacy has been shown to be a predictor of one's behavior, as well as where one chooses to spend effort and resources (Bandura, 1986). Higher levels of reported self-efficacy have been linked to better self-regulation and cognitive strategy use, which had implications for better exam performance in education (Adesola & Li, 2018). Higher levels of self-efficacy have been linked to greater life-satisfaction (Azizli et al., 2015). Additionally, a cross-cultural study conducted by Luszczynska and colleagues (2005), found that self-efficacy was universally linked to higher well-being, self-esteem, and self-regulation. The same study found that self-efficacy was strongly negatively correlated with anxiety and depression. Self-efficacy can be measured broadly or within specific domains. For the present study, self-efficacy was measured within the domain of engineering using the General Engineering Self-Efficacy Scale (Mamaril et al., 2016).

Self-Compassion Background Overview

Self-compassion has traditional roots in Eastern Buddhist traditions as a way of describing self-love and care towards oneself, especially with regards to suffering (Neff, 2003a). Self-compassion has piqued an interest in Western psychology, now described as a positive psychology concept that involves possessing a healthy attitude about oneself and being kind towards oneself in times of suffering or when facing hardships (Neff, 2003a). Self-compassion has been linked to increased resilience, well-being, and positive psychological functioning (Leary et al., 2007; Neff, 2003b). Self-compassion has also been shown to act as a protective factor against racial discrimination (Liu et al., 2020) and academic burnout (Kyeong, 2013). Additionally, meta-analyses have examined the relationship between self-compassion and well-being (Muris & Petrocchi, 2017; Zessin et al., 2015), and self-compassion and self-efficacy (Liao et al., 2021). Self-compassion encompasses three positive subcomponents: treating oneself with self-kindness in painful or difficult situations, accepting that one's suffering is a part of the collective human experience, and having a mindful awareness of emotions (Neff, 2003a). Contrary to these three positive subcomponents are their negative counterparts: self-judgment, isolation, and over-identification with negative emotions (Neff, 2003a).

Relationship Between Self-Compassion and Self-Efficacy

Self-compassion and self-efficacy have been linked to overall well-being, positive psychological functioning, and performance and achievement (Luszczynska et al., 2005; Bandura, 1977; Caprara et al., 2012; Leary et al., 2007; Neff, 2003b; Muris & Petrocchi, 2017; Zessin et al., 2015). A meta-analysis conducted by Liao and colleagues (2021), examined the

direct relationship between self-compassion and self-efficacy in 60 empirical studies. The researchers found an overall positive correlation between self-compassion total score and self-efficacy. Additionally, the researchers found positive correlations between the three positive subscales of self-compassion (self-kindness, common humanity, and mindfulness) and self-efficacy, and a negative correlation between the negative subscales of self-compassion (self-judgment, isolation, and over-identification) and self-efficacy. Self-compassion and self-efficacy are relevant to each other at a fundamental level because they are rooted in subjective evaluations of the self (Liao et al., 2021). There are several explanations for the strength of the relationship between the two concepts. Neff and colleagues (2005), posit that there are explanations for the relationship between self-compassion and self-efficacy at each level of the theoretical self-compassion positive subscales: common humanity, mindfulness, and self-kindness. Common humanity allows individuals to recognize that the collective human experience involves failure, and it is not unique to themselves, therefore maintaining one's self-efficacy in response to failure (Neff et al., 2005). Mindfulness may protect self-efficacy because instead of viewing one's shortcomings as indicative of one's own abilities, mindfulness helps individuals avoid over-identifying with negative emotions. This is done by employing effective emotion regulation strategies like cognitive reappraisal (Neff et al., 2005). Lastly, the self-kindness subscale may mitigate harsh judgment towards one's perceived competence or performance (Neff et al., 2005).

Other possible explanations for the relationship between self-compassion and self-efficacy include affective states and reactions to failure, perceived competence, and resilience factors (Liao et al., 2021; Bandura 1986; Neff et al., 2005; Neff, 2003; Neff & McGehee, 2010;

Speight, 2009). Self-compassion has a positive effect on affective states and reactions to failures, Liao and colleagues (2021) suggest that this may be a way in which self-compassion is linked to self-efficacy. Another way in which self-compassion is thought to be linked to self-efficacy is through perception of competence. Self-efficacy is related to one's beliefs about one's competence, and self-compassion is positively correlated with perceived competence (Bandura 1986; Neff et al., 2005). Finally, both self-compassion and self-efficacy have been positively linked to resilience (Neff, 2003; Neff & McGehee, 2010; Speight, 2009). Self-compassion may foster self-efficacy through resilience in the presence of difficult circumstances or personal feelings of inadequacy (Speight, 2009). Much of the literature examining the relationship between self-compassion and self-efficacy has been correlational, therefore there is a need for further research to investigate the causal relationship between self-compassion and self- efficacy. Overall, the two concepts seem to be linked based on factors related to positive self-perception and judgment, or lack thereof, of the self.

Gender and Race Discrimination in the Environment

In addition to implicit and explicit biases that woman in engineering face, discrimination has also been implicated as a deterrent for women pursuing engineering (Ceci et al., 2014; Karis, 2022; Benya et al., 2018; Ding et al., 2021; Settles, et al., 2006).

Discrimination can be described as the behavioral manifestation of biases in which a group is treated differently based on protected characteristics (American Psychological Association Dictionary, 2023). Examples of gender discrimination that women experience in the field of engineering include sexual harassment, unequal pay, and lack of career advancement

opportunities (Karis, 2022; Ding et al., 2018; Hunt, 2016; Benya et al., 2018). Women also report gender-based microaggressions in engineering education (Camacho & Lord, 2011).

Gender and race discrimination play an important role in the consideration of self-efficacy and self-compassion. In terms of self-compassion, previous research has suggested that self-compassion may act as a buffer against the negative effects of discrimination in one's environment (Liu et al., 2020; Browne et al., 2022; Rosenthal et al., 2023). The three positive subcomponents of self-compassion have been theorized to be protective in response to discrimination. Self-kindness may reduce negative affect after experiencing negative events involving the self (Leary et al., 2007; Browne et al., 2022). Mindfulness, specifically associated with effective emotion regulation strategies and adaptive cognitive processes, may be responsible for reappraising discriminatory experiences (Browne et al., 2022; Inwood & Ferrari, 2018; Wong & Yeung, 2017). Common humanity is linked to a sense of belonging, which has been shown to mediate discrimination and negative outcomes related to mental health (Liao et al., 2016; Lincoln et al., 2021).

Previous research has found that experiences of racial discrimination are associated with lower rates of self-efficacy (Hunter 1998; Wells, 2016; Richardson et al., 2013). One explanation for this relationship is that the internalization of discriminatory experiences individually and culturally may affect one's belief in their abilities to accomplish their goals (Richardson et al., 2013; Wells, 2016). For gender discrimination, the trend is similar with more gender discrimination being associated with lower self-efficacy (Kira et al., 2015). In the context of education, research has demonstrated that racial discrimination in teacher-student interactions results in lower academic self-efficacy (Kyere et al., 2023). However, previous

research has also found that those who report high levels of self-efficacy are protected from the negative effects of discrimination (Moradi & Risco, 2006; Lee & Ahn, 2012). This may be due to the role self-efficacy plays in mediating personal control and the distress associated with discrimination (Moradi & Risco, 2006).

Relevance to Women Pursuing Engineering in Higher Education

There have been great strides for the inclusion of women in scientific fields. However, there is still a large discrepancy in regard to mathematics centered fields, including engineering (Ceci & Williams, 2010; AAUW, 2022; Christnacht, 2019). Identified barriers for women pursuing a degree in mathematics intensive fields are spatial ability differences developed through implicit childhood biases, and explicit gender discrimination against women in education (Corbett & Hill, 2015; Ceci & Williams, 2010). Differences in mental rotation and spatial abilities between men and women are significant, and researchers have suggested that these differences are largely due to the social environment during development (Baenninger & Newcombe, 1995; Wai et al., 2009). For example, boys are often given building blocks as small children and then advance to dynamic video games during adolescence, helping to develop better spatial ability skills (Baenninger & Newcombe, 1995; Terlecki, Newcombe, & Little, 2007).

In terms of discrimination against women in engineering higher education, women's letters of recommendation are more likely to be shorter than those written for men and include less status terms, and women are less likely to receive post-doctoral fellowships (Trix & Psenka, 2003; Wenneras & Wold, 1997). A study conducted by Steinpreis and colleagues

(1999) distributed four curriculum vitae to academic faculty around the country related to job applications. The sole difference among the curriculum vitae was that one of the names was a stereotypical women's name and the other was associated with men. The job applications with the name associated with men were more likely to be hired and rated as more adequate in teaching, service, and research compared to the woman counterpart (Steinpreis et al., 1999). A similar study conducted by Moss- Racusin and colleagues (2012) thirteen years later found similar results. Faculty were less likely to support the resume of the student with the name associated with women and were less likely to hire the woman because they were viewed as less competent (Moss- Racusin et al., 2012).

These barriers to engineering education and careers in engineering all have the potential to threaten women's self-efficacy. Women report lower levels of self-efficacy than men in engineering higher education and post-graduate careers (Msambwa et al., 2023; Payeras et al., 2023; MacPhee et al., 2013). Previous research suggests a corresponding relationship between self-efficacy and interest, performance, and persistence in academia, particularly applicable to women studying engineering in higher education (Nauta et al., 1998; Nauta et al., 2002). Self-compassion has also been shown to have a relationship with learning and academic achievement goals (Neff 2005; Leppma & Darrah, 2022; Egan et al., 2021). Neff and colleagues (2005) explained the relationship between self-compassion and academic achievement as a positive relationship with mastery goals and a negative relationship with performance-avoidance goals. Researchers have shown that academic resourcefulness and grade point average (GPA) can be predicted by academic specific self-compassion (Martin et

al., 2019). Moreover, self-compassion was able to predict end of term course grades for undergraduate students in a study conducted by Egan and colleagues (2021).

Finally, researchers have suggested a potential relationship between self-compassion and self-efficacy on student outcomes, which may have implications for engineering higher education (Leppma & Darrah, 2022; Iskender, 2009). Self-compassion has been shown to be positively associated with self-efficacy and control beliefs about learning in university students (Iskender, 2009). In a study conducted by Iskender (2009), control beliefs about learning were positively associated with the three positive subscales of self-compassion, self-kindness, awareness of common humanity, and mindfulness. Another recent study conducted by Leppma and Darrah (2022), demonstrated that self-compassion and self-efficacy predicted math anxiety in undergraduates, greatly influencing feelings towards engineering as math is foundational to engineering practices. The results of this study revealed that as self-efficacy and self-compassion increased, math anxiety decreased, and both self-efficacy and self-compassion explained unique amounts of variance (Leppma & Darrah, 2022). This body of research has implications for the present study, examining the impact of a self-compassion induction intervention on engineering self-efficacy for women pursuing engineering in higher education.

CHAPTER 3

CURRENT STUDY

Based on this body of previous literature related to self-compassion, self-efficacy, discrimination in one's environment, and engineering education, the goal of the present study is twofold: to investigate the effects of a self-compassion mindstate induction, on engineering-specific self-efficacy for women pursuing engineering higher education and to examine how discrimination in one's environment may play a role in this effect. The implications of this research are important to the field of engineering education and contribute to the literature involving self-compassion, self-efficacy, and engineering education. Additionally, this research aims to provide support for the self-compassion mindstate induction. By investigating new ways to implement brief and cost-free positive psychology interventions, this research is contributing to the common goal of minimizing the gender gap for women in engineering in a way that is accessible to individuals of all socioeconomic statuses. Moreover, the development of interventions targeted to encourage women in engineering will help boost representation, mitigate social barriers to access for higher paying jobs, and decrease bias and stigma associated with women in engineering.

A meta-analysis of the two concepts indicates a positive correlation between self-compassion and self-efficacy (Liao et al., 2021). Both self-compassion and self-efficacy have been shown to have positive implications for women in STEM (e.g., Neff et al., 2005; Leppma & Darrah, 2022; Falco & Summers, 2019), it is hypothesized that a self-compassion mindstate induction will increase engineering-specific self-efficacy for women pursuing engineering. There are several reasons that this may be accomplished, including through the increase of self-

kindness and decrease of self-judgment and criticism. The self-compassion mindstate induction may help to extend one's experience to other underrepresented groups facing barriers to engineering in higher education and decrease feelings of isolation, a principle known as common humanity. Finally, mindfulness may also play a role by increasing one's mindful awareness of negative emotions to cognitively reappraise them into positive emotions. This study also explores how gender and race discrimination in the women's environment effects the self-efficacy before and after the intervention. Based on previous research, it is expected that those who report higher levels of discrimination will report lower levels of self-efficacy at baseline compared to those with lower levels of discrimination (Hunter 1998; Wells, 2016; Richardson et al., 2013; Kira et al., 2015; Kyere et al., 2023). The current study predicts that a brief self-compassion mindstate induction will increase feelings of engineering specific self-efficacy in women studying engineering at the university level and that levels of discrimination will explain part of this effect. Below are the hypotheses for the current study:

H1: Participants in the self-compassion mindstate induction intervention group will experience a significantly positive change in engineering self-efficacy scores from Time 1 to Time 2 compared to participants in the control group.

H2: Gender and race discrimination in the women's environment will play a role in the effect of the intervention on engineering self-efficacy.

CHAPTER 4

METHODOLOGY

The present study assumed a pre-test post-test control group design evaluating the effects of a self-compassion mindstate induction intervention on engineering self-efficacy compared to a comparable control condition. Engineering self-efficacy was defined by scores on the General Engineering Self-Efficacy Scale, this is considered one of the dependent variables. Engineering self-efficacy change was operationalized by subtracting pre-test scores by post-test scores for all participants. Self-compassion was defined by scores on the State Self-Compassion Scale Short Form, this is the second dependent variable. Self-compassion change was operationalized by subtracting pre-test scores by post-test scores for all participants. The independent variable was the manipulation of self-compassion by condition. Self-compassion was manipulated using the self-compassion mindstate induction. To capture gender and race discrimination in the participants' environment, a modified version of the Discrimination in Engineering Graduate Education Scale was utilized.

Participants

103 participants were recruited from an introductory engineering course and a university-based research platform at Arizona State University to participate in this study. Three participants were excluded from the study for failing to engage in the intervention, 18 were excluded because they did not identify as women, eight were excluded because they did

not report being in a major within the school of engineering, and one was excluded for not being at least 18 years old.

A total of 73 participants ($M_{age} = 18.86$, $SD_{age} = 1.64$; 39.7% White or Caucasian, 8.2% Black or African American, 4.1% Native American or Alaskan Native, 17% Asian, 3% Native Hawaiian or Pacific Islander, 6.8% Other, 4.1% Prefer not to say, 9.6% Biracial or Multiracial) were included in the study. Almost all participants were undergraduates, except for one graduate student. Participants received credit for their course based on their participation in the study if they were recruited from the introductory engineering course. Participants who signed up for the study through Arizona State University's Research Plus Me platform did not receive compensation. Research Plus Me is a university-based platform that encourages students to sign up to participate in research.

Participants were included in the study if they identified as women, were at least 18 years old, English speaking, currently attending the university, and pursuing a degree within the school of engineering. Several types of engineering were represented, including human systems engineering, robotics engineering, mechanical engineering, and more.

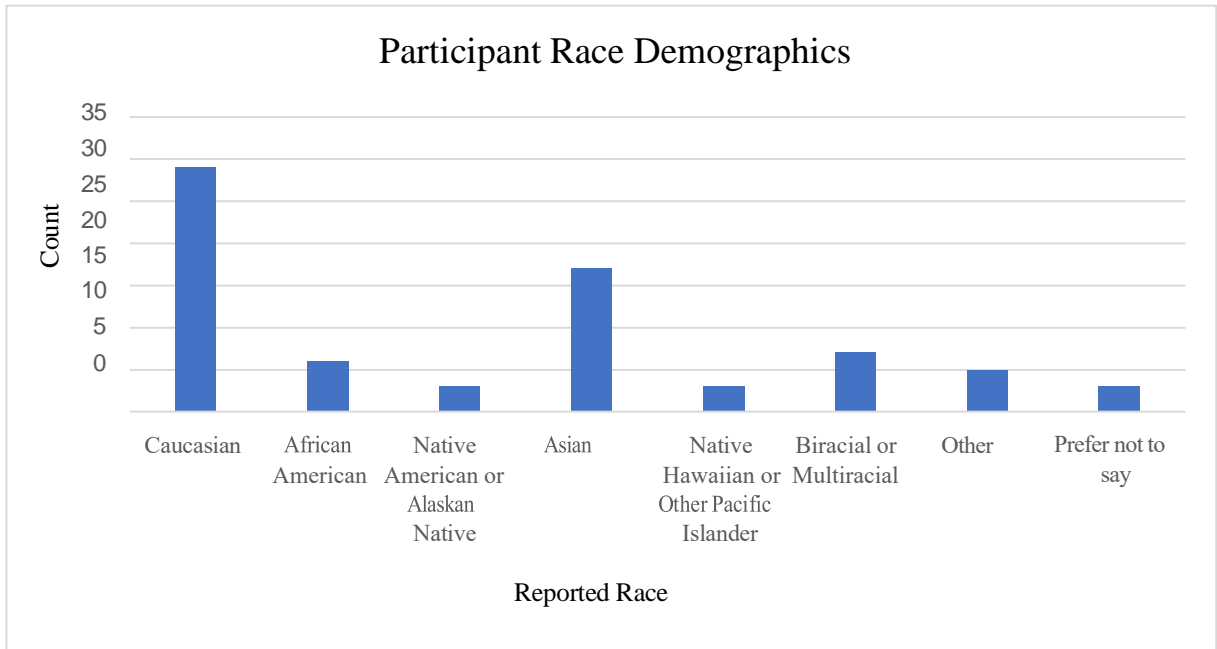


Figure 1. Participant Race Demographics

Procedure

The study was conducted virtually, participants accessed the study using a link to the Qualtrics survey. To begin, participants read over the informed consent. Participants had to select “I agree,” before moving on to the survey items. Participants then completed the first General Engineering Self-Efficacy Scale (GESES). Then all participants completed the modified Discrimination in Engineering Graduate Education Scale. This scale was modified to be relevant to undergraduates studying engineering in higher education. Next, participants were randomly assigned to participate in either the self-compassion mindstate induction or the complementary control condition. Before the participants began their assigned intervention, they all took the State Self-Compassion Scale

Short-Form (SSCS-SF). Once the participants have completed their assigned intervention, both groups completed the single item compliance check and the SSCS-SF for a second time. All participants then completed the GESES for a second time. Finally, all participants filled out a brief demographics survey at the end of the study that asked participants about their age, race, GPA, year in school and more. See Figure 2. below for the flow-chart for the study procedure.

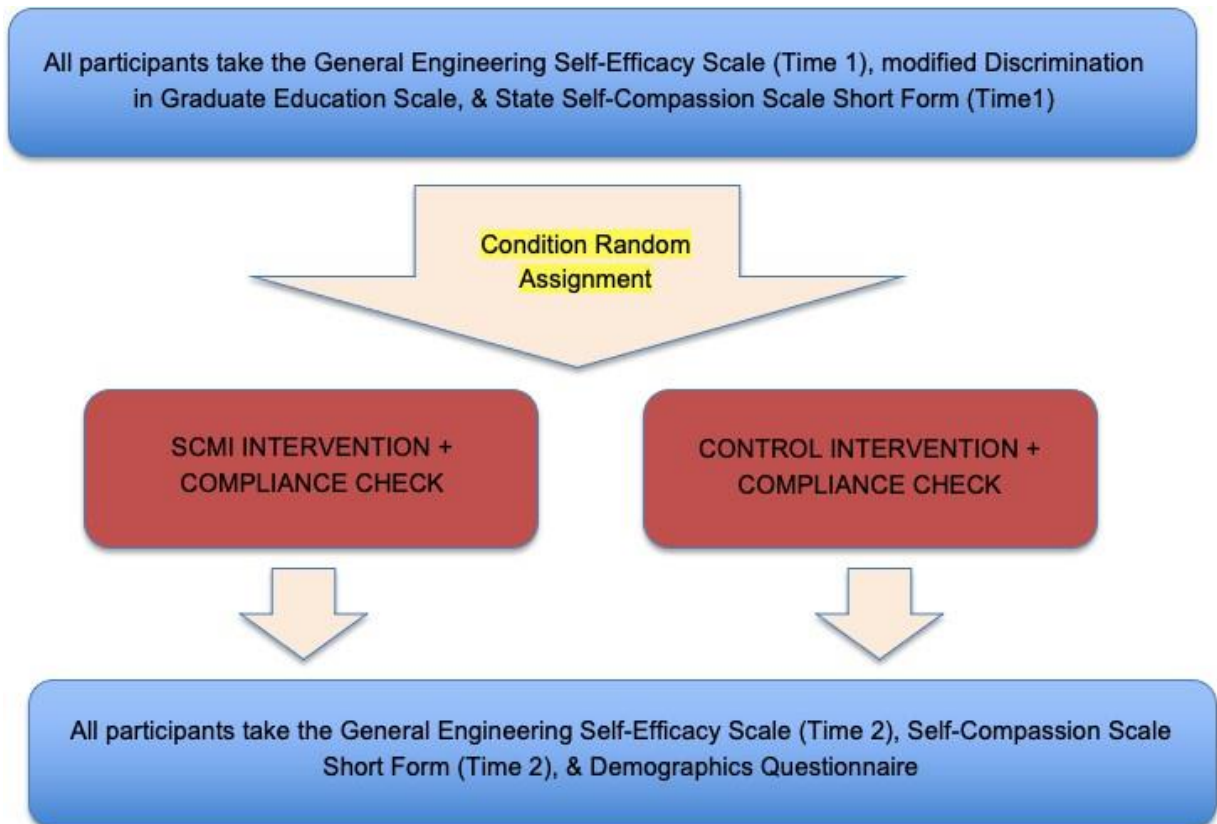


Figure 2. Visual flow-chart of procedure.

Materials

General Engineering Self-Efficacy Scale (GESES).

To capture participants' engineering specific self-efficacy, the General Engineering Self-Efficacy Scale was used, a copy of this survey is available in Appendix A (Mamaril, 2016). The General Engineering Self-Efficacy Scale includes six items related to participants' perceived ability to be successful in engineering. Examples of items include statements like, "I can master the content in even the most challenging engineering course if I try," and "I can do an excellent job on engineering-related problems and tasks assigned this semester." Participants were asked to rate their response to the six items using a 6-point Likert scale from 1 = "completely uncertain," to 6 = "completely certain." This scale was developed and validated by Mamaril (2016), who adapted the scale from Bong's (2001) academic self-efficacy scale and items from the Patterns of Adaptive Learning Scales (Midgley et al., 2000) to be engineering specific.

State Self-Compassion Scale Short-Form (SSCS-SF).

The State Self-Compassion Scale Short-Form (SSCS-SF) was used to measure state self-compassion for both groups before and after the intervention. The SSCS-SF was developed and validated by Neff and colleagues (2021) and contains 6 items to measure global levels of self-compassion. All items were rated on a five-point Likert scale that asks participants to rate how true each statement is for the way they are feeling towards themselves

regarding a difficult situation they are currently experiencing, 1 = “Not at all true for me,” to 5 = “Very true for me.” Some examples of items include, “I’m giving myself the caring and tenderness I need,” and “I’m keeping things in perspective.” Appendix B includes a copy of the SSCS-SF. The SSCS-SF was developed in conjunction with experimental Self-Compassion Mindstate Induction used in this study. The SSCS-SF was incorporated to ensure that the self-compassion mindstate induction effectively induced self-compassion for the self-compassion intervention group and ensures that the control intervention group did not induce self-compassion. It was also included to quantify levels of self-compassion when analyzing the relationship between self-compassion and engineering self-efficacy.

Modified Discrimination in Graduate Engineering Education Scale (DEGrE).

To capture gender and race discrimination in the participants’ environment at school, a modified version of the Discrimination in Graduate Engineering Education Scale (DEGrE) was used. The DEGrE was developed by Bahnson and colleagues (2022), to quantify the experience of sexism and racism in graduate education. The scale includes several factors to capture gender and race discrimination, including faculty interactions, student interactions, culture of sexism, and culture of racism. The scale was modified to be relevant to undergraduate students instead of graduate students because undergraduate students were the population of interest in the present study. The scale included 18 items asking participants to indicate their agreement with each statement on a scale from 1 (strongly disagree) to 7 (strongly agree). A couple of examples of statements were, “I hear comments that degrade women every week,” and “It is common for a student from a minority race/ethnicity to present an idea and get no response, and then for a

white student to present the same idea and be acknowledged.” Appendix C includes a copy of the modified DEGrE.

Modified self-compassion mindstate induction and control intervention.

Materials for the self-compassion mindstate induction and control condition were obtained from Dr. Kristin Neff’s website, a leader in self-compassion research (Neff, 2021). The intervention was modified slightly to be aimed at education. Both conditions were given the same instructions, which were as follows, “Please think about a particular situation you are experiencing right now at school that is painful or difficult. It could be some struggle in your coursework or research, or perhaps you are feeling inadequate in some way. Please don’t think of a situation in which you are upset with someone else, but instead think of a situation where you are feeling badly about yourself or else you are going through a hard time. Decide on a single situation that you will focus on throughout this study.” The self-compassion mindstate induction included three writing prompts, each encapsulating the positive subscales of self-compassion: mindfulness, common humanity, and self-kindness. The control prompts asked the participants to write a description of the problem, the people involved, and the words spoken. All responses were qualitatively coded using a codebook developed by the researchers to ensure that the participants followed the assigned instructions and engaged in the activity. The coding was conducted blindly to condition and two coders were used to ensure interrater reliability. A compliance check was given to both conditions after their assigned writing prompts. The compliance check was a single item question that asked participants to indicate what they just did from three options (‘A-C’). ‘A’ was the corresponding response for the self-compassion

mind state induction, 'B' referred to an irrelevant problem-solving task, and 'C' was the corresponding response for the neutral control condition. Participants in the mind state induction should have chosen 'A' and participants in the control condition should have chosen 'C'. The compliance check was included to ensure that participants in the control condition did not spontaneously write about themselves in a self-compassionate way, therefore inducing a self-compassion mind state. Appendix D includes a copy of both interventions and the compliance check.

CHAPTER 5

DATA ANALYSIS AND RESULTS

The statistical analyses for this study were conducted using IBM SPSS Statistics version 29.0.2.0 (IBM Corp, 2023). To examine the results of the present study, first a correlation analysis was conducted to understand the data from a global perspective. Based on the correlation matrix, there were no significant correlations between any of the variables and discrimination scores. However, there were several significant positive correlations between self-compassion scores and engineering self-efficacy scores assessed using an alpha value of 0.05. There was a positive correlation between engineering self-efficacy from Time 1 to Time 2, $r(71) = .84, p < .001$ and self-compassion from Time 1 to Time 2, $r(71) = .56, p < .001$. Levels of engineering self-efficacy and self-compassion were positively correlated at Time 1, $r(71) = .29, p < .05$, and Time 2, $r(71) = .27, p < .05$. Engineering self-efficacy and self-compassion change scores were computed prior to the analysis by subtracting Time 1 scores from Time 2 scores for each measure. Change in self-efficacy was negatively correlated with engineering self-efficacy at Time 1, $r(71) = -.41, p < .001$. Change in self-compassion was negatively correlated with self-compassion at Time 1, $r(71) = -.57, p < .001$, and positively correlated with self-compassion at Time 2, $r(71) = .37, p < .37$. Finally, change in self-compassion and change in self-compassion were positively correlated, $r(71) = .29, p < .05$. See Table 1. below for a correlations and descriptive statistics.

Table 1

Means, Standard Deviations, and Correlations

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6
1. Discrimination Score	3.21	1.24						
2. Self-Efficacy Time 1	28.23	5.41	-.11					
3. Self-Efficacy Time 2	29.70	5.00	-.01	.84**				
4. Self-Compassion Time 1	3.16	.62	-.05	.29*	.27*			
5. Self-Compassion Time 2	3.34	.55	-.06	.13	.27*	.56**		
6. Change in Self-Efficacy	1.47	3.02	.17	-.41**	.16	-.07	.22	
7. Change in Self-Compassion	.18	.55	.00	-.19	-.03	-.57**	.37**	.29*

Note. * $p < 0.05$, ** $p < 0.01$, (2-tailed).

For the main analysis, a multivariate analysis of covariance (MANCOVA) was performed to examine if participants' self-compassion and engineering self-efficacy increased based on their randomly assigned intervention condition, including discrimination scores as a covariate. The MANCOVA was conducted on two dependent variables: engineering self-efficacy and self-compassion. Adjustment was made for one covariate: discrimination in the participant's environment. The independent variable was condition with two levels, control and self-compassion mindstate induction (SCMI). Significance was assessed using an alpha value of 0.05.

Tests of within subjects contrasts revealed no statistically significant relationship between condition and self-compassion scores from Time 1 to Time 2, $F(1, 69) = 0.002$, $p =$

.97, or condition and engineering self-efficacy scores from Time 1 to Time 2, $F(1, 69) = 2.20$, $p = .143$. Additionally, no significant relationship was found for self-compassion from Time 1 to Time 2 with the discrimination covariate, $F(1, 69) = 0.74$, $p = .39$. However, a significant relationship was detected for engineering self-efficacy from Time 1 to Time 2 with the discrimination covariate, $F(1, 69) = 4.86$, $p = .03$. This indicated that the increase in self-efficacy at Time 1 to Time 2 was significant across both conditions when variance attributed to discrimination scores was controlled for. Based on the correlation matrix, discrimination was negatively correlated with engineering self-efficacy pre ($r = -.11$) and post ($r = -.01$) test scores and positively correlated with engineering self-efficacy change ($r = .17$). The more discrimination the participants reported, the less engineering self-efficacy they had at Time 1 and Time 2. However, the more discrimination reported also equated to a greater change in engineering self-efficacy.

The model including all variables, time, condition, and discrimination, revealed no significant interaction for self-compassion $F(1, 69) = 1.82$, $p = .18$. So, although, participants in the SCMI condition experienced a slightly larger increase in self-compassion compared to the control condition, it was not significant. This is demonstrated in means reported in Table 2. and the visualization in Figure 3. However, the three-way interaction model with condition, time, and discrimination scores did indicate a significant interaction for engineering self-efficacy, $F(1, 69) = 6.51$, $p = .01$. This suggests that condition did have a statistically significant effect on engineering self-efficacy when discrimination scores were accounted for in the model. Figure 4. below visualizes the increase in self-efficacy from Time 1 to Time 2 for each condition.

Table 2

Descriptive Statistics by Condition

Variable	Condition	<i>M</i>	<i>SD</i>	N
1. Self-Efficacy Time 1	Control	27.94	5.33	36
	SCMI	28.51	5.54	37
2. Self-Efficacy Time 2	Control	28.72	5.16	36
	SCMI	30.65	4.71	37
3. Self-Compassion Time 1	Control	3.30	0.52	36
	SCMI	3.03	0.68	37
4. Self-Compassion Time 2	Control	3.26	0.51	36
	SCMI	3.41	0.58	37

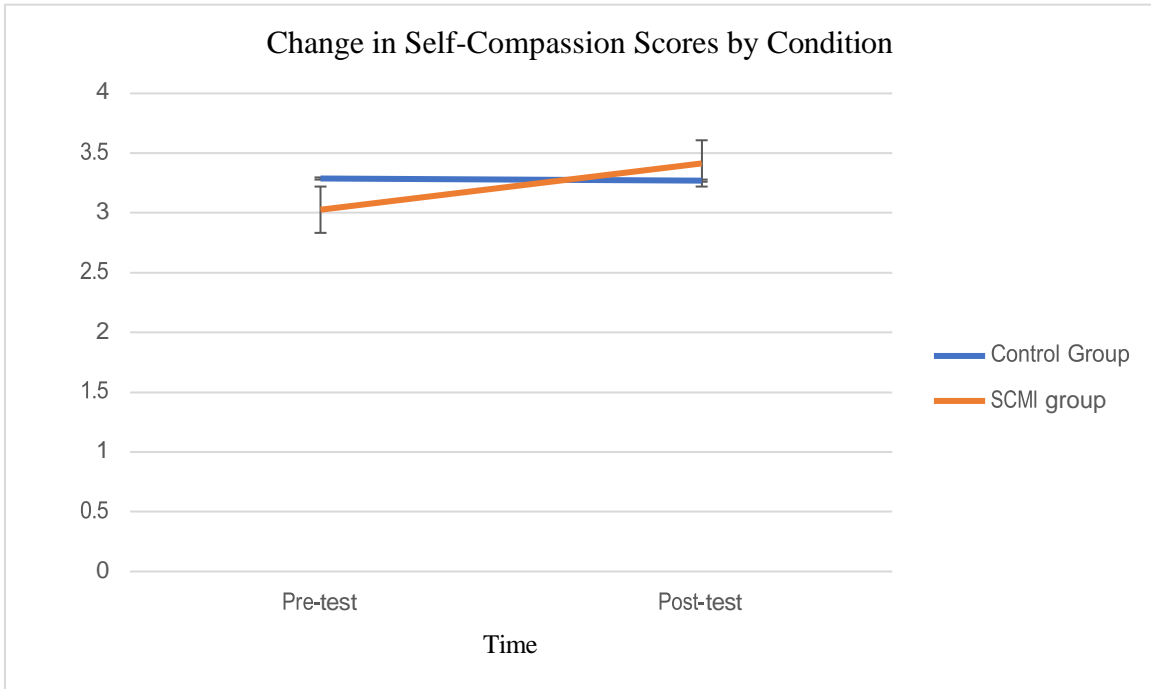


Figure 3. Average Self-Compassion Score by Condition at Time 1 and Time 2.



Figure 4. Average Self-Efficacy Score by Condition at Time 1 and Time 2.

CHAPTER 6

DISCUSSION

The purpose of this study was to examine the effect of the self-compassion mindstate induction on engineering self-efficacy in women pursuing engineering in higher education. This study examined self-compassion and engineering self-efficacy before and after either a self-compassion mindstate induction or control task, considering how gender and race discrimination from faculty and peers in one's environment played a role in this effect. The randomly assigned task conditions both involved a journaling exercise, with the self-compassion mindstate induction being geared towards the participant journaling about a difficulty or struggle from a self-compassionate perspective and the control task being neutral.

The first hypothesis posited that participants in the self-compassion mindstate induction intervention group would experience a significantly larger change in engineering self-efficacy scores from Time 1 to Time 2 compared to participants in the control group. The results did not directly support this model. Due to constraints involving time, only 73 participants were included in the present study. More participants should have been included to examine the true effect of the intervention on the dependent variables, engineering self-efficacy and self-compassion. Another limitation of the given sample is the representation of race. The racial makeup of this study does not necessarily represent the racial makeup of the broader population in the United States. Additionally, all

participants were college students from a large southwest university. Future work in this area should include participants from universities in other geographic regions as gender and race discrimination may differ significantly based on region. This study only included women. Men and individuals identifying as third gender and non-binary were excluded from this study because including multiple gender identities was outside of the scope of this project. The present study had limited resources in terms of time and a lack of funding for recruitment. Focusing on individuals who identify as women ensured sample homogeneity. Having a homogenous sample of women provided more straightforward understanding of the effect of the intervention. However, this research could be particularly important to individuals who identify as third gender or non-binary due to gender discrimination these groups face. Future research should examine how men, women, and third gender or non-binary individuals differ in the effect of self-compassion on engineering self-efficacy using the self-compassion mindstate induction.

Another limitation of the present study that may have impacted the results was that all measures were self-reported. There are several limitations to using self-report measures including response biases and introspective ability. Several measures included in this study were related to the self, which may have introduced the opportunity for social desirability bias and inaccurate introspection. Additionally, another limitation concerning the study materials is the temporal nature of the intervention. The self-compassion mindstate intervention materials were only presented to the participants once. Future work should consider asking the participants to engage in the self-compassion mindstate intervention

several times over the course of a specified period. It is reasonable to assume that repeated exposure to the intervention may reveal a different effect on self-efficacy. This study also had inherent limitations due the nature of online studies. Online studies introduce confounds related to elements in the individuals study environment, including distractions, what time of day they participate, whether they are alone or around other people, and more.

The second hypothesis aimed to explore if gender and race discrimination in the women's environment played a role in the effect of the intervention on engineering self-efficacy. The multivariate analysis of covariance revealed a significant increase in engineering self-efficacy at Time 1 and Time 2 regardless of condition when variance attributed to discrimination was controlled for in the model. One explanation for this may be that participants in the control condition spontaneously induced self-compassion through the act of writing about themselves, even when given the neutral instructions (Neff, 2021). This suggests that the act of journaling alone may have significantly increased self-efficacy when discrimination was controlled for. It may also be relevant that more participants are needed to accurately assess effect of both conditions.

The data also revealed that participants in the self-compassion mindstate induction condition experienced a statistically significant greater increase in engineering self-efficacy from Time 1 to Time 2 compared to the control condition, but only if the model included the three-way interaction with the covariate, discrimination score. This is more aligned with hypothesis one, in that participant in the self-compassion mindstate induction condition experienced a significant increase is in self-efficacy, but only when

discrimination in the participant's environment was controlled for. Based on correlational analyses higher levels of experienced gender and race discrimination in the participants' environment at the university level, from faculty and other students, were associated with lower engineering self-efficacy scores at Time 1 and Time 2. However, higher levels of reported discrimination explained a significant amount of variance in regard to greater increases in engineering self-efficacy, suggesting that students experiencing more discrimination experienced more growth self-efficacy.

Due to the important role that gender and race discrimination participants experienced played in the current study, future work should examine discrimination more directly. The present study included discrimination as an exploratory covariate. Reported levels of discrimination should be examined quasi-experimentally within the context of self-compassion and self-efficacy. The intervention materials could also be modified to encourage participants to write about difficult situations involving experiences of discrimination. This could be done similarly to the way they were modified to be geared towards difficult situations involving higher education in this study. Previous research suggests that journaling about traumatic or stressful experiences may mitigate the negative effects associated with the experience (Donnelly & Murray, 1991; Smyth, 1998; Ullrich & Lutgendorf, 2002).

Finally, this study did not investigate how the intervention affected individuals based on race and ethnicity. Future work should consider the effect of the intervention on self-efficacy across several groups of individuals from different racial and ethnic

backgrounds quasi-experimentally. It is reasonable to assume to that a woman who experiences the intersectionality of gender and race discrimination would respond differently than a Caucasian woman. Additionally, this study grouped gender and race discrimination together, future work should examine how the specific type of discrimination (race versus gender) may be related to engineering self-efficacy and self-compassion within the context of engineering higher education.

CHAPTER 7

CONCLUSION

The results of this study suggest that engaging in a self-compassion mindstate induction may increase engineering specific self-efficacy when gender and race discrimination in one's environment is controlled for. The effect of self-compassion on engineering self-efficacy is in line with the previous research discussed in the meta-analysis conducted by Liao and colleagues (2021) demonstrating a strong positive correlation between the two concepts across 60 studies. The self-compassion mindstate induction intervention asked participants to reflect on a difficult situation they were experiencing at the university through the lens of the three subcomponents of self-compassion: self-kindness, common humanity, and mindfulness. Each of these subcomponents has been theorized to explain the connection between self-compassion and self-efficacy (Neff et al., 2005), which may explain the present results. When discrimination was controlled for, the self-compassion mindstate induction may have increased engineering self-efficacy through allowing participants to mindfully assess the difficult situation, revealing that it was not indicative of their ability and helping to not over-identify with the negative emotions (Neff et al., 2005). The common humanity prompt may have encouraged the participants to recognize that they are likely not the only woman majoring in engineering experiencing these challenges, maintaining self-efficacy (Neff et al., 2005). Finally, the self-kindness prompt may have mitigated its negative counterpart, self-judgement, which has been shown to be particularly damaging to one's self-efficacy (Iskender, 2009; Neff et al., 2005).

A key take-away from present study is that the effect of the self-compassion mindstate induction intervention only significantly increased engineering self-efficacy when variance attributed to gender and race discrimination was controlled for. Previous research has linked more experiences of gender and racial discrimination with lower levels of self-efficacy (Hunter 1998; Wells, 2016; Richardson et al., 2013; Kyere et al., 2023; Kira et al., 2015). It is plausible that individuals that came into the study with lower levels of self-efficacy due to discrimination had more room to grow after experiencing the intervention. Discrimination in engineering is a significant deterrent for women pursuing engineering, so it makes sense that controlling for this force would reveal a stronger relationship between the self-compassion condition and self-efficacy (Ceci et al., 2014; Karis, 2022; Benya et al., 2018; Ding et al., 2021; Settles, et al., 2006).

The results of this study contribute to the literature examining the relationship between engineering specific self-efficacy and self-compassion and demonstrate the potential for self-compassion based positive psychology-based interventions. This brief intervention is accessible, regardless of socioeconomic status, gender, race, location, and other factors, as it is cost-free, can be done individually, and does not require more than paper and a pencil. This intervention could be implemented by teachers in schools to support students' engineering self-efficacy. For example, teachers could provide their students with the three self-compassion mindstate induction prompts at points in the school year when students may need extra encouragement such as during standardized testing periods. The development and research into interventions aimed at encouraging women in engineering might help promote representation and increase the number of role models and help alleviate sociocultural barriers associated with

higher paying jobs. These broader implications could create a positive upward spiral effect, an idea often seen in positive psychology research, where one positive outcome mutually enhances another positive outcome (Garland et al., 2011; Kok et al., 2013; Fredrickson & Joiner, 2002). Encouraging women in higher education to pursue degrees in engineering is important to creating a more diverse and innovative workforce. Reuben and colleagues (2014) found that gender bias is often selected over performance, hindering innovation. Lack of women in engineering also results in the development of products and systems based only on the perception of men in engineering (Williams, 2014). Supporting women in engineering is important to the overall success of the field. Investigating interventions with this common goal lays the groundwork for future research in this area and contributes to the conversation about the importance of minimizing the gender gap in engineering higher education, as well as the post-graduate career landscape.

Finally, this study was aimed at mitigating the impact of systematic barriers for women in engineering higher education. However, it is arguable that it is not the responsibility of those in underrepresented groups to solve problems related to the systematic discrimination and bias affecting equity and equality (Llorens et al., 2021). Attacking systematic change should be at the forefront in addressing these issues and disparities. The present study did not have the resources required for an intervention at the systematic scale. Addressing systematic barriers related to the pursuit and retention of women in engineering has important implications for society. More gender diversity in the workplace has been linked to superior corporate performance (Catalyst, 2004; Catalyst, 2011). The National Center for Women and Information Technology has also reported that representation of women in all roles within an organization's

structure is related to better outcomes (2014). Future work should continue to address systematic barriers providing more support for legislation protecting underrepresented groups and supporting a culture of diversity and inclusion.

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APPENDIX A

GENERAL ENGINEERING SELF-EFFICACY SCALE

General Engineering Self-Efficacy Scale

Please read each statement and indicate how certain you are about each statement based on the following scale:

Completely uncertain

Completely certain

1

2

3

4

5

6

1. I can master the content in the engineering-related courses I am taking this semester.
2. I can master the content in even the most challenging engineering course if I try.
3. I can do a good job on almost all my engineering coursework if I do not give up.
4. I can do an excellent job on engineering-related problems and tasks assigned this semester.
5. I can learn the content taught in my engineering-related courses.
6. I can earn a good grade in my engineering-related courses.

APPENDIX B

STATE SELF-COMPASSION SCALE SHORT FORM (SSCS-S)

The State Self-Compassion Scale Short Form (SSCS-S)

Think about a situation you are experiencing right now that is painful or difficult. It could be some challenge in your life, or perhaps you are feeling inadequate in some way. Please indicate how well each statement applies to how you are feeling toward yourself right now as you think about this situation, using the following scale:

Not at all true for me					Very true for me
1	2	3	4	5	

1. I'm giving myself the caring and tenderness I need.
2. I'm obsessing and fixating on everything that's wrong.
3. I'm remembering that there are lots of others in the world feeling like I am.
4. I feel intolerant and impatient toward myself.
5. I'm keeping things in perspective.
6. I feel like I'm struggling more than others right now.

APPENDIX C

MODIFIED DISCRIMINATION IN GRADUATE EDUCATION SCALE (DEGRE)

Instructions: Please read each statement and indicate your level of agreement from *strongly disagree (1)* to *strongly agree (7)*

1. In class, all faculty treat students equally
2. In class, all faculty are respectful of different races and ethnicities
3. In class, faculty answer my questions with respect
4. In class, faculty never talk down to students
5. In class, all students treat each other equally
6. In class, all students are respectful of different races and ethnicities
7. In class, other students answer my questions with respect
8. In class, students never talk down to other students
9. I hear sexist comments every semester
10. I hear comments that degrade women every week
11. It is common for the female student to present an idea and get no response, and then for a male student to present the same idea and be acknowledged
12. I hear racist comments every semester
13. I hear comments that degrade racial minorities every week
14. It is common for a student from a minority race/ethnicity to present an idea and get no response, and then for a white student to present the same idea and be acknowledged
15. I am comfortable discussing engineering or technical topics with my professors
16. I am comfortable discussing personal topics with my professors
17. I am comfortable discussing engineering or technical topics with other students
18. I am comfortable discussing personal topics with other students

APPENDIX D

MODIFIED INTERVENTION MATERIALS

[Bolded text in brackets is information for researchers only. Note that the examples of self-compassion writing given below should be changed so that they are appropriate for the cultural context of participants and the purposes of the study.]

Please think about a particular situation you are experiencing right now at school that is painful or difficult. It could be some struggle in your coursework or research, or perhaps you are feeling inadequate in some way. Please don't think of a situation in which you are upset with someone else, but instead think of a situation where you are feeling badly about yourself or else you are going through a hard time. Please do not include the names of others when responding to these prompts. Decide on a single situation that you will focus on throughout this study. Each response should be around 200 words.

[State measures inserted here, answered in reference to the painful or difficult situation.]

We would now like you to take part in a brief exercise, to see if it is helpful in dealing with this painful or difficult situation regarding school.

[1. Mindfulness writing prompt]

Please complete this brief writing exercise and follow the instructions as closely as possible. In the space below, please write about what thoughts and emotions are coming up for you right now regarding this difficult school situation. Note any uncomfortable emotions you may have, such as feeling stressed, ashamed, sad, anxious, and so on. As you write and notice your feelings, see if you can validate your experience with an attitude of acceptance and non-judgment. Try not to downplay your feelings, but at the same time please try not to exaggerate them either.

(For example, "I feel frustrated about the fact that my professor doesn't ask me to join his research lab, unlike the other men in the class. I feel like if I were a male student, it would be easier to get in and it's not fair. This is really hard for me right now...")

*Remember-- your responses are completely anonymous and your writing is confidential. Don't worry about spelling, sentence structure, or grammar.

[SPACE FOR WRITING]

[2. Common humanity writing prompt]

In the space below, please write about how other people may share similar feelings when encountering situations like this.

Please do not use other people's names. Consider that experiencing difficult situations is a part of being a college student, and that you are not alone. Although the way people struggle is different and the amount of challenge varies, all students will face difficulties in college. What you are experiencing is not abnormal, but is a part of the college experience.

(For example, "I am not the only student who struggles with these types of projects. Part of being a college student is learning how to overcome difficult assignments. Most people have a difficult time with these kinds of projects because college is challenging. It's not just me...")

[SPACE FOR WRITING]

[3. Self-kindness writing prompt]

In the space below, please write any words of support, encouragement and kindness to yourself that would be helpful to hear right now.

If you are not sure what to say, imagine what you would say to a classmate who was struggling with a similar difficult situation. What words would you use to convey compassion, support, and non-judgemental understanding? Now see if you can use this as inspiration for what to say to yourself.

(For example, "You're doing the best you can. I'm so sorry you're struggling with this. It's going to be okay. I will help you and support you to get through this...")

[SPACE FOR WRITING]

Please take some time to read what you wrote to yourself and see how it feels to hear these words of kindness and concern directed towards you.

Notice if anything is particularly comforting or helpful.

Take a few slow, deep breaths as you read your own words. Let yourself receive this support.

[Compliance check and post-test state measures completed in reference to the difficult situation inserted here.]

Control Condition

[Bolded text in brackets is information for researchers only. Note that the examples of self-compassion writing given below should be changed so that they are appropriate for the cultural context of participants and the purposes of the study.]

Please think about a particular situation you are experiencing right now at school that is painful or difficult. It could be some struggle in your coursework or research, or perhaps you are feeling inadequate in some way. Please don't think of a situation in which you are upset with someone else, but instead think of a situation where you are feeling badly about yourself or else you are going through a hard time. Please do not include the names of others when responding to these prompts. Decide on a single situation that you will focus on throughout this study. Each response should be around 200 words.

[State measures inserted here, answered in reference to the painful or difficult situation.]

We would now like you to take part in a brief exercise, to see if it is helpful in dealing with this painful or difficult situation.

[1. Description writing prompt]

Please complete this brief writing exercise and follow the instructions as closely as possible. In the space below, please write about what exactly is occurring in this difficult situation. Try to be as descriptive as possible.

(For example, "My group for a class project is having a difficult time working together. I want to go one direction with the project while other members think we should do it differently because...")

*Remember-- your responses are completely anonymous and your writing is confidential. Don't worry about spelling, sentence structure, or grammar.

[2. People involved writing prompt]

In the space below, please write about who is involved in the situation if it involves more than just you. Please describe the people involved with as much detail as possible, without using their names, even if you are the only one involved (in this case describe yourself).

(For example, "My group members, the professor, have all met to discuss the differences of opinion about the project. The professor supports me, but the other students do not. The other students are younger than me... ")

*Remember-- your responses are completely anonymous and your writing is confidential. Don't worry about spelling, sentence structure, or grammar.

[SPACE FOR WRITING]

[3. Words spoken writing prompt]

In the space below, please write any words that have been spoken in the situation, either what you have said to yourself, what other people have said to you, or what you have said to other people. Please use as much detail as possible, but do not use other people's names.

(For example, "I told my professor that I really didn't want to work with this group anymore and that I wanted to work alone. She told me that I should try to work it out with them...")

*Remember-- your responses are completely anonymous and your writing is confidential. Don't worry about spelling, sentence structure, or grammar.

[SPACE FOR WRITING]

Please take some time to read what you wrote and see if anything particularly stands out for you.

[Compliance check and post-test state measures completed in reference to the difficult situation inserted here.]

Compliance check. **[It is important to include a compliance check because many participants spontaneously write to themselves self-compassionately in the control condition, especially when it directly follows completing a state self-compassion measure.]**

Please indicate what you were just asked to do: (A) Write about your feelings in an accepting and validating way, consider how going through difficult situations is part of being human, write to yourself like a supportive friend; (B) Write about the situation and try to figure out

how to solve the problem; or (C) Write the details of the situation, who is involved and what was said with as much detail as possible.

Those in the SCMI condition pass the compliance check if they respond A and the neutral controls if they respond

APPENDIX E

INSTITUTIONAL REVIEW BOARD EXEMPTION

EXEMPTION GRANTED

Heather Lum

IAFSE-PS: Human Systems Engineering (HSE)

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Heather.Lum@asu.e

du Dear [Heather](#)

[Lum](#):

On 9/13/2023 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Using Self-Compassion to Boost Women's Engineering Self-Efficacy in Higher Education
Investigator:	Heather Lum
IRB ID:	STUDY00018592
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	<ul style="list-style-type: none"> ï Informed Consent , Category: Consent Form; ï Protocol , Category: IRB Protocol; ï SONA recruitment , Category: Recruitment Materials; ï ThesisSurvey_revised.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2)(ii) Tests, surveys, interviews, or observation (low risk) on 9/12/2023.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required.

Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Taylor Kampf

Heather Lum

Taylor Kampf

Erin Chiou

Rod Roscoe

Jessica Lee