Advances in Engineering Education

2023: VOLUME 11 ISSUE 1
DOI: 10.18260/3-1-1153-36039

Implementation and Feasibility of a Group Mindfulness Intervention for Undergraduate Engineering Students

ELIZABETH DOLIN DALTON

AND

TOMÁS ESTRADA
Elizabethtown College
1 Alpha Drive
Elizabethtown, PA, 17022

ABSTRACT

Students' mental health and well-being are increasingly recognized as urgent and important needs in engineering education. Mindfulness-based interventions, in which students learn and practice present-focused techniques such as meditation and deep breathing, have been demonstrated to positively affect college students' well-being. The use of such interventions for engineering students specifically, however, has not been thoroughly examined. In this work, we examine the feasibility and utility of a group-based mindfulness intervention for 48 undergraduate engineering students. Participants completed four weekly, one-hour group mindfulness sessions led by the study authors. Qualitative and quantitative data were collected before and after the intervention to assess the impact of the intervention on participants' trait mindfulness, perceived stress, intellectual curiosity and exploration, and weekly mindfulness practices. Compared to participants in a control condition, participants engaging in the group intervention demonstrated an increase in trait mindfulness and weekly mindfulness practice, and lower perceived stress. The intervention did not have a significant impact on participants' intellectual curiosity and exploration. The group mindfulness intervention was well-received, with a majority of participants attending all four sessions, rating them as helpful, and reporting that they would retain the length and frequency of the sessions. Results suggest that group-based mindfulness practices may be a feasible way to support the well-being of undergraduate engineering students. We conclude with a discussion of the applications and implications of this work for other educators.

Key words: Mental health, Stress, Extracurricular

INTRODUCTION

The mental health and well-being of students is increasingly recognized as an urgent need in higher education broadly (American Council on Education 2019; Lipson, Lattie, and Eisenberg 2019), and engineering education specifically (Danowtiz and Beddoes 2018). There is evidence that students' levels of stress and anxiety are on the rise, and that students' psychological adjustment is associated with their academic success and adjustment (Wyatt, Oswalt, and Ochoa 2017). Thus, students' psychological wellness is an area of interest and concern to all educators. While there is evidence that students' stress is on the rise, there is concurrently data that college students are increasingly comfortable and willing to seek out mental health support and services (Lipson, Lattie, and Eisenberg 2019), although not all students are getting equal help and face different levels of stigma (Kam, Mendoza and Masuda 2019). Mindfulness practices are increasingly gaining support as an effective and well-received strategy for promoting the health and wellbeing of college students (Bamber and Schneider 2016). However, relatively little is known about the effects of mindfulness practices on engineering students, nor is the feasibility and acceptability of mindfulness-based practices established with this particular population.

In this introductory section, we establish a conceptual framework for our work by first providing background on mindfulness in general. We then discuss trait mindfulness and mindfulness interventions, and we further hone in by examining previous work on mindfulness in engineering education specifically. Having situated our study in this context, in the rest of the paper, we present our main contribution, methods, results, discussion, conclusions and recommendations.

Mindfulness: Conceptual Background

A widely used definition of mindfulness is presented by Kabat-Zinn (2013): "Mindfulness means paying attention in a particular way: on purpose, in the present moment, and nonjudgmentally." Thich Nhat Hanh, a celebrated Buddhist practitioner, activist, and teacher, offers his own definition: "Mindfulness shows us what is happening in our bodies, our emotions, our minds, and in the world. Through mindfulness, we avoid harming ourselves and others." (Hanh 1991). Typical examples of mindfulness exercises are breathing meditation, sitting meditation, walking meditation, and yoga (movement meditation). Other areas include metta or lovingkindness meditation and compassion meditation (Salzberg 2015), which focus on the cultivation of acceptance and compassion for oneself.

The origins of mindfulness and meditation can be traced back thousands of years to spiritual traditions in India and other parts of Asia. However, it was not until the late 20th Century that mindfulness became recognized as a legitimate field of study by Western scientific communities. Since the 1980s, a rapidly growing number of Western scholars have begun to study and document the

impact of these practices on various aspects of health and wellbeing, such as stress, pain reduction, and memory (Siegel 2017, Ricard 2003). For example, Kabat-Zinn (2013) summarizes many promising results of mindfulness-based stress reduction (MBSR) and Goleman and Davidson (2017) provide a comprehensive overview of studies documenting how mindfulness practices may result in permanently altered traits. More broadly in Western society, the impact of mindfulness has also grown dramatically in recent decades, in terms of number of practitioners, teachers, and recognition in everyday conversations.

Trait Mindfulness and Interventions

While the term mindfulness is frequently used to refer to specific practices, approaches, or attitudes, *trait mindfulness* refers to the extent to which an individual engages mindfully and nonjudgmentally with their internal and external experiences. For example, a person high in trait mindfulness may be in tune with and comfortable describing their emotions and other internal sensations, and be adept at focusing on present-moment activities. Facets of undergraduate students' trait mindfulness – specifically, acting with awareness and nonjudgment – are associated with emotional well-being (Bodenlos 2015). Undergraduate students' trait mindfulness is associated with lower levels of state anxiety in high-pressure testing situations, thus facilitating improved accuracy (Bellinger, DeCaro, and Ralston 2015). Several mechanisms have been identified that help to explain the connection between mindfulness traits and practices and positive mental health effects. Specifically, mindfulness may help to facilitate the regulation of attention and emotion, which in turn help one to better cope with and respond to stressors and challenges, yielding a positive effect on mental health (Burzler et al. 2019; Hölzel et al. 2011). Additionally, mindfulness may help people cultivate a less fixed or static perception of the self, which may promote adaptability and flexibility and thus promote positive mental health (Burzler et al. 2018).

Given the established positive benefits of trait mindfulness for students and the general population, it is reasonable to consider interventions that might enhance or improve trait mindfulness. Mindfulness-based interventions have demonstrated a range of positive effects in the general population, including enhanced trait mindfulness, reduced symptoms of worry and stress, enhanced well-being, and improved attentional control (Chin et al. 2020; Felver, Morton, and Clawson 2018; Querstet et al. 2020). Brief single mindfulness interventions have also been shown to improve quiz performance among undergraduate students (Calma-Birling and Regan 2017).

Mindfulness in Engineering Education

There is some emerging work on the topic of mindfulness in engineering education specifically. This is in part in response to an increased recognition of the mental health needs of engineering students.

A 2018 study found that engineering students are at significantly higher risk of suffering from mental illness than the general population (Danowitz and Beddoes 2018). Given the established association between mindfulness and mental well-being in the general and college student populations, it is worthwhile to explore this topic among engineering students specifically, a group that may exhibit higher-than-average rates of psychological distress. A few researchers have begun to implement brief mindfulness-based interventions with engineering students. Huerta (2018) facilitated a study in which 92 engineering students received a 45-minute introduction to mindfulness. In general, students' responses to questions following the mindfulness presentation indicated that the information was well-received, with more than half the participants indicating they would be interested in additional workshops on mindfulness (Huerta 2018). While this points to engineering students' openness to information on mindfulness, this study did not assess whether the presentation had an impact on students' trait mindfulness or mental well-being using survey measures administered both before and after the intervention. Ge et al. (2019) examined the impact of a one credit course on thriving, which included lessons on gratitude, meaning, and mindfulness, on 12 engineering students. While the sample size precluded meaningful statistical analysis, the results indicated general improvement in gratitude and meaning throughout the course, with a decline in trait mindfulness (Ge et al. 2019). Miller and Jensen (2020) invited students to participate in brief mindfulness activities at the beginning of a synchronous online course during the COVID-19 pandemic; students' qualitative feedback (n = 12) indicated that they appreciated and enjoyed the exercises. Our own prior pilot study provided initial support for the impact of a four week mindfulness intervention on engineering students' trait mindfulness (n = 21; Estrada and Dalton 2019). In recent work, Huerta et al. (2021) explored the benefits of a similarly structured four week mindfulness intervention for first year engineering students. Students in this study (n = 35), which did not include a control comparison group, completed post-intervention, but not pre-intervention, open-ended survey questions and interviews about their experiences (Huerta et al. 2021). While again the post-intervention data suggested that the intervention was well-received and that students reported a perception that their mindfulness had increased in open-ended question responses, the lack of pre-intervention data collection precludes statistical analysis of the effect of the intervention on change in students' trait mindfulness or other aspects of their well-being.

There is also evidence from non-intervention, survey-based data that there are correlations between mindfulness and positive psychological and academic outcomes among engineering students. For example, engineering students' trait mindfulness is correlated with facets of academic success, including innovation and business skills self-efficacy (Estrada and Dalton 2019; Rieken et al. 2017; Rieken, Schar, and Sheppard 2016). Beddoes and Danowitz (2021) conducted an online survey of 669 engineering students and found that those who reported using yoga and meditation (practices that

incorporate mindfulness) reported less recent hopelessness and depression. Although correlational in nature, these studies lend further support to the potential utility of mindfulness-based practices among engineering students.

Overall, the initial and emerging research points to the potential efficacy and suitability of mindfulness interventions for engineering students. However, many of these studies have been limited by small sample sizes, lack of control groups, lack of measurement of pre-intervention and post-intervention data, and, in most cases, brevity of the intervention. Thus, the feasibility of multi-session mindfulness interventions and impact of said interventions on engineering students' trait mindfulness, practice of mindfulness, and psychological wellbeing remain poorly understood.

MAIN CONTRIBUTION

Having explored the conceptual framework for our work by starting with mindfulness in general, then mindfulness interventions and trait mindfulness, and finally mindfulness in engineering in particular, we now provide our main contribution. The present work assessed the implementation of a four week group mindfulness intervention for undergraduate engineering students, utilizing a waitlist control condition. Part of the aim was to assess the feasibility of mindfulness groups for this population, by tracking students' attendance and soliciting their feedback on session length, frequency, and usefulness. Additionally, survey measures were administered before and after students' participation, in order to gauge the effect of group participation on students' trait mindfulness, weekly mindfulness practice, perceived stress, and intellectual curiosity and exploration. Participants' quantitative and qualitative feedback on the experience were systematically collected, such that recommendations for implementing and improving the experience can be offered. This study builds upon prior literature suggesting that mindfulness interventions are well-received by engineering students, by incorporating comparison to a control group, and assessing whether a mindfulness intervention produces changes in engineering students' stress, trait mindfulness, and intellectual curiosity and exploration by systematically measuring these variables before and after implementation of the intervention.

METHODS

Participants and Procedures

Participants included 48 undergraduate engineering majors (sophomores, juniors, and seniors) at Elizabethtown College who were recruited from four courses in the major: Circuit Analysis, Signals

and Systems, Fall Seminar, and Control Systems. Students were recruited for the study via flyers advertising the study and announcements made by course instructors at the beginning of the semester in eligible classes. Students were offered extra credit in the aforementioned courses in exchange for study completion. Regardless of whether they were assigned to complete the intervention or control conditions, all participants completed study surveys (described below) and received the same extra credit in exchange for study completion. The sample was predominantly white (77%; 9% biracial/multiracial, 6% Latino/Hispanic, 2% Asian, 2% Black/African American, 4% missing/prefer not to answer), male (59%; 38% female, 3% missing/prefer not to answer), and 20.5 years old (range 18–23).

The study took place over three semesters (Spring 2019, Fall 2019, and Spring 2020). The first semester consisted of intervention groups only. Beginning in the second semester (Fall 2019) a waitlist control comparison group was added in order to provide a stronger assessment of the effects of the intervention. A waitlist control comparison was selected so that all study participants would eventually receive the mindfulness intervention, and to allow for comparison of the intervention to typical campus life. After providing informed consent, study participants were randomly assigned to either the immediate intervention or waitlist control conditions. Participants in the waitlist control condition became eligible to receive the intervention following the waitlist delay and completed study surveys at the start of the semester, upon conclusion of their time on the waitlist, and then again following completion of the intervention. While a waitlist control design was initially intended for the Spring 2020 semester, the abrupt shift to remote education necessitated by the COVID-19 pandemic caused all enrolled participants to be converted to a control condition. Students in the control condition completed the same study questionnaires as students in all other conditions and received the same extra credit for their participation. Upon conclusion of their participation in the control condition, these students were provided with resources for mindfulness practice as they were not able to be offered participation in the mindfulness intervention. Limitations of this shift during the Spring 2020 semester are presented in the Discussion section. In total, 34 students completed the intervention only condition, seven completed a waitlist control condition followed by the intervention, and seven served as control only. All study procedures were approved by the Institutional Review Board at Elizabethtown College.

Mindfulness Intervention Description

Overview. The mindfulness groups were based on a mindfulness-based stress reduction intervention developed by Kabat-Zinn (2003) and Stahl and Goldstein (2010). This intervention was selected because it has been demonstrated to have a positive impact on students' well-being (Ramler et al. 2016), and because the available workbook (Stahl and Goldstein 2010) is highly accessible and provides step-by-step explanations and instructions for a wide variety of mindfulness practices.

Participants in the intervention groups (which ranged in size from 11–15 participants) met for one hour a week over the course of four weeks. Intervention meetings took place from 4:00–5:00 PM on Wednesdays or Thursdays, and were led by co-author Elizabeth Dalton, who holds a doctorate in clinical psychology and has prior training in mindfulness-based interventions. Study co-author and engineering professor Tomás Estrada also attended all intervention meetings; both co-authors participated in all mindfulness activities and discussion alongside the study participants. Sessions were held in a non-classroom meeting space and chairs were arranged in a circle, such that all participants could see and easily engage with one another (see Appendix 1).

Session Descriptions. Each of the four weekly sessions included psychoeducation on a specific mindfulness topic, one or more experiential mindfulness practices, reflection and discussion, and suggestions for at-home practice. Each session emphasized the idea that mindfulness practices can take place formally, i.e., as a part of a guided meditation, or informally, i.e., by way of enhanced attention to and engagement in any present activity. Sessions 2–4 began with brief guided meditations to help participants bring their focus and awareness into the sessions (see University of California, Los Angeles Mindfulness Awareness Research Center 2021 for examples), followed by a brief recap of the content introduced in the prior session and a check in about at-home practices from the week (e.g., "How did your at-home practices go?" "Did anyone experience any barriers or challenges in engaging in at-home practices?"). Specific activities incorporated in each session are outlined below.

Session 1. Prior to beginning the first session, participants provided written informed consent and completed the pre-intervention surveys described in the following section. Participants were briefed on confidentiality and privacy of information discussed in the group meetings, and informed that participation in exercises and discussion was encouraged, but not required. Additionally, the following was covered:

- Information on and Discussion of a Mindfulness Topic: Students' understanding of and prior experiences with mindfulness were discussed. A common definition of mindfulness as "being in the present moment, with intention, and without judgment" was introduced and students' reactions were elicited (Kabat-Zinn 2013). Students were informed that they should not feel pressure to have any particular experience of or reaction to a given mindfulness exercise. Mindfulness was framed as an attitude towards one's experiences, rather than something that can be done correctly or incorrectly. Students were invited to write down and share their goals for mindfulness practice (e.g.. "What led you to join this group? What are you hoping to change as a result of this experience? What personal strengths might help you achieve these goals?").
- Experiential In-Session Practices: Mindful eating of a raisin was introduced as the first in-session practice. The group instructor led participants in slowly and deliberately eating a raisin, incorporating all of their five senses (Stahl and Goldstein 2010, 18–21). Following this activity,

participants were encouraged to reflect on their experience (e.g., "What observations did you have of this experience in terms of sight, touch, sound, smell and taste? Was anything surprising? Did any thoughts or memories emerge while doing this practice?"). Next, participants engaged in a mindful check-in practice, in which they were invited to sit silently for a few moments while observing internal experiences such as their thoughts, emotions, and physical sensations (Stahl and Goldstein 2010, 21–23).

- Suggested at-home practices: Participants were invited to make a plan to practice either mindful eating or a mindful check-in at home prior to the next group meeting (Stahl and Goldstein 2010, 24–25).

Session 2

- Information on and Discussion of a Mindfulness Topic: Information about the body's response to stress was provided (see American Psychological Association 2018 for an example guide and information), and mindfulness as a means of coping with stress was discussed. Participants were informed that as they learn to respond to stressors mindfully, they may begin to notice and transform default patterns of unawareness associated with stress.
- Experiential In-Session Practices: Participants practiced reading a book passage mindfully and were asked to reflect on their experiences (e.g., "How was this both different from and similar to non-mindful reading?").
- Suggested at-home practices: Participants were invited to weave mindfulness into an activity in their everyday life (such as eating, reading, or a task such as folding laundry or washing dishes; Stahl and Goldstein 2010, 35–37).

Session 3

- Information on and Discussion of a Mindfulness Topic: Eight attitudes of mindfulness as described by Stahl and Goldstein (2010, 41–45) were introduced: beginner's mind, nonjudgment, acknowledgment, non-striving, equanimity, letting be, self-reliance, and self-compassion. Participants were invited to discuss how they might apply some of these attitudes to their daily lives.
- Experiential In-Session Practices: Participants were invited to adopt one of the eight aforementioned mindful attitudes while engaging in an eyes-closed drawing task. Specifically, participants were invited to hold a pen or pencil in their hands and close their eyes while drawing anything (e.g., shapes, geometric patterns) on a piece of paper with deliberate, mindful awareness. Next, participants were invited to engage in a guided loving-kindness meditation (University of California, Berkeley The Greater Good Science Center 2021).

- Suggested at-home practices: Participants were invited to apply one of the eight mindful attitudes to an activity of their choosing (Stahl and Goldstein 2010, 46–47).

Session 4

- Information on and Discussion of a Mindfulness Topic: Taking a mindful approach to physical sensations and experiences was discussed. Participants also reflected on progress towards the goals they had established at the beginning of the group meetings.
- Experiential In-Session Practices: The group leaders led participants in holding a mindful yoga pose and engaging in mindful walking (Stahl and Goldstein 2021, 121–137).
- Conclusion: Participants were provided and shared with one another resources for further mindfulness practices (see, for example, University of California, Los Angeles Mindful Awareness and Research Center 2021; University of California, Berkeley Greater Good Science Center 2021). Upon conclusion of the session, participants completed the post-intervention measures described below.

Measures

The measures used to assess students' experience of the intervention are described below.

Mindfulness. Participants' trait mindfulness before and after the intervention (or control period) was assessed using the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al. 2006). The FFMQ is a 39-item questionnaire measuring five distinct facets of mindfulness on a 5 point scale. Specifically, the measure assesses one's ability to engage in mindful observation (e.g., "I notice how foods and drinks affect my thoughts, bodily sensations, emotions."), description (e.g., "Even when I'm feeling terribly upset, I can find a way to put it into words."), action with awareness (e.g., "I'm [not] easily distracted."), nonjudgment ("I [don't] tell myself that I shouldn't be thinking the way I'm thinking."), and nonreaction (e.g., "I watch my feelings without getting lost in them."). The FFMQ is commonly used in mindfulness intervention studies and demonstrated excellent reliability in the present sample, consistent with prior studies (present study average alpha = 0.91; Baer et al. 2006, Goldberg et al. 2015).

Intellectual Curiosity and Exploration. Participants' intellectual curiosity and willingness to explore intellectual information was measured before and after the intervention (or control period) with the Curiosity and Exploration Inventory (CEI-II; Kashdan et al. 2009). The CEI-II is a 10-item scale assessing motivation to seek out knowledge and new experiences (e.g., "I am at my best when doing something that is complex or challenging."), and a willingness to embrace new and unexpected experiences (e.g. "Everywhere I go, I am out looking for new things or experiences.") on a five point scale. The CEI demonstrated good reliability in this study, consistent with prior studies (present study average alpha = 0.80; Kashdan et al. 2009; Setyowati et al. 2020).

Perceived Stress. Participants' stress was assessed before and after the intervention (or control period) using the Perceived Stress Scale (PSS, Cohen, Kamarck, and Mermelstein 1983), a 10-item scale assessing participants' subjective stress from the past month on a 0–4 rating scale (e.g., "In the last month, how often have you felt nervous and "stressed"?). The PSS has well-established reliability and validity with good reliability in the present sample, consistent with prior studies (present study average alpha = 0.86; Anwer et al. 2020; Cohen and Williamson 1988; Tavakol and Dennick 2011).

Perception of Group and Use of Mindfulness. Upon completion of the intervention, participants provided qualitative and quantitative feedback on the perceived helpfulness of the intervention, types and frequency of mindfulness practice outside of the groups, and other feedback about elements of the intervention to sustain or change.

Data Analysis

Quantitative and qualitative data were analyzed to assess students' experiences with and responses to the group mindfulness intervention. Quantitative data analysis was conducted using IBM Statistics Software Version 26 (IBM Corp. 2019). Data was tested for normality to assess appropriateness of using parametric vs. non-parametric testing procedures. The Shapiro-Wilk test is one of the most commonly used tests to assess normality of continuous data and is considered most appropriate for small sample sizes ($n < 50$; Mishra et al. 2019). Levene's test was used to assess that the population variances of the dependent variable were homogeneous for all groups (Gastwirth, Gel, and Miao 2009). Results indicated that curiosity and intelligence scores and perceived stress scores met assumptions of normality and homogeneity of variance across intervention groups. Thus, for these variables, tests of the effect of the intervention group were conducted using mixed ANOVA, which is appropriate for tests of the interaction between a within-subjects factor (e.g., time) and a between-subjects factor (e.g., mindfulness intervention vs. control) on a continuous dependent variable (e.g., stress).

Trait mindfulness violated assumptions of homogeneity of variance (Levene's statistic = 5.97, $p < .01$) and weekly times practicing mindfulness violated assumptions of normality in the immediate intervention and control groups (immediate intervention group Shapiro-Wilk statistic = 0.70, $p < .01$; control group Shapiro-Wilk statistic = 0.73, $p < .01$; waitlist control group Shapiro-Wilk statistic = 0.60, $p < .01$). Due to the violations of assumption of normality and homogeneity of groups for trait mindfulness and number of weekly mindfulness practices, the non-parametric Kruskal-Wallis H test was used rather than the mixed ANOVA to assess group differences for these variables (Lund and Lund 2018; Ostertagová et al. 2014). As the Kruskal-Wallis H Test assumes independence of groups, analyses were conducted such that the delayed intervention and waitlist control groups were not directly compared.

Both the mixed ANOVA and Kruskal-Wallis H tests were conducted such that the immediate intervention, delayed intervention, control group, and waitlist control group were treated as separate

groups. This was done to allow for post-hoc testing of any differences between each of the groups (for example, between the immediate and delayed intervention group, or waitlist control vs. true control group). For both ANOVA and Kruskal-Wallis H analyses, post hoc pairwise comparisons test significance values were adjusted by the Bonferroni correction for multiple tests.

RESULTS

The results from the surveys are presented quantitatively and qualitatively in this section and the accompanying figures and tables. This information is intended to provide an understanding of students' experience of and response to the group mindfulness intervention. In the discussion section, we delve further into the meaning and application of these findings.

Quantitative Findings

Survey response rates were high, with between 93 and 98 percent of participants having complete data for each survey.

Impact of the Intervention on Trait Mindfulness. A Kruskal-Wallis H test showed that there was a statistically significant difference in change in trait mindfulness between the intervention groups, $\chi 2(3) = 8.00$, $p = 0.02$, with a mean rank trait mindfulness change score of 32.62 for the immediate intervention group, 30.07 for the delayed intervention group, 20.14 for the control group, and 16.94 for the waitlist control group. Post hoc pairwise comparisons indicated that there were no significant differences between the control and waitlist control conditions, or between the immediate and delayed intervention groups. The immediate intervention group differed significantly from both the control group (11.31, $p = .046$) and waitlist control groups (13.43, $p = .02$). The delayed intervention group did not differ significantly from the control group (9.29, $p = 0.25$). Table 1 contains mean scores, standard deviations, and ranges for mindfulness scores at baseline and follow up for each intervention group. Figure 1 depicts the nature of the interaction between time (baseline and follow up) and intervention group (immediate intervention, delayed intervention, control, and waitlist control) on trait mindfulness, demonstrating an increase in trait mindfulness scores for participants in the intervention groups and a decrease in trait mindfulness scores for participants in the control groups.

Impact of the Intervention on Mindfulness Practice. A Kruskal-Wallis H test showed that there was a statistically significant difference in change in weekly mindfulness practice between the intervention groups, $\chi 2(3) = 23.693$, $p < .001$, with a mean rank trait mindfulness change score of 36.19 for the immediate intervention group, 26.71 for the delayed intervention group, 13.29 for the control group, and 10.69 for the waitlist control group. Post hoc pairwise comparisons indicated that there were no significant

Table 1. Descriptive Statistics for Primary Study Variables by Intervention Group, at Baseline and Follow-Up.

Intervention Group	Trait Mindful. Baseline	Trait Mindful. Follow Up	Times Mindful. Baseline	Times Mindful. Follow Up	Perceived Stress Baseline	Perceived Stress Follow Up	Curiosity Explor. Baseline	Curiosity Explor. Follow Up
Immediate Intervention (n = 34)								
Mean	124	128	0.60	3.32	14.09	14.26	33.09	35.94
Standard Deviation	16.10	17.11	1.15	3.29	5.78	5.30	5.96	6.69
Range	80–154	89–161	0–5	0–14	1–26	1–30	22–45	23–55
Delayed Intervention (n = 8)								
Mean	129	131	0.19	1.60	16.63	14.57	31.50	31.14
Standard Deviation	9.75	5.10	0.37	0.58	3.85	3.26	7.33	8.93
Range	118–148	125–140	0–1	1–2.5	13–24	8–18	22–40	19–43
Control (n = 8)								
Mean	128	124	0.63	0.71	17.63	24.00	30.50	35.71
Standard Deviation	21.08	25.93	1.22	0–3.5	3.78	8.45	4.66	5.28
Range	97–160	89–157	0.95	0–2	13–22	10–33	23–39	28–42
Waitlist Control (n = 8)								
Mean	129	125	0.19	0.18	14.00	16.50	31.50	31.00
Standard Deviation	9.45	4.13	0.37	0.37	2.45	4.00	7.33	7.03
Range	118–148	118–130	0–1	0–1	11–19	12–24	22–40	23–43

differences between the control and waitlist control groups, or between the delayed intervention and immediate intervention groups. The immediate intervention group differed significantly from both the control group (22.91, p <.001) and waitlist control group (25.50, p < .001). The delayed intervention group did not differ significantly from the control (13.43, p = .12). Table 1 contains mean scores, standard

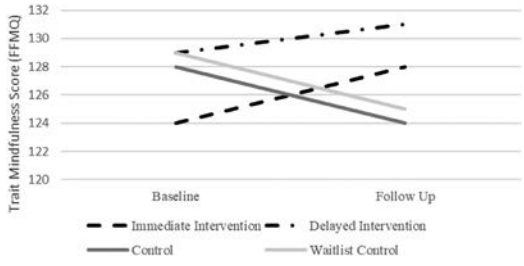

Figure 1. Effect of Intervention Group on Trait Mindfulness.

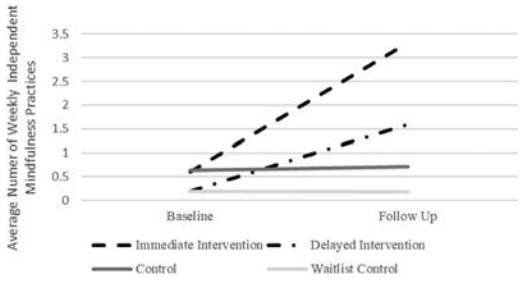

Figure 2. Effect of Intervention Group on Weekly Independent Mindfulness Practice.

deviations, and ranges for number of independent weekly mindfulness scores at baseline and follow up for each intervention group. Figure 2 depicts the nature of the interaction between time (baseline and follow up) and intervention group (immediate intervention, delayed intervention, control, and waitlist control) on weekly independent mindfulness practice, demonstrating an increase in mindfulness practice in the intervention groups and no change in mindfulness practice in the control groups.

Impact of the Intervention on Perceived Stress. Results of the mixed ANOVA indicated that there was a significant effect of intervention group on perceived stress ($F(1, 37) = 3.92$, $p = .01$). Post hoc comparisons indicated that there were no significant differences between the control and waitlist control groups, or between the delayed and immediate intervention groups. The immediate intervention group differed significantly from the control group (mean difference = −6.24, $p < .001$), but not the waitlist control group. The delayed intervention group did not differ significantly from the control group (mean difference = −4.71, $p = 0.32$). Table 1 contains mean scores, standard deviations, and ranges for perceived stress scores at baseline and follow up for each intervention group. Figure 3 depicts the nature of the interaction between time (baseline and follow up) and intervention group (immediate intervention, delayed intervention, control, and waitlist control) on perceived stress scores, demonstrating an upward

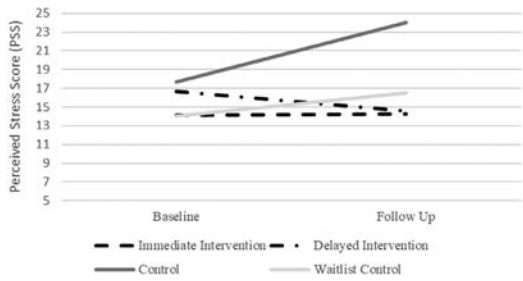

Figure 3. Effect of Intervention Group on Perceived Stress.

trend in perceived stress for the control groups and a slight downward trend in perceived stress for the intervention groups. This suggests that the mindfulness intervention may have buffered against the increase in stress experienced by students in the control group over the course of the semester.

Impact of the Intervention on Intellectual Curiosity and Exploration. Results of the mixed ANOVA indicated that there was not a significant effect of intervention group on intellectual curiosity and exploration ($F(1, 38) = 2.21$, $p = 0.10$).

Relationship Between Stress and Mindfulness at Follow-Up. The relationship between perceived stress and mindfulness at study follow-up was assessed for participants who completed the intervention. There was a significant, negative correlation between trait mindfulness and perceived stress (Pearson's $r(41) = -0.61$, $p < .001$), indicating that higher trait mindfulness was associated with lower perceived stress. There was no significant correlation between perceived stress and the number of independent weekly mindfulness practices per week.

Feasibility. Participants attended an average of 3.5/4 sessions (range 2–4), and rated the perceived helpfulness of the sessions a 6 on a 7 point scale (corresponding with "pretty helpful."). The majority (76%) of participants reported they would retain the frequency of session meetings, while 24% reported they would like to meet more than once a week. The majority (85%) of participants reported they would retain the hour-long session meeting, while 13% recommended meeting for a shorter period of time, and 2% reported preferring to meet for more than one hour.

Post Hoc Power Analysis. As outlined in Caldwell, Lakens, and Parlett-Pelleriti (2021), the power analysis for a simple mixed ANOVA with a 2-way interaction indicates that a sample size of 46 would yield a power of 91.25% (Faul et al. 2007; Lakens and Caldwell 2021). While these results are consistent with the present sample size (n = 48), this assumes equal distribution between control and experimental conditions, which was not present in the current study. Thus, the present study may have been under-powered to detect effects.

Qualitative Findings

Participants' Perceptions of Changes to Sessions. Participants provided open-ended feedback to the question "What is something you would change about the mindfulness sessions?" Forty-two percent (n = 20) of participants left the question blank or indicated that there was nothing they would change about the sessions. Approximately one-third (n = 15) of participants identified a topic or in-session activity they would increase or decrease (e.g., "discuss specific strategies to use with test taking," "spend longer on the techniques," "more unique styles of meditation"). Twelve percent of participants (n = 6) identified a change related to the time/length of session (e.g., "meet for more than 4 weeks," "make the sessions longer," "make the sessions shorter"), and 12% (n = 6) identified a change related to the physical meeting space (e.g., "more open space," "comfier chairs"). The single

most commonly identified piece of feedback in response to this question was to hold the sessions in a larger space (n = 4).

Strengths of Sessions to Retain. Participants provided open-ended feedback to the question "What is something you would keep the same about the mindfulness sessions?" Ten percent (n = 5) of participants reported that they would retain "everything." Thirty-eight percent (n = 18) reported that they would retain the in-session mindfulness practices (e.g., "activities," "mindfulness exercises," "mindful breathing"). Fourteen percent (n = 7) specifically identified that they would retain the variety/range of mindfulness activities, and 10% (n = 5) identified that they would retain the practice of beginning each session with a mindfulness activity (e.g., "starting each session with a guided mindful check-in" which permitted "getting in the right headspace"). Additionally, participants reported they would recommend retaining the group format (12%, n = 6), meeting space (9%, n = 4), and length/frequency of meetings (7%, n = 3).

Types of Mindfulness Practices Outside of Sessions. Participants described the types of mindfulness activities they used on their own outside of the weekly mindfulness sessions. Participants reported most frequently engaging in mindful physical activity, such as walking or yoga (27%, n = 13), followed by meditation practices (17%, n = 8) and mindful eating (16%, n = 7.52; see Figure 4 for complete results).

Barriers to Session Attendance. Participants described any barriers that got in the way of attending the weekly mindfulness sessions. The most common reasons identified were academic (35%, n = 16; e.g. "needed the time to finish a lab report"), athletic (15%, n = 7; e.g. "soccer practice"), medical (15%, n = 7; e.g., "doctor appointment"), issues with transportation (10%, n = 5; e.g. "car trouble"), and family (10%, n = 5; e.g., "parents came to visit").

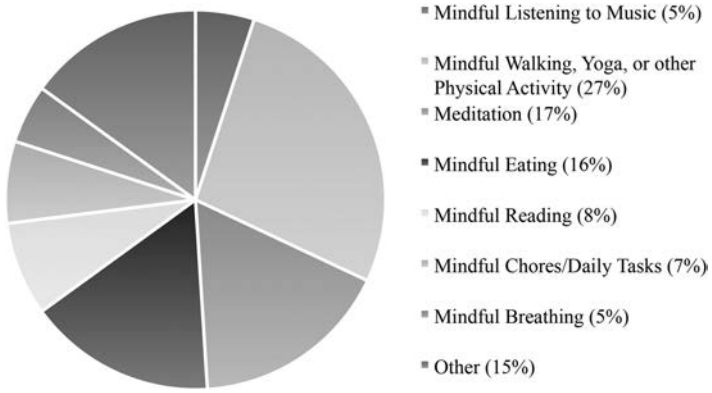

Figure 4. Participants' Independent Mindfulness Practices.

Changes in Group Implementation Across Semesters

Based on participant feedback during the first semester intervention, a few changes were made to the intervention in the second semester. First, weekly between-session reminder emails were sent to all participants, encouraging them to continue practices outlined in the previous session and providing additional links and resources for independent mindfulness practice. Second, in an effort to better understand the impact of the intervention on participants' trait mindfulness and perceived stress, a waitlist control condition was added such that participants signing consent were randomized to either begin the mindfulness group immediately, or following a four week delay. Finally, while the authors' original intention was to include an additional intervention and control condition in the third semester, COVID-19 disrupted these plans, and thus all participants enrolled in the study were converted to a control condition (and provided with resources for mindfulness practice upon conclusion of their participation).

In order to assess whether the changes made across semesters impacted the effectiveness of the interventions, the statistical models (mixed ANOVA and Kruskal-Wallis H) described in the above Quantitative Findings section were run again, this time comparing participants receiving the intervention in the first semester of implementation to those receiving the intervention in the second semester of implementation. There was no significant difference between first and second semester groups on change in trait mindfulness, change in weekly mindfulness practice, perceived stress, or intellectual curiosity and exploration.

DISCUSSION

The present work sought to build upon emerging evidence of the utility of mindfulness practices to support the wellbeing of college students generally (Bamber and Schneider 2016) and engineering students specifically (Miller and Jensen 2020). The present study expanded upon existing research on mindfulness in engineering education by providing a four week mindfulness intervention with waitlist control to 48 students over several semesters, and systematically collecting qualitative and quantitative feedback from participants before and after the intervention. Consistent with previously published work, the mindfulness intervention was well received by engineering students (Ge et al. 2019; Huerta 2018; Huerta et al. 2021; Miller and Jensen 2020). Participants in the study generally attended session meetings (mean = 3.5/4) and the majority reported that the weekly session frequency (76%) and hour-long length (85%) were appropriate.

In addition to demonstrating the acceptability and feasibility of a four week group mindfulness intervention for engineering students, the present study lends support to the efficacy of this intervention.

Compared to those in the control condition, students enrolled in the mindfulness groups demonstrated a significant increase in their overall trait mindfulness. This is consistent with prior work in general healthy samples demonstrating an effect of mindfulness interventions on trait mindfulness (Querstet et al. 2020). This converges with prior literature suggesting that engineering students perceived an improvement in their mindfulness following a four week mindfulness intervention, and extends that literature by incorporating comparison to a control group and qualitative assessment of trait mindfulness before and after the intervention (Huerta et al. 2021). In this sample, the change in trait mindfulness was largely driven by an increase in mindful observation. Most, if not all, of the mindful practices introduced in the intervention – e.g., mindful breathing, mindful walking, mindful eating – involved elements of mindful observation. Given participants' extensive practice with this particular facet of mindfulness, it is not surprising that mindful observation accounted for the observed change in trait mindfulness. Future mindfulness interventions for engineering students might deliberately seek to cultivate other facets of mindfulness such as mindful description, acting with awareness, nonjudgment, and non-reaction, through exercises that explicitly cultivate these attitudes.

Notably, the results of the present study indicate that not only did engineering students attend and appreciate the weekly mindfulness sessions, they also increased their use of mindfulness practices outside of sessions. This suggests an impact of the intervention on participants' behavior, thus extending prior literature on the use of mindfulness interventions among engineering students. This may be attributable in part to efforts in the present study to suggest specific at-home mindfulness practices, send between-session email reminders and links to mindfulness scripts and activities, and check in with participants about their between-session practices at the start of each session.

While the intervention did not decrease participants' perception of stress in the present sample, there was evidence that the intervention buffered against the increase in stress exhibited by those in the control condition. It may be that engineering students' perceived stress generally increases over the course of the semester (as was seen in our control condition participants), and that mindfulness practice serves to mitigate this increase. This topic warrants further investigation, however, as prior studies have lent support for the ability of mindfulness interventions to reduce stress and enhance well-being in healthy samples (Chin et al. 2020; Felver, Morton, and Clawson 2018; Querstet et al. 2020). The intervention did not have a significant effect on participants' intellectual curiosity and exploration when compared to the control, which may be because intellectual curiosity and exploration trended towards increasing in all engineering students over the course of the semester.

Several limitations of the present work should be kept in mind when interpreting the results. The sample size is small, limiting generalizability. The study may also be under-powered to detect effects, due in part to unequal distribution of participants across groups. This may in particular have contributed to failure of the delayed intervention group (n = 7) to consistently yield significant

effects on the outcome variables in comparison to the control groups. Furthermore, while the use of the same group co-leaders increases internal validity of the study, this practice decreases external validity. Nonetheless, efforts were made to mitigate these effects by using easily accessible materials, such as the Stahl and Goldstein workbook (2010), to guide the intervention. Additionally, the study included implementation in the Spring 2020 semester, which was disrupted by the COVID-19 pandemic, necessitating that all participants enrolled in the study at that time be shifted to a control group condition. Unfortunately, this precluded these participants from being able to participate in the intervention and meant that this group differed from the waitlist control group approach utilized in the Fall 2019 Semester. The COVID-19 pandemic significantly altered students' experiences of the Spring 2020 semester and may have shifted their stress levels or possibly their trait mindfulness levels. Prior literature on the effects of the COVID-19 pandemic on college students' experience of stress is mixed; while some studies found that students reported high levels of stress associated with the pandemic onset and a pandemic-related increase in school-focused anxiety (Hicks, Caron, and Smilek 2021; Johnson et al. 2022), others found negative effects of the pandemic on mood, but not stress (Copeland et al. 2021), while still others found that college students reported less stress after shifting to remote education in the spring of 2020 (Rettew et al. 2021). Post-hoc analyses were used to directly compare the control group (Fall 2019) to the waitlist control group (Spring 2020) in the present sample. These post-hoc analyses found no significant difference between these two control groups in terms of change in students' trait mindfulness, change in students' perceived stress, or change in students' weekly mindfulness practice. While these post-hoc analyses suggest similarity in the degree of change in key study variables in control participants in Fall 2019 and Spring 2020, it is nonetheless important to acknowledge that the Spring 2020 semester did not represent campus life as usual, and may have had effects on students' stress that were undetected in the present study. Future work might consider the effects of mindfulness interventions on students learning remotely. Certain limitations commonly associated with quantitative analysis and intervention studies should also be acknowledged; namely, the study authors were involved in both the intervention and data analysis, selection bias may have influenced the findings, and the threshold used to determine statistical significance ($p < .05$), though commonly used, is not definitive (Hjalmarson and Moskal 2018). Finally, future work on this topic should include longer-term follow up with participants, to ascertain whether the observed effects on engineering students' trait mindfulness and engagement with mindful practices persist over time. While a waitlist control design was utilized in this study, future work comparing a mindfulness intervention to an active control condition is important (Goleman and Davidson 2017). Despite these limitations, the study is strengthened by its use of a waitlist control condition and systematic collection of quantitative and qualitative data, allowing for both affirmation and expansion of prior work on the topic.

CONCLUSION AND RECOMMENDATIONS

In our sample, engineering students were willing to engage in group mindfulness outside of class time, and most felt that meeting once a week for an hour over the course of four weeks was appropriate. Notably, we scheduled the meetings when we knew courses and lab sections were not meeting, nonetheless, students' other obligations (e.g,. academics, athletics) still conflicted occasionally with their participation. In this sample, study participants did engage in mindfulness practice outside of the weekly meetings. In terms of practices adopted outside of sessions, the most commonly identified were mindful engagement in physical activities such as yoga or walking, and formal mindful meditation practices. These preliminary results suggest that introduction of these specific types of mindful practices may be especially well-received by engineering students. Based on our results, we recommend that educators and mental health professionals seeking to provide group mindfulness activities for engineering students introduce a wide variety of both formal and informal mindfulness practices, provide clear and specific suggestions (with reminders) for engagement with mindfulness outside of the formal meeting times, begin sessions with a brief guided mindfulness activity, and ideally meet in a large, non-classroom meeting space with comfortable seating arranged in a circle. In our case, sessions were led by both co-authors, and, given the setting in a small liberal arts college, students knew and were likely comfortable with the engineering professor. This comfort, familiarity, and modeling of mindfulness practices by a known faculty mentor may also have contributed to the feasibility and success of the intervention.

Because of the various positive effects on engineering students' trait mindfulness, we recommend that faculty interested in the topic consider how to adapt these interventions to their own settings. For example, future studies could explore how to expand these interventions for large classes or remote/virtual learning environments. One difficulty that engineering faculty may have for implementation of mindfulness interventions is that they not feel well-versed enough in the topic to lead a session. In such cases, we recommend collaborating with colleagues in other disciplines or providers in student wellness or counseling services. If possible, we would encourage exploring the possibility of integrating mindfulness interventions within the curriculum, so that all engineering students in a cohort, and not just a self-selected subset, could benefit from the practices.

ETHICS APPROVAL

This research was approved by the Institutional Review Board at Elizabethtown College.

DISCLOSURE STATEMENT

The authors have no conflicts of interest to disclose.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the study participants and research assistants Yusuf Chaudhry and Meghan Keenan for their assistance.

REFERENCES

American Council on Education. 2019. "Pulse Point presidential survey on student mental health and well-being." https://www.higheredtoday.org/2019/08/12/college-student-mental-health-well-survey-college-presidents/

American Psychological Association. 2018. "Stress effects on the body." Created November 1st, 2018. https://www.apa.org/topics/stress/body

Anwer, Shahnawaz, Manzar, Alghadir, Ahmad H., Salahuddin, M., and Unaise A. Hameed. 2020. "Psychometric Analysis of the Perceived Stress Scale Among Healthy University Students." *Neuropsychiatric Disorders and Treatment* 16: 2389–2396. https://doi:10.2147/NDT.S268582

Baer, Ruth A., Smith, Gregory T., Hopkins, Jaclyn, Krietemeyer, J., and Lesley Toney. 2006. "Using self-report assessment methods to explore facets of mindfulness." *Assessment* 13: 27–45. https://doi.org/10.1177/1073191105283504

Beddoes, Kacey and Danowitz, Andrew. 2021. "Engineering Students Coping with COVID-19: Yoga, Meditation, and Mental Health." ASEE Conference Proceedings. Virtual Conference. https://peer.asee.org/37073

Bamber, Mandy D. and Joanne K. Schneider. 2016. "Mindfulness-based meditation to decrease stress and anxiety in college students: A narrative synthesis of the research." *Educational Research Review* 18: 1–32. https://doi.org/10.1016/j.edurev.2015.12.004

Bellinger, David B., DeCaro, Marci S., and Patricia A. S. Ralston. 2015. "Mindfulness, anxiety, and high-stakes mathematics performance in the laboratory and classroom" *Consciousness and Cognition* 37: 123–132. http://dx.doi.org/10.1016/j.concog.2015.09.001

Bodenlos, Jamie S. 2015. "Facets of dispositional mindfulness and health among college students." *The Journal of Complementary and Alternative Medicine* 21, no. 10: 645. https://doi.org/10.1089/acm.2014.0302

Burzler, M. A., Voracek, M., Hos, M., & Tran, U.S. 2019. "Mechanisms of Mindfulness in the General Population." *Mindfulness* 10: 469–480. https://doi.org/10.1007/s12671-018-0988-y

Caldwell, Aaron R., Lakens, Daniël and Chelsea M. Parlett-Pelleriti. *Power Analysis with Superpower*. Netherlands Organisation for Scientific Development, 2021. https://aaroncaldwell.us/SuperpowerBook/

Calma-Birling, Destany and Regan A. R. Gurung. 2017. "Does a Brief Mindfulness Intervention Impact Quiz Performance?" *Psychology, Learning, & Teaching* 16, no. 3: 323–335. https://doi.org/10.1177/1475725717712785

Chin, Brian, Brown, Kirk W., Wright, Aidan, G. C., Lindsay, Emily K., Greco, Carol M., Smyth, Joshua M., and J. David Creswell. 2020. "Mindfulness Interventions Improve Momentary and Trait Measures of Attentional Control: Evidence From a Randomized Controlled Trial." *Journal of Experimental Psychology: General* 150, no. 4: 686–699. https://doi.org/10.1037.xge0000969

Cohen, Sheldon, Kamarck, Tom, and Robin Mermelstein. 1983. "A global measure of perceived stress." *Journal of Health and Social Behavior* 24: 386–396.

Cohen, Sheldon and Gail M. Williamson. 1988. "Perceived Stress in a Probability Sample of the United States." In *The Social Psychology of Health*, edited by Shilynn Spacapan and Stuart Oskamp. Newbury Park, CA: Sage.

Copeland, William E., Ellen McGinnis, Yang Bai, Zoe Adams, Hilary Nardone, Vinay Devadanam, Jeffrey Rettew, and Jim J. Hudziak. 2021. "Impact of COVID-19 Pandemic on College Student Mental Health and Wellness." *Journal of the American Academy of Child & Adolescent Psychiatry* 60 (1): 134–41. https://doi:10.1016/j.jaac.2020.08.466

Danowitz, Andrew, and Kacey Beddoes. 2018. "Characterizing Mental Health and Wellness in Students Across Engineering Disciplines." In Proceedings of the 2018 Collaborative Network for Engineering and Computing Diversity Conference, Crystal City, Virginia. https://strategy.asee.org/29522

Estrada, Tomás, and Elizabeth D. Dalton. 2019. "Impact of Student Mindfulness Facets on Engineering Education Outcomes: An Initial Exploration." In Proceedings of the 126th Annual American Society for Engineering Education Conference, Tampa, Florida.

Faul, Franz, Edgar Erdfelder, Albert-Georg Lang, and Axel Buchner. 2007. "G*Power 3: A Flexible Statistical Power Analysis Program for the Social, Behavioral, and Biomedical Sciences." *Behavior Research Methods* 39, no. 2: 175–91. http://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower.html

Felver, Joshua C., Morton, Melissa L., and Adam J. Clawson. 2018. "Mindfulness-Based Stress Reduction Reduces Psychological Distress in College Students." *College Student Journal* 52, no. 3: 291–298.

Gastwirth, Joseph L., Gel, Yulia R., and Weiwen Miao. 2009. "The Impact of Levene's Test of Equality of Variances on Statistical Theory and Practice." *Statistical Science* 24, no. 3: 343–360. https://doi.org/10.1214/09-STS301

Ge, Julianna S., Berger, Edward J., Major, Justin C., and J. M. Froiland. 2019. "Teaching Undergraduate Engineering Students Gratitude, Meaning, and Mindfulness." In Proceedings of the 126th Annual American Society for Engineering Education Conference, Tampa, Florida.

Golderg, Simon B., Wielgosz, J., Dahl, Cortland, Schuyler, B., MacCoon, D. S., Rosenkranz, M., Lutz, A., Sebranek, C. A., and Richard J. Davidson. 2016. "Does the Five Facet Mindfulness Questionnaire measure what we think it does? Construct validity evidence from an active controlled randomized clinical trial." *Psychological Assessment* 28, no. 8: 1009–1014. https://doi.org/10.1037/pas0000233.

Goleman, Daniel and Richard Davidson. 2017. *Altered Traits*. New York: Penguin Random House.

Hahn, Thich Naht. 1991. *Peace is Every Step: the Path of Mindfulness in Everyday Life.* New York, NY: Bantaom Books.

Hjalmarson, Margaret A. and Barbara Moskal. 2018. Quality Considerations in Education Research: Expanding Our Understanding of Quantitative Evidence and Arguments. *Journal of Engineering Education* 107: 179–185. https://doi.org/10.1002/jee.20202

Hicks, Lydia J., Emilie E. Caron, and Daniel Smilek. 2021. "SARS-CoV-2 and Learning: The Impact of a Global Pandemic on Undergraduate Learning Experiences." *Scholarship of Teaching and Learning in Psychology*, April. https://psycnet.apa.org/doi/10.1037/stl0000250

Hölzel, Britta K., Lazar, Sara W., Gard, Tim, Schuman-Olivier, Zev, Vago, David R., and Ulrich Ott. 2011. "How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective." *Perspectives on Psychological Science* 6: 537–559. https://doi.org/10.1177/1745691611419671

Huerta, Mark V. 2018. "Inner Engineering: A Convergent Mixed Methods Study Evaluating the Use of Contemplative Practices to Promote Resilience Among Freshman Engineering Students." Proceedings of the Annual American Society for Engineering Education Conference, Salt Lake City, Utah.

Huerta, Mark V., Carberry, Adam R., Pipe, Teri, and Ann F. McKenna. 2021. Inner engineering: Evaluating the utility of mindfulness training to cultivate intrapersonal and interpersonal competencies among first-year engineering students. *Journal of Engineering Education*: 1–35. https://doi.org/10.1002/jee.20407

IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Johnson, Kimberley T., Paula G. Williams, Lisa G. Aspinwall, and Brian J. Curtis. 2022. "Resilience to Stress-Related Sleep Disturbance: Examination of Early Pandemic Coping and Affect." *Health Psychology, Developing Resilience in Response to Stress and Trauma*, 41 (4): 291–300. https://doi.org/10.1037/hea0001169

Kabat-Zinn, Jon. 2003. "Mindfulness-based stress reduction (MSBR)." *Constructivism in the Human Sciences* 8 (2): 73–107.

Kabat-Zinn, Jon. 2013. *Full Catastrophe Living: Using the Wisdom of Your Body and Mind to Face Stress, Pain, and Illness.* New York: Bantam Books.

Kam, Brandt, Mendoza, Hadrian and Akihiko Masuda. 2019. Mental Health Help-Seeking Experience and Attitudes in Latina/o American, Asian American, Black American, and White American College Students. *International Journal for the Advancement of Counselling* 41, 492–508. https://doi.org/10.1007/s10447-018-9365-8

Kashdan, Todd B., Gallagher, Matthew W., Silvia, Paul J., Winterstein, Beate P., Breen, William E., Tehrar, Daniel, and Michael F. Steger. 2009. "The Curiosity and Exploration Inventory-II: Development, factor structure, and psychometrics." *Journal of Research in Personality* 43: 987–998.

Lakens, Daniël and Aaron Caldwell. 2021. "Simulation-Based Power Analysis for Factorial Analysis of Variance Designs." *Advances in Methods and Practices in Psychological Science* 4, no 1. https://doi.org/10.1177/2515245920951503

Lipson, Sarah K., Lattie, Emily G., and Daniel Eisenberg. 2019. "Increased rates of mental health service utilization by U.S. college students: 10-year population-level trends (2007–2017). *Psychiatric Services* 70: 60–63. https://doi.org/10.1176/appi.ps.201800332

Lund, Adam, and Mark Lund. "Kruskal-Wallis H Test using SPSS Statistics." Laerd Statistics. Lund Research Ltd. 2018. https://statistics.laerd.com/spss-tutorials/kruskal-wallis-h-test-using-spss-statistics.php

Miller, Isabel and Karin Jensen. 2020. "Introduction of Mindfulness in an Online Engineering Core Course During the COVID-19 Pandemic." *Advances in Engineering Education* 8, no. 4: 1–7. https://par.nsf.gov/servlets/purl/10300416

Mishra, Prabhaker, Pandey, Chandra M., Singh, Uuttam, Gupta, Anshul, Sahu, Chinmoy, and Amit Keshri. 2019. "Descriptive statistics and normality tests for statistical data." *Annals of Cardiac Anaesthesia* 22 no.1: 67–72. https://doi.org/10.4103/aca.ACA_157_18

Ostertagová, Eva, Ostertag, Oskar, and Josef Kováč. 2014. "Methodology and Application of the Kruskal-Wallis Test." *Applied Mechanics and Materials* 611: 115–120. https://doi.org/10.4028/www.scientific.net/AMM.611.115

Querstet, Dawn, Morison, Linda, Dickinson, Sophie, Cropley, Mark, and Mary John. 2020. "Mindfulness-based stress reduction and mindfulness-based cognitive therapy for psychological health and well-being in nonclinical samples: A systematic review and meta-analysis." *International Journal of Stress Management* 27, no. 4: 394–411. https://doi.org/10.1037/str0000165

Ramler, Taylor R., Tennison, Linda R., and Patsy Murphy. 2016. "Mindfulness and the College Transition: The Efficacy of an Adapted Mindfulness-Based Stress Reduction Intervention in Fostering Adjustment Among First-Year Students." *Mindfulness* 7: 179–188. https://doi.org/10.1007/s12671-015-0398-3

Rettew, David C., Ellen W. McGinnis, William Copeland, Hilary Y. Nardone, Yang Bai, Jeff Rettew, Vinay Devadenam, and James J. Hudziak. 2021. "Personality Trait Predictors of Adjustment during the COVID Pandemic among College Students." *PLoS ONE* 16 (3). https://doi.org/10.1371/journal.pone.0248895

Ricard, Mathieu. 2003. *Happiness: a guide to developing life's most important skill.* New York, NY: Little, Brown.

Rieken, Beth, Schar, Mark, Shapiro, Shauna, Gilmartin, Shannon K. and Sheri Sheppard. 2017. "Exploring the Relationship between Mindfulness and Innovation in Engineering Students." In Proceedings of the 124th Annual American Society for Engineering Education Conference, Columbus, Ohio.

Rieken, Beth, Schar, Mark, and Sheri Sheppard. 2016. "Trait mindfulness in an engineering classroom: An exploration of the relationship between mindfulness, academic skills, and professional skills." In 2016 IEEE Frontiers in Education Conference (FIE), Erie, Pennsylvania.

Salzberg, Sharon. 1995. *Lovingkindness: The revolutionary art of happiness.* Boston: Shambhala.

Setyowati, Anggi, Chung, Min-Huey, Yusuf, Ah, and Setya Haksama. 2020. "Psychometric of the Curiosity and Exploration Inventory-II in Indonesia." *Journal of Public Health Research* 9, no. 3: 1745. https://doi.org/10.4081/jphr.2020.1745

Siegel, Daniel. 2007. *The mindful brain: Reflection and attunement to the cultivation of well-being*. New York, NY: Norton.

Stahl, Bob, and Elisha Goldstein. 2010. *A Mindfulness-Based Stress Reduction Workbook*. Oakland, CA: New Harbinger Publications.

Tavakol, Mohsen and Reg Dennick. 2011. "Making Sense of Cronbach's Alpha." *International Journal of Medical Education* 2: 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

University of California, Berkeley The Greater Good Science Center. 2021. "Loving-Kindness Meditation." Accessed June 8th, 2021. https://ggia.berkeley.edu/practice/loving_kindness_meditation

University of California, Los Angeles Mindfulness Awareness Research Center. 2021. "Free Guided Meditations." Accessed June 8th, 2021. https://www.uclahealth.org/marc/audio

Wyatt, Tammy J., Oswalt, Sara B., and Yesenia Ochoa. 2017. "Mental Health and Academic Performance of First-Year College Students." *International Journal of Higher Education* 6, no. 3: 178–187.

AUTHORS

Dr. Elizabeth Dalton is an Assistant Professor in the Department of Psychology at Elizabethtown College, in Elizabethtown, PA. Dr. Dalton received her B.A. in Psychology from Amherst College in 2009 and her Ph.D. in Clinical Psychology from the University of California, Los Angeles in 2017. Her research interests include the effects of stress and mood on health and health behavior practices.

Dr. Tomás Estrada is an Associate Professor in the Department of Engineering and Physics at Elizabethtown College, in Elizabethtown, PA. He received his B.S. in Electrical Engineering from Universidad de Costa Rica in 2002 and his M.S. and Ph.D. (both in Electrical Engineering) from the University of Notre Dame in 2005 and 2009, respectively. His research interests include control systems, engineering education, technology-related entrepreneurship, and sustainable engineering applications.

APPENDIX 1: PHOTOGRAPH OF THE ROOM USED FOR GROUP MINDFULNESS SESSIONS