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Inner Engineering: A Convergent Mixed Methods Study Evaluating the Use of Contemplative Practices to Promote Resilience Among Freshman Engineering Students

Mr. Mark V. Huerta, Arizona State University

Mark Huerta is a second year PhD student in the Engineering Education Systems & Design (EESD) program at Arizona State University. His primary research interest is integrating the ideas behind mindfulness among engineering students to promote resilience, self-regulated learning, and creativity. Mark is also the Chairman and Director of Programs of a non-profit called 33 Buckets, which empowers rural communities in developing countries to develop solutions for their drinking water problems. Before enrolling in the EESD program, Mark obtained a BS and MS in Biomedical Engineering at ASU.

Inner Engineering: A Convergent Mixed Methods Study Evaluating Freshman Engineering Students' Perception on the Utility of Mindfulness in Cultivating Resilience

Abstract

Despite evidence of the positive effects of mindfulness-based practices on a variety of dimensions including resilience and mental health, in general, there is little to no research on the use of these practices to support engineering education. The integration of mindfulness holds potential for helping engineering students combat stress, which is on the rise among college students. The purpose of this study is to evaluate whether engineering students would be receptive to integrating contemplative practices (e.g. mindfulness meditation) to cultivate and reinforce resilient behavior in both their personal lives and in their education. This study presents the results of a brief intervention deployed to approximately 92 freshman engineering students at a large southwestern institution. The intervention introduced engineering students to contemplative practices including mindfulness meditation and discussed how these practices could be integrated into their lives to more effectively handle challenging moments including those inherent in studying engineering. Using a convergent mixed methods design, this study uses a survey with open and closed-ended responses to evaluate levels of mindfulness and resilience, and to investigate students' interest levels of mindfulness practices. The paper will present an overview of the literature on the connection between mindfulness and resilience, details of the study design, and findings from the qualitative analyses. Results from this study will contribute to a gap in engineering education literature on how mindfulness may assist in developing resilient behavior among engineering students.

Introduction

Many college students are struggling to find mental balance. Mental health problems have become rampant among American college students who report feeling overwhelmed by stress, anxious, and depressed at alarming rates. In the previous two weeks prior to completing the National College Health (NCHA) assessment, 51.4% of students felt overwhelmed by all they had to do, 22.1% of had felt overwhelming anxiety, and 10.6% felt so depressed it was difficult to function (n = 79,266; American College Health Association, 2013). The problem is getting worse as the rate of mental disorders such as anxiety and depression appear to be trending upward. In a 2015 survey, 95% of college counselors reported noticing more students are experiencing severe psychological problems than in previous years (Center for Collegiate Mental Health, 2017). Anxiety is now the presenting concern for over 50% of students who seek support through college counselors (50.6%) followed by depression (41.2%) (Reetz et al, 2016).

Chronic stress can lead to both physical and mental health problems. Chronic stress can trigger the development of mental illness (e.g. anxiety or depression) or exacerbate an existing mental illness in the early stages. In fact, most lifetime mental disorders are in the early stages or begin during the average age of a typical college student (Kessler et al, 2005). Chronic stress also leads to the overproduction of cortisol, which causes increased inflammation in the body, which can lead to physical illnesses. Chronically stressed students are likely to experience more fatigue, an inability to concentrate, and irritability, and, over time, this can negatively impact academic performance. In fact, 30.3% students who participated in the NCHA assessment self-reported

that stress negatively affected their individual academic performance. This was by far the most impactful factor with anxiety being second at 21.8%.

What's interesting to note is that contrary to popular belief, stress is not necessarily a bad thing. Stress can be defined as the emotional and physical response to a perceived internal or external pressure or challenge. Stress is a part of life and, in moderation, it can increase alertness, motivation, and performance as the sympathetic nervous system is activated. If an aversive stressor persists long enough though, the body's energy resources will be depleted in an attempt to restore the body to homeostasis (Seyle 1956, 1974, 1976, 1978). To reach their academic potential, students must achieve mental balance by learning to regulate their stress.

There is mounting evidence that mindfulness practice can be a useful tool to alleviate excess stress by increasing focus and concentration, emotional regulation, and equanimity among students (Sivilli and Pace, 2014). Jon Kabat-Zinn, perhaps the most recognized researcher of mindfulness meditation, defined mindfulness as awareness that arises through paying attention, on purpose, in the present moment, non-judgmentally. Mindfulness involves a meta-awareness and an acceptance of one's thoughts, feelings, body sensations, and external environment on a moment-to-moment basis. Mindfulness can be cultivated through regular meditation and other contemplative practices hence the term mindfulness meditation.

Jon Kabat-Zinn is the founder of a mindfulness intervention known as the Mindfulness-Based Stress Reduction (MSBR) program, the most well-known mindfulness-based intervention (MBI) with a standardized curricula and formalized training programs. MSBR was initially developed in 1979 to help people with pain management, but over the last 30 plus years has evolved and is now available in over 200 medical centers, hospitals, and clinics (Flowers, 2014). MBIs have applied to treat many clinical symptoms including: anxiety, depression, chronic pain, immune system function, heart disease, substance abuse, and eating disorders (Ludwig and Kabat-Zinn, 2008). Mindfulness has also been shown to enhance cognitive skills, brain function, immune system function, emotional regulation and coping with stress, psychological resiliency, pro-social behavior and communication skills, and support mental health problems (Mackenzie, 2015). Specifically, mindfulness meditation has been shown to improve focus, attention, working memory, and academic performance (Jha et al., 2007; Mrazek et al., 2013). Brain-imaging studies have shown that people who meditate over an extended period show changes in brain structure, neurocircuitry, and cerebral blood flow (Fox et al., 2014; Newberg et al., 2010; Lutz et al., 2008). The success of MSBR has led to many other MBIs. There is now ample compelling evidence that mindfulness can support a wide variety of benefits.

There have been many MBI studies that have been completed on college students specifically. Bamber and Schneider (2016) recently completed a narrative synthesis of 57 MBI studies on college students. Out of these MBI studies researchers examined anxiety in 40, self-reported stress in 34, physiological stress in 11, and mindfulness in 24. 33 of the 40 studies showed significant decreases in anxiety; 25 of the 34 studies showed significant decreases in stress; and 22 of the 24 studies showed an increase in mindfulness. This overall synthesis demonstrates mindfulness shows promise in decreasing stress and anxiety among college students. The 57 studies varied in their MBI approach. The most common MBI program was the 8-week MSBR program. Most of the studies used their own mindfulness meditation program

though. Several of the studies used MBIs specifically designed for college students including Mindfulness-Based Coping with University Life and the Koru Mindfulness Program. Most of the studies focused on general college student populations, but several studies focused on specific groups like law students (Danitz & Orsillo, 2014), nursing students (Song & Lindquist, 2015), and student athletes (Goodman et al., 2014). Overall, there appears to be an opportunity to focus on students involved in other highly rigorous degree programs like engineering.

Purpose

So far, there is very sparse literature on the connection between mindfulness and engineering. One study explored the relationship between mindfulness and innovation in engineering and found that dispositional mindfulness significantly correlated with innovation self-efficacy among students (Rieken et al, 2017). This study defined innovation self-efficacy as one's confidence in their ability to innovate. There was another study that demonstrated mindfulness correlated with business skills self-efficacy (i.e. students' confidence in performing business skills) and the intent to pursue a career in a start-up or entrepreneurship (Rieken, Schar, and Sheppard, 2016). The purpose of this study is to evaluate whether engineering students would be receptive to potentially integrating contemplative practices such as mindfulness meditation to cultivate and reinforce resilient behavior in both their personal lives and in their education. There appear to be connections for mindfulness to support the engineering design process, an often times ambiguous process that involves empathy to understand a customer's needs and creativity to design an effective solution. Additionally, mindfulness could help support a growth mindset and increased productivity among engineering students by promoting resilience, the ability to bounce back from stress more effectively. Despite, the scope of the overall problem with stress and abundance of literature signaling the effectiveness of MBI's, mindfulness has not been much of a discussion topic among engineering education scholars and educators.

Methods

Intervention

During the fall semester of 2017, the researcher facilitated a 45-minute overview of mindfulness in eight different sections of an introductory freshman course that all engineering students are required to take. Each of these sections has a maximum of 19 students. This course is designed for students to learn about the institution's mission, the importance of an entrepreneurial approach to problem solving, solutions to sustainability challenges, and the importance of social embeddedness. This course also has students gain awareness on academic integrity, the value of engaging in research activities, and learning how to take an interdisciplinary perspective. One of the other secondary topics covered in this freshman introductory class is health and well-being. An overview of mindfulness provided a natural substitute for this particular class. Guest speakers frequently visit this course, so it was not unusual to have someone come in to discuss mindfulness. Based on logistical constraints, the researcher presented during the 12th week of the course.

The presentation given by the researcher included two main sections: (1) mindset and (2) inner engineering. The section on mindset discussed the ideas of growth vs fixed mindset. The main idea that was communicated is that challenges and failure are a part of life, but an

individual with a growth mindset believes that with effort they can learn and improve, and eventually persevere through these challenges. It also highlighted that simply being a passive observer or blaming circumstance doesn't help one's situation and that shying away from challenges (avoidant-performance orientation) won't lead to growth. This section was also intended for students to reflect and think critically about their current mindset and approach to learning, and identify areas where they can improve. This section supports the notion that one can change their mindset by highlighting scientific evidence from the fields of neuroplasticity and epigenetics.

The inner engineering section relates closely to the ideas of mindfulness. It highlighted the importance of closely monitoring one's thoughts, emotions, and physical sensations through metacognitive monitoring. The researcher discussed how prevalent the mind wandering state (i.e. cognitive discourse) is in our daily experiences, and that it doesn't always serve us well especially when the thoughts become irrational or negative over an extended period of time, as it can lead to chronic stress. The researcher then discussed the importance of developing habits to manage stress since chronic stress can lead to negative mental and physical problems. Finally, the presentation transitioned to discussing how regular practice of mindfulness meditation and other contemplative practices have been shown to help people cultivate awareness and attention, which can help them become more self-aware and deliberate in their decision-making. Flow state was used to describe the idea of being fully immersed in the present moment. Lastly, the researcher shared scientific evidence showing how mindfulness can help one become more mentally and physically balanced, and therefore can lead to many benefits. The researcher used examples to help describe the stress response, and how mindfulness stabilizes the breath and heart.

In terms of selecting the content, the researcher attempted to strike a balance between contextualized knowledge and abstract knowledge to promote transfer. Some of the ideas presented like growth mindset and mindfulness are very abstract concepts. These concepts were grounded in real world examples. For example, to help convey the idea of being immersed in the present moment (a characteristic of mindfulness), students were asked to share what it feels like to be in flow state. The presentation was also strategically segmented so the researcher never lectured for more than 10 minutes at a time to maintain student engagement. Several think-pair-share activities were integrated to provide time for students to reflect, and then share their thoughts with a classmate.

Data Collection

At the beginning of the presentation, students were asked to respond to closed-ended survey questions to evaluate their levels of mindfulness and resilience. At the end of the presentation students were asked to fill out a short reflection that asked them what they found interesting, what they learned, what was unclear, whether they intended to integrate contemplative practices in their lives more, and finally whether they would be interested in similar workshops in the future. The overall intent of the survey was to get initial feedback from students and gain a better idea of engineering students' mindset and gauge their baseline mindfulness and resilience levels. The overall sample size for the survey was 92 students. To maintain consistency, all of the scales were kept or converted to a 1-7 Likert Scale. To measure

mindfulness, the most well-known scale called the Mindfulness Attention Awareness Scale (MASS) was used (Brown and Ryan, 2003). To measure resilience, 6 items were used from Brief Resilience Scale (BRS) developed by Smith et al (2008).

Results

Closed-Ended Survey Questions

The results of all the closed-ended survey items can be seen in Tables 1 and 2. For the MAAS, mindfulness is inversely related to the score. In other words, the higher the score for a given item, the less mindful the student may be for that particular item. An example is "I drive on automatic pilot" and then wonder why I went there". Overall the respondents average ranged from 2.6 to 4.9 on each item with an average of 3.5 on all the items. The highest average answers (or items in which students exhibit less mindfulness include) were "I find myself preoccupied with the future or the past" (4.91) and "I forget a person's name almost as soon as I've been told it for the first time" (4.33). The lowest scored items (or items in which students exhibit more mindfulness) were "I drive places on "automatic pilot and then wonder why I went there" (2.39) and "I snack without being aware that I'm eating" (2.61). Overall this indicates that students exhibit average mindfulness scores and that there is room for improvement. For resilience, students were asked to rate from strongly disagree to strongly agree from a 1 to 7 Likert scale on a total of 16 items. Higher scores indicate students have more resilience. The average score for resilience was 4.24 with the range being 3.55 to 4.88. Overall the scores indicate that that engineering students overall believe they are somewhat resilient, but once again there may be room for improvement.

Open-Ended Survey Questions

The opened-ended responses indicate that students found a lot of the content to be interesting. In particular, students found the ideas of growth vs fixed mindset, how to manage stress, flow state, and paying attention to your thoughts through metacognitive monitoring, to be the most interesting. 34 students discussed growth mindset vs fixed mindset as a topic they learned about or found interesting. 40 students discussed stress as a topic they found interesting or learned more about. Many of these 40 students mentioned learning that moderating stress can increase performance and that the idea of stress was reframed in their mind as not necessarily a bad thing, but something to maintain a balance of. 14 students explicitly mentioned learning about or thought it was interesting that metacognitive monitoring and/or mindfulness meditation can be used to become more self-aware of their thought patterns. 25 students also thought the topic of flow state was interesting and a useful way to convey the idea of being "in the moment".

Several students also commented that the lesson stimulated reflection about their mindset and/or way of thinking. In fact, 42 students wrote that they had the intention of integrating contemplative practices like mindfulness meditation more in their lives after the presentation. 4 students indicated they didn't believe they had time or could sit still and meditate, or they had no interest. The rest of the students did not respond to this prompt in their reflection. Overall, it appears at least a good portion of the students found the presentation to be thought-provoking and several students commented in-person or in the survey that it was a great presentation despite not being prompted. For the open-ended prompt asking what topics were unclear, just

about every student put “nothing” or described the presentation as being very clear and that the content was explained well. Two students however did write that it wasn’t made clear what fixed mindset was, and one student indicated they were still unclear on the topic of metacognition.

The final question of the survey asked students whether they would be interested in participating in workshops next year that further expand on these topics; 47 said yes, 36 said no, and 9 did not respond. This indicates that the majority of students genuinely found the content interesting and were interested in learning more. Overall, this is a positive take away and signifies a mindfulness program could garner attention from a good amount of engineering students.

Table 1

MASS Survey Results

Item	Avg. Score
1. I could be experiencing some emotion and not be conscious of it until some time later.	3.49
2. I break or spill things because of carelessness, not paying attention, or thinking of something else.	2.85
3. I find it difficult to stay focused on what's happening in the present.	3.20
4. I tend to walk quickly to get where I'm going without paying attention to what I experience along the way.	3.88
5. I tend not to notice feelings of physical tension or discomfort until they really grab my attention.	3.25
6. I forget a person's name almost as soon as I've been told it for the first time.	4.33
7. It seems I am "running on automatic," without much awareness of what I'm doing.	3.38
8. I rush through activities without being really attentive to them.	3.41
9. I get so focused on the goal I want to achieve that I lose touch with what I'm doing right now to get there.	3.36
10. I do jobs or tasks automatically, without being aware of what I'm doing	3.37
11. I find myself listening to someone with one ear, doing something else at the same time.	3.91
12. I drive places on "automatic pilot" and then wonder why I went there.	2.39
13. I find myself preoccupied with the future or the past.	4.91
14. I find myself doing things without paying attention.	3.48
15. I snack without being aware that I'm eating.	2.61

Table 2

Resilience Survey Results

Item	Avg. Score
1. I tend to bounce back quickly after hard times	4.88
2. I have a hard time making it through stressful events (R)	3.55
3 It does not take me long to recover from a stressful event	4.88
4. It is hard for me to snap back when something bad happens (R)	3.93
5. I usually come through difficult times with little trouble	4.27
6. I tend to take a long time to get over set-backs in my life (R)	3.93

Note: Reverse question scores were adjusted to reflect higher score indicates more resilience

Next Steps & Conclusion

This pilot study indicates that the presentation was well-received by many of the engineering students and that there would be interest among many of them to participate in future workshops on the topic of mindfulness. The study also indicates there is room for improvement among these students in their ability to develop their attention and awareness as well as their resilience. There appears to be an opportunity to explore the potential benefits of integrating mindfulness programs for engineering students and that many students would be interested in participating in such an extracurricular program. The researcher intends to now create a mindfulness program at his respective institution to further evaluate how MBI's could support engineering students in various dimensions including focus, well-being (resilience, sleep, health, etc.), and academic performance (e.g. creativity, productivity, etc.). Finally, beyond engineering students, future research could explore how mindfulness training impacts engineering faculty and could support them in their research work, teaching, and mentoring students.

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