



## MINDFULNESS FOR ENHANCING LEARNING IN ENGINEERING EDUCATION

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### ABSTRACT

Technology is evolving at a rapid rate, thereby introducing more complex problems that engineers must be able to engage with. Increasingly complex problems require new ways of thinking, and more innovative, creative, and collaborative responses. To lead this technological evolution, engineers are challenged to engage with lifelong learning and ongoing problem solving. The learning and creative thinking skills needed for innovation relies on an open and receptive mindset – a key component of mindfulness. Mindfulness has previously been shown to enhance creativity, focus, mental clarity, and divergent thinking skills required for problem solving. Furthermore, mindfulness has been shown improve interpersonal relationships and communication – paramount to effective collaboration when working on solutions to complex problems as a team. In this paper, the perceptions of mindfulness and its effects on engineering professionals in the workplace are explored. Data were collected using structured interviews with a purposive sample of practicing South African engineers, and a survey sent out to a larger sample. Data were analysed using content analysis for the interviews and statistical regression analysis for the survey. It was found that engineers believed that consistent learning was a vital aspect of job performance. Findings revealed that mindfulness was correlated to lower stress, fatigue, and turnover intention, while improving productivity, innovation, emotional intelligence, and communication. Results indicate that through cultivating mindfulness, engineering professionals will be more equipped to continuously learn, create, and innovate in a productive manner. The study proposes that mindfulness is introduced at undergraduate level in engineering education as a key skill in preparing graduates for the workplace.



## 1 INTRODUCTION

### 1.1 Background to the Research

The rapid rate of technological evolution is likely to continue for the foreseeable future. As technology progresses, more complex challenges and problems present themselves. Engineers play an important role in technological evolution, and as challenges become increasingly complex, and work environments change, engineers must be able to adapt and engage with change in an effective, generative, and productive manner. Such change may require certain knowledge and skillsets possessed by engineers, so that they can continue to contribute with the latest knowledge and advancements while still being able to offer valuable input [1]. This can enable engineers to be suitably equipped when engaging with the increasingly complex challenges, which require new ways of thinking, as well as more innovative, creative, and collaborative responses. Lifelong learning, problem solving, and divergent thinking skills are vital in empowering engineers to continue to lead the technological revolution, while offering creative and innovative solutions to challenging problems.

The learning and creative thinking skillsets needed for innovation rely on an open, curious, and receptive mindset, which includes divergent thinking. Instead of focusing on the development of these skills, engineering education mostly focuses on narrow, analytical, and convergent thinking skills [2]. This comes at the expense of learning creative, divergent thinking skills which are essential in aiding engineers in developing innovative solutions to increasingly complex engineering problems. Rather than focusing solely on developing narrow, analytical and convergent thinking skills, engineering education should begin to focus on the cultivation of creative, innovative, and divergent thinking skills [3]. This does not mean that analytical, convergent thinking skills should be ignored, but rather both sets of skills should be emphasised to ensure that graduate engineers are well-equipped to deal with a rapidly changing industry.

Mindfulness is a practice that has its roots in ancient Buddhist psychology and philosophy. The practice of mindfulness has been adopted as a way for individuals to quieten the mind, which can lead to a range of mental, emotional, physical, and physiological benefits. Previously, there have been negative stigmas attached to mindfulness and meditation, and many academics and scientists previously perceived it as an esoteric and spiritual practice. In recent decades however, research into mindfulness has increased exponentially. Empirical research and studies have demonstrated that a wide variety of benefits can be experienced by individuals through engaging in mindfulness practice (e.g. Rieken, et al. [2], Good, et al. [4], Kersemaekers, et al. [5]). Furthermore, developments in Magnetic Resonance Imaging (MRI) have allowed researchers to observe the effects that mindfulness practice can have on the brain. Existing research has proven that regular mindfulness practice leads to new neural pathways growing, as well as the beneficial altering of the size and structure of the brain, such as an increase in grey matter (responsible for the processing of memory, emotions, sensory perceptions, speech, self-control, and decision making), the thickening of the hippocampus (responsible for helping memory and learning), and a reduction in the size of the amygdala (which leads to a reduction in stress) [6]. More objective data, such as those offered by brain scans through MRI, have led to increased interest in mindfulness amongst scientific communities and therefore an increasing number of mindfulness-related studies emerging as time progresses.

Existing research has indicated that regular mindfulness practice can enhance individuals' learning ability [7], innovation and divergent thinking skills [2], and wellbeing; while reducing stress and emotional exhaustion [8]. Mindfulness can therefore equip practitioners more effectively for dealing with the challenges of a dynamic, changing work environment that engineers often face. Moreover, engineers with experience in mindfulness will improve their learning ability, innovation, and divergent thinking skills, which can give them an advantage when it comes to learning new concepts and keeping pace with the rapidly advancing technological evolution.

### 1.2 Value of the Research

Through ongoing learning and the development of innovation, and creativity skills, engineers are more likely to be able to produce effective solutions to complex challenges that society faces. The nature of these challenges are likely to become more complex with time, as natural resources begin to dwindle, new ways of doing things need to be established, and new challenges present themselves as society adapts and evolves.

Mindfulness has been shown to enhance learning ability, creativity, divergent thinking, innovation, job satisfaction, employee well-being and overall perceived quality of life. Through the cultivation of these



skillsets and traits, engineers will be more suitably equipped to engage with complex challenges and commit to a process of lifelong learning. Graduate engineers with mindfulness practice experience are more likely to produce more innovative, creative, and novel solutions to the challenges faced by an evolving society and rapidly advancing technological industry. This has the potential to enhance their careers, as they will not only be able to provide more value to the engineering industry but will also be more suitably equipped to managing and reducing their stress levels and mental health, while improving their overall wellbeing and job satisfaction.

### 1.3 Research Aims and Questions

This paper reports on a study that investigates the relationship between mindfulness and learning in engineering professionals. The following research questions were addressed:

1. *How does mindfulness enhance learning in engineering professionals and students?*
2. *How can mindfulness practice be used to enhance lifelong learning, creativity, and innovation in engineering professionals and students?*

## 2 CONCEPTUAL FRAMEWORK

### 2.1 Mindfulness

A widely used definition for mindfulness in scholarly literature was formulated by Kabat-Zinn [9], and states that mindfulness is: *“the awareness that emerges through paying attention on purpose, in the present moment, and nonjudgmentally to the unfolding of experience moment by moment.”* (p. 145). Dane [10] proposed a definition for mindfulness that also included an aspect of presence, describing it as *“a psychological state in which one focuses attention on events occurring in the present moment”* (p106). Evidently, fundamental aspects of mindfulness include presence and attention to present-moment experiences. Going forward, when the term ‘mindfulness’ is used, Kabat-Zinn’s definition of mindfulness will be referred to as his definition holistically encapsulates the foundations of mindfulness in a clear, unambiguous manner. For the purposes of this research study, mindfulness will be viewed as a state, as proposed by Dane [10].

In most scholarly literature, the fundamental bases of mindfulness are attention and awareness. Almost all conceptual models of mindfulness include these characteristics. Brown, et al. [11] describe awareness as *“the conscious registration of stimuli, including the five physical senses, the kinaesthetic senses, and the activities of mind”*. While attention and awareness interact, they are still distinctive from one another – attention is engaged when a stimulus is strong, and it is possible to lack awareness while paying attention. Conversely, it is possible to be aware that one is paying attention or paying attention to being aware of a phenomenon. Good, et al. [4] used a conceptual model that suggests the key pillar of mindfulness is solely attention, and that all benefits that arise are due to the cultivation of attention; namely in the areas of stability (how consistently one can hold focus), control (directing attention amid competing demands), and efficiency (referring to the economical use of cognitive resources). For the purposes of this research study, the conceptualised model of mindfulness will include aspects of attention and awareness, with a focus on present-moment awareness, owing to Kabat-Zinn’s (2003) definition of mindfulness.

The attention and awareness that arises when an individual is in a mindful state should be non-judgmental and non-discriminatory in nature, and rather as objectively as possible without attaching any emotional value to any events unfolding. In other words, when mindfully processing phenomena, there is no comparison, categorisation, or evaluation on the current experiences that are unfolding; nor is there any contemplation, reflection, or rumination on events or experiences based on memory or preconditioning. Instead, mindfulness promotes non-interference and non-judgment towards any experience that may arise, and simply allows inputs to enter an individual’s field of awareness by simply *noticing and observing* what is taking place. Mindfulness involves experiential processing of phenomena unfolding [11], which refers to phenomena occurring in both one’s internal world (consisting of thoughts, feelings, and emotions) as well as one’s external world (consisting of external stimulus and sensations) while simply *observing and noticing* what may arise. It is important, however, not to judge or to attempt to assign meaning to anything. In addition to these qualities, the attention and awareness that is cultivated due to mindfulness is also flexible, meaning the field of awareness can be adjusted accordingly – it can move back to gain a larger perspective on what is taking place (known as clear awareness), or it can ‘zoom’ in on situational details (focused attention) [11]. This



feature can allow mindful individuals to alter their perceptions and limiting thoughts to obtain greater clarity and understanding in certain situations where it is required that the bigger picture is seen.

When the topic of mindfulness is discussed, the construct of past, present, and future is taken into account. Brown, et al. [11] suggests that humans' minds oscillate between memories of the past and projections into the future. Too seldom, do humans experience the present moment for what it is. This is often caused because humans 'forget' that we only exist in the present, and that there is no tangible, direct contact with either the past or the future – they are both simply constructs of our imagination. While this 'oscillatory time travel' serves a useful biological purpose of protecting, maintaining, and improving the self, or one's identity (which is a set of ideas about oneself that defines *who* they are in relation to the world), it often comes at the detriment of one's mental and emotional well-being (by dwelling on painful past memories or excessively worrying about future outcomes). Mindfulness helps to increase the amount of mental time spent being aware in and of the present moment, through the cultivation of *present-oriented consciousness*. Zimbardo and Boyd [12] importantly point out that this is not to be confused with 'living for the present', which is associated with hedonism, impulsiveness, and fatalism. On the contrary, mindfulness has been inversely related to these characteristics.

## 2.2 Salutory Effects of Mindfulness in the Context of Learning, Wellbeing, and Performance

An open, receptive mindset, necessary for learning and creative thinking, is a key component of mindfulness. Mindfulness has previously been shown to enhance creativity, focus, mental clarity, innovation, and divergent thinking skills required for problem solving. Existing research has revealed compelling evidence that there is a causal relationship between mindfulness and creative innovation achievement, and therefore learning [6]. However, psychologists are still attempting to establish the exact mechanisms through which mindfulness can aid innovation [13]. Mindfulness may be able to enhance learning indirectly as one of its most common applications is for stress reduction [14]. Vogel and Schwabe [15] found that stress can limit an individual's ability to retrieve memories and learn effectively, suggesting that mindfulness could be used as an effective tool to counteract stress-based learning difficulties.

The effects of a changing and challenging environment, such as the environment that presents itself in the engineering workplace in the face of rapidly evolving technology, can be mitigated in employees through mindfulness. It has been shown that organisational mindfulness held value for organisations to help respond to a changing and challenging workplace, while mindfulness also provided benefits to organisations which included improved learning, increased job satisfaction, and reduced employee turnover and absenteeism [16]. Mindfulness has been shown to enhance individual learning ability, as it leads to increased activation in the prefrontal cortex – the region of the brain responsible for higher-order thinking, judgment, decision-making, and planning. Researchers found in long-term meditators that the cortical regions responsible for processing sensory input were thicker, and that meditation increased brain activity involved with learning and memory processes, emotional regulation, self-reflection, and perceptiveness [6]. Ching, et al. [7] conducted a study involving 359 university students who engaged in regular meditation practice. Results showed that through regular meditation, students possessed improved mental and physical stamina and school performance, enhanced learning ability, increased memory, and faster reaction times.

Mindfulness has been shown to enhance personal well-being, both directly and indirectly. Well-being can be directly enhanced as mindfulness can add clarity and vividness to current experiences; encouraging closer sensory, moment-to-moment contact with life without first interpreting, analysing, and judging everything that is going on. This can reduce the emotional and mental distress that could arise due to the judgment and discrimination towards current events unfolding, thereby allowing a state of peaceful equanimity to arise – a quality that significantly enhances an individual's sense of well-being.

Indirectly, mindfulness can lead to enhanced individual well-being by improving self-regulating functioning that comes with sustained attention and awareness of psychological, somatic, and environmental stimuli [11]. These claims of improved well-being have been backed up by studies, where significant correlations have been found between mindfulness and: mental health, lower levels of emotional disturbance (such as depression, anxiety, and stress), higher levels of subjective well-being (higher positive affect and satisfaction with life), and eudemonic well-being (vitality and self-actualisation) [17]. Baer, et al. [18] found that mindfulness was negatively related to neuroticism, while Walach, et al. [19] proved that mindfulness was negatively correlated to psychological distress. Furthermore, mindfulness is associated with greater general awareness, understanding, acceptance of emotions, and improved ability to correct mood states [17]. It has



been shown that mindful individuals were less likely to be emotionally volatile and less negatively reactive, and that an 8-week mindfulness intervention training program reduced participants' neural reactivity and negative reaction to sadness-inducing stimuli [20]. This has been proven not only through empirical research, but also neurologically through brain scans of the amygdala and prefrontal cortex associated with threat response [21]. When individuals experience higher levels of well-being, they are more likely to feel motivated satisfied at their workplace, enabling them to produce higher quality work in an efficient manner. Therefore, through improving employee well-being, mindfulness is likely to improve individual's workplace performance, including engineering professionals.

Considerable research has gone into the field of mindfulness and its relation to cognitive performance – including both cognitive flexibility (the generation of new perspective taking and responding instead of reacting based on previous mental conditioning) and cognitive capacity (the fluid intelligence of individuals) [4]. Contrary to popular belief, Good, et al. [4] states that working memory and fluid intelligence is malleable, and that these qualities can be cultivated and improved within individuals through mindfulness training. Through improving cognitive flexibility and capacity, engineering professionals could benefit as it would enable them to develop new perspectives when solving problems. Additionally, the improved working memory and fluid intelligence would mean that professionals could recall information more quickly and may offer better insights through fluid intelligence.

### **3 METHODOLOGY**

#### **3.1 Research Approach**

This research study aims to investigate topics that are personal to individuals, such as learning, mindfulness, and creativity. These states are subjective, and are experienced differently between individuals, each of whom possess differing mental constructs, beliefs, and understandings of the world. It was therefore deemed most applicable to adopt a constructivist- and interpretivist-based philosophical stance, which lends itself to subjectively experienced phenomena. This was more suited to the research study compared to an objectively rooted positivist philosophical standpoint.

A mixed methods case study approach was adopted for this research study, where the cases were engineering professionals in South Africa. This approach allowed for rich data and descriptions to be obtained from the participants.

The goal of this research study was to clearly understand the current situation in the engineering workplace context, in terms of mental health, mindfulness, job performance, and employee well-being. This was achieved with an in-depth study with individuals as cases. The perception of mindfulness as an effective practice to improve mental health among engineers was also explored.

This research study required an appropriate sampling design. A probability sampling design was used for the survey, and Simple Random Sampling was used for this part of the research. The population was identified as professionals working at an engineering firm in South Africa, as an engineer or otherwise. The important aspect was that the respondents were employed by an engineering company, as all employees working in this sector would be able to offer valuable insights into the nature of mental health and mindfulness within this context.

Purposive sampling was used for the structured interviews. Participants who were interviewed were not randomly selected from the sample, as they were selected based on their work experience, job position in the organisation, and their perceived contribution to the research study. To ensure that a suitable sample group was selected, a mixed purposive sampling approach was used.

#### **3.2 Data Collection and Analysis**

A 40-item self-report survey was used in conjunction with an open-questioned semi-structured interview, consisting of 16 questions. The survey consisted of five sections: Mindfulness, Fatigue, Stress Levels, Productivity, and Well-being in the workplace. The survey questions helped to elicit a score for each of the respondents in every one of the five sections. The survey provided clarity when addressing the aim of gaining insight into the mental health situation in the corporate engineering sector in South Africa, and assisted in answering the research questions pertaining to mindfulness. Additionally, relationships could be established between each of the sections in the survey through regression analysis, which helped gain valuable insights into the research aims and questions. The survey was a unique combination of existing





survey questions dealing with mindfulness, fatigue, stress, wellbeing, and job satisfaction. The structured interview made up the qualitative aspect of the mixed methods approach. The interviews directly questioned the mental health situation in the engineering sector in South Africa, as well as the perceptions of mindfulness among engineers working in South Africa. In addition to this, the interview also helped in answering the research questions directly.

Statistical analysis was used to analyse the surveys. The numerical survey data was exported into *Statistica*, a statistical analysis software tool. This software was used to conduct regression analysis of the survey data, which would help establish relationships between the variables (different sections of the survey). A combination of both Linear and Multiple regression was used to establish relationships between the five main categories from the survey (Stress levels, fatigue, job satisfaction, mindfulness, and productivity), which offered insight as to how the variables related to one another, as well as the strength of the correlations.

Audio recordings of the interviews were transcribed and imported to *NVivo 12*, which was used to conduct the qualitative data analysis. Content analysis was used to analyse the data, which were coded using an inductive approach. Transcribed data was analysed for any emergent themes and categories, allowing the data to naturally unfold and tell their own story. The emergent codes from the transcribed interview data were then categorised into broader themes and categories. The same process was used to code relationships between categories. Whenever an interviewee related two or more themes/categories together in some way, a relationship emerged. Through coding the relationships, a clearer picture could be painted of what was being said by the interviewees, and how various categories related to one another.

Since the research study involved human participants, ethics approval was obtained from the Faculty of Engineering and the Built Environment at the University of Cape Town.

## 4 RESULTS AND CONCLUSION

The findings from the analysis of data from the 10 participants interviewed, and 65 survey responses are presented below. While 10 interviews may be too few to obtain true representativeness of the entire population being studied, the diverse range of individuals who were interviewed and each participants' insights into collective problems faced by engineers means that the data collected should be sufficiently generalisable. Furthermore, additional survey responses are required to obtain true statistical significance, the responses collected so far are proposed to represent trends that emerge from the sample population.

### 4.1 Perceptions of Mindfulness and its Effects on Job Performance Amongst Engineering Professionals in South Africa

Among the participants who were interviewed, 60% of them believed that mindfulness revolved around an aspect of awareness. A further 20% understood mindfulness as being aware of and absorbed in the present moment. Both of these beliefs are supported by existing literature on the topic of mindfulness (e.g. Kabat-Zinn [9], Brown and Ryan [17]). Other participants believed that mindfulness included aspects of gratitude, mental health, physical health, and finding a healthy balance to life.

When questioned about how mindfulness could be used to enhance job performance as an engineer, a wide range of responses were elicited from participants. A majority of participants (60%) claimed that mindfulness was an effective way of reducing stress, while 40% of participants believed that learning was an important aspect to being a successful engineer. The former statement suggests that mindfulness could enhance learning in engineers, as several participants believed that in order to learn effectively, it was important to have low stress levels. This is supported by Vogel and Schwabe [15], who found that high stress levels correlated to a lower rate of memory retrieval and effective learning in individuals. Through a reduction in stress, and therefore improvement in learning, an individual is predicted to be a more successful engineer professional.

Half of the participants believed that mindfulness practice would enhance productivity in individuals, meaning they would be more efficient when engaging with the task at hand, and therefore more efficient at their workplace. A further 20% of the participants suggested that mindfulness would result in an improvement in time management, which ties in to productivity. Regardless of what the task is, an improvement in productivity would mean that an individual can complete it more effectively with greater attention to detail and fewer errors being made – a sentiment that was reflected by a participant who was interviewed. This would apply to a task such as learning too, suggesting that through improving productivity in individuals,



mindfulness can indirectly enhance an individual's ability to learn, and therefore function more effectively and successfully as an engineering employee.

30% of participants stated that mindfulness could lead to an improvement in interpersonal skills and emotional intelligence, which would be likely to lead to an employee's success in the engineering workplace. These skills tie in to effective collaboration and communication in an organisational context, and can enhance a team's ability to work together to find innovative and creative solutions to complex problems that present themselves through the advancement of technology and an evolving society. An additional 20% of participants suggested that mindfulness would lead to an improvement in one's self-confidence and self-perceived workplace identity. When an individual appears more self-confident in the workplace, they are more likely to elicit respect, come across as more trustworthy and reliable, and gain credibility in their organisation, thereby increasing their chances of success, promotion, and notable influence within their organisation [22]. Self-confidence relates to positive self-image, which suggests that individuals with higher self-confidence would be more adequately equipped to deal with setbacks, such as those experienced during the learning process when aiming to understand new concepts.

Other perceptions of mindfulness and its effects on job performance, which were proposed to a lesser extent by participants, included decreased burnout, less rumination, and fewer mental health issues. In contrast, participants believed that mindfulness could lead to an increase in quality of work, enhanced mental clarity and capacity (thus leading to improved job performance), better quality of life, increased focus, improved self-awareness, and enhanced intellect.

#### 4.2 Learning, Job Performance, and Mindfulness

Of the participants interviewed, 40% of them indicated that learning was a key aspect to successful job performance as an engineering professional. Participant 3 suggested that learning and upskilling oneself, even when it was not part of the job description, could enhance an individual's job performance as an engineer and would enhance workplace identity and self-esteem as it would *'make your day-to-day life at the job easier, and with that, you get less depression, you get less resignation...'*. Participant 5 believed that learning was strongly linked to personal growth, and that as a junior engineer, learning was critically important to adapting to the working environment. This was reflected by participant 8 too, who stated that learning was paramount to job performance, particularly as an engineer who is new to the work environment, as it is expected that there is a lot that new employees would not know. Lastly, participant 9 believed that as new, more novel ways of completing tasks evolved with time, it was important for engineers to be dedicated to learning and adapting as technology progresses. This participant also indicated a concern that older engineers in the workplace were often unwilling to adapt and use newer, more efficient ways of doing things, which reflects a closed, narrow mindset. Mindfulness is a means to cultivating an open, receptive mindset that enhances creativity, innovation, and flexibility [3], which would likely assist senior engineers in opening themselves up to newer ways of doing things in a creative, innovative manner.

Participants believed that mindfulness could actively improve learning skills in individuals. Participant 3, who had had experience in mindfulness practice, believed that mindfulness could enhance mental clarity, which in turn, could improve one's rate of learning as one is able to engage more fully with the task at hand since there is less mental clutter and external thoughts. Participant 5 stated that *'when one is stressed and under a lot of pressure, learning falls out the window'*. The same participant went on to explain that they believed that mindfulness could improve one's quality of life, productivity, and time management, and that this could indirectly enhance an individual's learning ability. Participant 8 suggested that mindfulness could reduce the rate of errors when an engaging with a task, which could increase the rate at which learning could take place. Participant 9 believed that learning was made significantly harder when experiencing a state of stress, and that mindfulness could be used as a means to reduce stress. This was supported by Vogel and Schwabe [15]. In this way, it is believed that mindfulness could enhance learning.

#### 4.3 Collaboration for Problem Solving and Mindfulness

A significant proportion of participants believed that interpersonal skills, including communication, teamwork, and emotional intelligence, was an indicator of successful job performance in the engineering sector. Participants 1 and 9 indicated that teamwork was a crucial trait to determine successful job performance, participants 3 and 10 cited communication, and participants 6 and 10 suggested emotional intelligence was an important trait. All of the aforementioned traits are conducive to effective collaboration in a team-based



environment. Through improving interpersonal dynamics, and therefore enhancing effective communication and collaboration, engineering organisations would be more suitably equipped to working together to find solutions to increasingly complex challenges.

Participant 1 stated that being able to rely on and ask for help from others in a team was important when collaborating on finding a solution to a problem, and participant 9 believed that people skills and being able to effectively work in a team was paramount to successful job performance as an engineer. Participant 3 indicated that communication and responsiveness was important to succeeding in the workplace, and participant 10 claimed that being able to communicate '*large ideas in a simple and easy to understand way*' was a vital aspect to effective collaboration and job performance. Participant 5 explained that by being emotionally intelligent, and if '*you know yourself, you know what your capabilities are, capacities are, you don't have to... you won't overcommit yourself, you'll be able to say no, you'll be able to manage your relationships*', that individuals would be able to perform and collaborate more effectively in an organisational, team-based environment. Participant 5 went on to state that they believed that younger engineers coming in to the workplace were generally more eager to learn, as well as being more emotionally intelligent to senior engineers. In doing so, this participant believed that younger engineers were contributing to a more productive and collaborative workplace environment for engineers.

When questioned about how mindfulness could enhance teamwork, communication, or emotional intelligence, participants all believed that there existed a positive relationship between mindfulness and the abovementioned interpersonal skills. Participant 8 believed that engineers generally '*have a lot of IQ but not a lot of EQ*', and that mindfulness could be used as a means to enhance emotional intelligence (EQ) in engineering professionals. Participant 9 highlighted that '*Mindfulness is very important, especially with the people skills, especially if you're a manager*', and that managers who were more mindful were more adequately equipped to managing teams and facilitating collaboration amongst employees. This agrees with existing research carried out by Shonin, et al. [23], who found that managers who had received mindfulness training showed significant improvements in job performance (as rated by supervisors) compared to a control group and their initial performance. Participant 10 claimed that in order to communicate effectively, individuals require a certain level of mental clarity and mindfulness. Without these states being active when communicating, the participant claimed that one is more likely to be closed off and consumed with one's own thoughts, and therefore more likely to miss cues and lack coherent emotional understanding.

Through effective collaboration, which requires coherent communication, teamwork, and emotional intelligence, engineering professionals are more likely to be able to develop creative and innovative solutions to complex problems that present themselves as technology continues to advance. Findings suggest that mindfulness can enhance communication, teamwork, and emotional intelligence, and therefore improve collaborative efforts within an engineering organisation.

#### 4.4 Statistical Analysis of Survey

Statistical analysis of the survey revealed relationships between the five variables, namely Fatigue, Stress, Job Satisfaction, Productivity, and Mindfulness. The table below highlights the findings, which were obtained through linear and multiple statistical regression analysis:

Dependent Variable	Independent Variable(s)	Correlation (R)	p-value (statistical significance) [ $<0.05$ ]	Correlation Type/Significance
Mindfulness	Fatigue	0.311	0.0116	Negative (significant)





Mindfulness	Stress	0.171	0.173	Negative (insignificant)
Mindfulness	Job Satisfaction	0.153	0.223	Positive (insignificant)
Mindfulness	Productivity	0.345	0.00486	Positive (significant)
Mindfulness	Stress and Fatigue	0.311	0.0424	Significant
Mindfulness	Productivity and Job Satisfaction	0.349	0.0178	Significant
Mindfulness	Stress, Fatigue, Productivity, and Job Satisfaction	0.400	0.0310	Significant

The statistical linear regression analysis revealed that there were statistically significant relationships between mindfulness and fatigue, and productivity. The relationship between mindfulness and fatigue, and productivity, showed that there were moderate correlations between mindfulness and the independent variables mentioned. This suggests that mindfulness can effectively be used as a practice to reduce fatigue while enhancing productivity amongst engineers. Statistically insignificant relationships ( $p > 0.05$ ) emerged between mindfulness and stress, and job satisfaction. A weak correlation existed between mindfulness and stress, and job satisfaction. These findings suggest that higher levels of mindfulness cannot be used to predict lower stress levels and higher incidences of job satisfaction among engineers. Based on the review of existing literature and the data obtained through the structured interviews, it can be concluded that the statistical relationship that emerged between mindfulness and stress is incorrect, and this may be due to the relatively low number of survey responses gathered at this point in the research study.

Multiple regression analysis revealed that statistically significant relationships emerged between mindfulness and stress/fatigue, mindfulness and productivity/job satisfaction, and mindfulness and stress/fatigue/productivity/job satisfaction. All the aforementioned relationships between mindfulness and the respective independent variables demonstrated a moderate correlation between the variables. This suggests that higher levels of mindfulness can be used to predict lower rates of detrimental variables investigated (stress/fatigue) among engineering professionals, and that higher levels of mindfulness can be used to predict higher rates of beneficial variables investigated (job satisfaction and productivity) in the survey.

## 5 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings presented, the following conclusions and recommendations can be made:

- Mindfulness can be used by engineering professionals to assist engineers in adequately coping with a challenging and changing workplace environment.
- Mindfulness can be used as an effective practice to enhance job performance and lifelong learning as an engineering professional.
- Mindfulness practice should be introduced to undergraduate engineering students to improve academic performance, reduce stress, and enhance learning ability.
- Mindfulness can be used as a practice to enhance individual well-being, productivity, and job satisfaction, while reducing stress, fatigue, and turnover intention.
- A higher number of interviews should be conducted to ensure representativeness, and a larger survey response is required to ensure that the sample data accurately represents the population.

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## 6 APPENDIX

### 6.1 Interview Questions

1. How would you describe your own mental health in the workplace environment? 1.1. How would you describe the broad mental health situation in the engineering sector?
2. What do you consider the three most important indicators to determine job performance in the engineering sector?
3. What can you comment on stress and fatigue levels in this sector? 3.1. Do you think they are related to one another?  
3.2. How would these states affect job performance in your opinion?
4. What can you say about employee well-being in the engineering sector? 4.1. Do you feel as if companies do enough to ensure the well-being on their employees?  
4.2. Are you satisfied at your place of work? Do you expect to find new employment in the next 2 years?
5. How would you describe your own productivity in the workplace? 5.1. What do you understand by the term 'productivity'?  
5.2. What is your general perception of productivity in the engineering sector in South Africa?
6. What does the term "mindfulness" mean to you? What do you understand by it?
7. How do you think mindfulness could affect the three most important job performance indicators mentioned above?
8. How do you think mindfulness could affect job performance in the engineering sector, if at all?
9. Please add any additional comments or reflections on the questions posed in this interview.
10. Would you be interested in partaking in a mindfulness intervention running over 8 weeks, to observe what effects it has on your job performance?



## 6.2 Survey Questions

### Mindfulness Section

1. I am able to appreciate myself.
2. I see mistakes and difficulties without judging them.
3. I accept unpleasant experiences.
4. I am friendly to myself when things go wrong.
5. In difficult situations, I can pause without immediately reacting.
6. I am patient with myself and others.
7. I rarely break or spill things due to carelessness, not paying attention, or thinking of something else.
8. I find it easy to stay focused on what's happening in the present.
9. I always remember a person's name after I've been told it for the first time.
10. I am aware what I'm doing, and always feel in control.
11. I take time when engaging in activities, and am fully attentive to them.
12. I listen to someone fully, without doing anything else at the same time.

### Fatigue Section

1. Work brings on fatigue.
2. Fatigue interferes with carrying out certain duties and responsibilities.
3. Stress brings on my fatigue.
4. My motivation is lower when I am fatigued.
5. Long periods of inactivity bring about my fatigue.
6. Resting does not reduce my fatigue.
7. Sleeping does not lessen my fatigue.
8. Positive experiences do not lessen my fatigue.
9. I am easily fatigued.
10. Fatigue causes frequent problems for me.
11. Fatigue interferes with carrying out certain duties and responsibilities.
12. Fatigue interferes with my work, family and social life.

### Job Satisfaction and Turnover Intention Section

1. I am satisfied with my job.
2. I feel valued, and my contribution appreciated, at my place of work.
3. I look forward to going to work.
4. My managers always value my feedback and contributions.
5. I am likely to remain with the same employer for the next next 2 years.

### Productivity Section

1. I am productive at my workplace.
2. My mood has little effect on my levels of productivity.
3. Others would describe me as being productive and hardworking.
4. Being at work increases my productivity.
5. Stress has little effect on my productivity levels.

### Stress Section

1. I am frequently stressed at work.
2. I often find myself worrying about things that have not happened yet and are not likely to happen.
3. After a stressful situation arises, it takes me a long time to no longer feel stress.
4. I find it difficult to feel relaxed.
5. I struggle to find a healthy work-life balance.
6. I feel like I have little control over my life at work.