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Emotional Intelligence of Undergraduate Engineering Students With and Without Internships

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This is to certify that the doctoral dissertation by

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Abstract

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MS, University of Applied Sciences Aachen, Germany, 2018

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Dissertation Submitted in Partial Fulfillment

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Abstract

Workplace expectations for engineers have changed in the 21st century due to rapid technology advances, globalization, customer centricity, and team-based design practices, which require engineering graduates to have well-developed emotional intelligence (EI) to perform at high levels in the engineering profession. To fill the gap between engineering employers' expectations and academic preparation of engineering students, internships in engineering industries have shown many benefits as work-based educational strategies in higher engineering education. However, it is not known whether internships also address needed EI levels in engineering students. The purpose of this basic quantitative study was to determine whether global and domain EI scores of undergraduate engineering students differed based on the participation in an internship in engineering industries. Guided by Petrides's EI theory and TEIQue-SF questionnaire, a stratified non-probabilistic sample of 206 undergraduate engineering students across U.S. colleges volunteered to provide EI scores in an anonymous online survey. Multivariate analyses of covariance, controlling for age and gender in a posttest-only-with-control-group design, indicated that EI domain scores for sociability and emotionality may be useful to determine levels of EI skills in engineering students in conjunction with internships. Whereas sociability appeared to be slightly higher in students with internships, emotionality did not. The findings of this study may initiate the investigation of the perception, the need, and the challenges of EI development in engineering education and in engineering practice, thereby contributing to positive social change by providing more understanding on how best to educate tomorrow's holistic engineers.

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Chapter 1: Introduction to the Study

Globalization and interdisciplinary design choices in the 21st century have shifted expectations on the engineering profession (Bae et al., 2022; Goldberg et al., 2016; Hirudayaraj et al., 2021). The traditional view of an engineer as an individual contributor of innovative ideas to solve isolated problems has been accompanied by the need to work in teams and with customers to optimize engineering solutions (Boyatzis et al., 2017; Gilar-Corbi et al., 2018; Goldberg et al., 2016). Therefore, the highly technical competencies taught in postsecondary engineering education alone are no longer sufficient for effective performance in engineering professions (Boyatzis et al., 2017). Intra- and interpersonal competencies have become increasingly important in the education of professionally successful engineers (Lappalainen, 2017; Ozek, 2018; Skipper et al., 2017; Yong & Ashman, 2019). Nevertheless, there is a skill gap between engineering graduates and employers' work expectations (Bae et al., 2022; Hirudayaraj et al., 2021; Kolmos & Holgaard, 2018). According to employers, most desired skill sets in entry-level engineers related to social-emotional competencies have not been achieved on a satisfactory level (Hirudayaraj et al., 2021). But students may gain social-emotional skills when they participate in internships in engineering industries, which leads to improved employability (Feijoo et al., 2019; Gillespie et al., 2020). Furthermore, engineering students have exhibited differences in the perception of their social-emotional competencies and sociability based on their participation in internships (Hora, Parrott, and Her, 2020). Both intra- and interpersonal skills are domains of emotional intelligence (EI) that address self-perception of emotionality, sociability, wellbeing, and self-control (Petrides, 2009a). However, it was unclear in the literature whether the EI of undergraduate engineering students differ based on the participation in an internship in engineering industries during their postsecondary education.

This study adds to the existing literature by identifying the potential usefulness of internships in engineering education to address the gap in social-emotional competencies between engineering graduates and workforce expectations on future engineers. Although internships in engineering industries were viewed as high impact activities with benefits for the development of holistic professional competencies in students (Wolfgram et al., 2020), very little research has been done regarding the level of EI in undergraduate engineering students with and without internship participation. The first step in this line of research was to determine whether there were differences in social-emotional competencies in engineering students with and without internships. This knowledge may help to understand whether internships should be further explored as a reason for potential differences in engineering students' EI. Due to the scope of this basic quantitative study, results cannot be used to conclude a causal-comparative relationship between internships and EI but instead may be used to decide on further research to determine why, how, and in what capacity internships may be useful to improve undergraduate engineering education. Ultimately, this study may assist to inform decisions about the directions of the research that will help to improve the education of tomorrow's engineers.

Chapter 1 provides a summary of the background of this study with recent empirical literature in the scope of the study topic. I describe the problem and the purpose of this study, followed by the research question, the hypotheses, and a description of the theoretical framework underlying the research question. Furthermore, I will detail the nature of this study and a short summary of the methodology used for analysis. I include definitions of key terms, assumptions, scope of the study, delimitations, and limitations of this study. This chapter concludes with a statement justifying the significance of this study and the implications for positive social change.

Background

Some scholarly researchers studying engineering education have uncovered skill gaps in social-emotional competencies between engineering graduates and work expectations from engineering employers (Hirudayaraj et al., 2021; Kolmos & Holgaard, 2018). However, student internships in engineering industries were identified as a potential high impact educational strategy to enhance students' intra- and interpersonal skills, leading to increased employability immediately after graduation (Feijoo et al., 2019; Gillespie et al., 2020). EI is the combining factor that underlies intra- and interpersonal skills leading to social-emotional competencies (see Petrides, 2009a), which is trainable through life events and practice in a realistic work environment (Goleman, 2018; Hadgraft & Kolmos, 2020). Therefore, findings in the literature from the three topic areas regarding internships in engineering education, EI, and the trainability of social-emotional competencies in higher education were essential to understand the focus of this study addressing the potential usefulness of internships for EI development in undergraduate engineering students.

Within the first topic, internships needed to be defined. Student internships in engineering industries in postsecondary engineering education are regulated under the U.S. Department of Labor (U.S. Department of Labor [Factsheet #71], n.d.) and the National Association of Colleges and Employers (NACE, 2018). Characteristics of these pregraduation internships have been defined as experiential activities providing students' temporary exposure to practical and professional settings in their chosen field of study that benefit their formal academic education (National Association of Colleges and Employers [NACE], 2018). Many authors reported on benefits of student internships in the industries regarding their transition into the workforce (Bender, 2020; Kövesi & Kálmán, 2019; Myint et al., 2021), increased employment opportunities (Baert et al., 2021), better career crystallization (Arrayan, 2020; Ozek, 2018), and attitude improvement (Minnes et al., 2020). For employers and engineering educational institutions, student internships have helped to increase academic-industry collaborations leading to better reputation and pregraduation talent screening (Ozek, 2018). However, due to lack of a critical mass and equal access to internship opportunities for all students (Moss-Pech, 2021; Robinson et al., 2020) and other logistical obstacles (Birhan & Merso, 2021; Powers et al., 2018), student internships in engineering industries are primarily offered as extracurricular activities or as technical electives in engineering education (Best Colleges, 2021). About 50% of engineering students were reported to participate in an internship in the industries while enrolled in an engineering postsecondary degree program (Kapoor & Gardner-McCune, 2020; Laguador et al., 2020).

Available student internships in formal engineering education have also been related to specified student competencies, such as communication skills (Wilson & Kaufmann, 2020), entrepreneurial competencies (Nachammai et al., 2020; Ranabahu et al., 2020), ethical behavior (LeFrancois et al., 2021), and holistic competencies associated with people-skills (Chowdhury et al., 2020; Hoosain & Sinha, 2018; Myint et al., 2021). Furthermore Gillespie et al. (2020) indicated the existence of positive relationships between internship participation and psychosocial factors, such as the development of EI in students, based on a meta-analysis of reviewed literature. However, the literature was lacking reports that combined EI measures with student internship participation in engineering industries.

As studies with EI measures were sparce in the literature on engineering education, further understanding of what is known about EI in postsecondary education in general was also critical for the background of this study. Historically, many studies have reported assessment of EI in students and professionals of non-technical fields with strong emphasis on direct human interactions, such as psychology, business, management, and health care (Kotsou et al., 2018). In non-technical fields, EI training was associated with improved interpersonal skills around patients (Ha et al., 2021; Mao et al., 2021) and intrapersonal skills concerning stress-coping and burnout (Di Lorenzo et al., 2019; Foster et al., 2018), as well as improved leadership and performance skills through the development of conscious awareness of emotions in others and self (Gilar-Corbi et al., 2019; Nelson et al., 2017). In business, EI was correlated to entrepreneurship (Nawaz et al., 2019, 2021; Yitshaki, 2021).

Although changes in the expectations on the successful 21st century engineer to work with clients and in multidisciplinary teams (see Antoniadou et al., 2020) require similar professional inter- and intrapersonal competencies as in mentioned non-technical fields, comparative studies between engineering students and medical or humanities students showed significant differences in EI between students of technical versus non-technical disciplines (Perikova et al., 2021; Štiglic et al., 2018; Utami & Hitipeuw, 2019). These differences in EI between students of technical and non-technical disciplines may be due to engineering education's focus on teaching technical expertise with little emphasis on social-emotional competencies (Feijoo et al., 2019; Hirudayaraj et al, 2021). Despite the understanding that EI was considered the underlying mediating factor (Hamzah et al., 2021; Koç, 2019; Liu & Boyatzis, 2021) or directly related to desired professional and employability skills in engineering (Chand et al., 2019; Flores et al., 2020; MacCann et al., 2020), attempts of EI training in engineering education has been exploratory, sometimes limited in scientific methodologies (Hodzic et al., 2017; Kotsou et al., 2018).

Nevertheless, engineering employers and alumni have suggested real-world experiences, such as internships in engineering industries, as a possibility to enhance EI skills in engineering students (Bae et al., 2022; Boyatzis et al., 2017; Hadgraft & Kolmos, 2020; Mikkonen et al., 2018). Because EI regarded as social-emotional skill set is considered trainable through experiences (Goleman, 2018; Mattingly & Kraiger, 2019; Nelson et al., 2017; Petrides, 2010, 2021), best practices of EI learning strategies in higher education were reported in the literature. According to a synthesis of literature reports, best practices to successful long-term development of EI competencies in adult learning entailed integrated EI learning experiences in various subject matter contexts during multiple weeklong activities rather than isolated EI intensive training sessions (Hodzic et al., 2017; Kotsou et al., 2018; Schoeps et al., 2019). Therefore, student internships in engineering industries may be considered as an intervention in postsecondary engineering education that may provide the lacking course-integrated development of EI competencies in students (Hadgraft & Kolmos, 2020; Hora, Parrott, & Her, 2020; Marsono et al., 2017). However, I could not find studies that exhibit EI measures in interning engineering students in the literature.

The literature also provided findings on influencing factors on EI measures that needed to be addressed to minimize confounding variables for my study. Gender and age have been recognized by several EI theorists (Boyatzis, 2018; Goleman, 2018; Petrides, 2010, 2021) as factors that may impact EI. However, findings in the literature remained controversial about age and gender as influences on summative or domain EI scores (Bibi et al., 2020; Costa et al., 2021; Encinas & Chauca, 2020; Lawson et al., 2021), depending on cultural differences in the upbringing of individuals (Esnaola et al., 2017; Meshkat & Nejati, 2017) or on the choices of the applied EI measures (Aloiseghe, 2018). Furthermore, global EI scores alone may miss the intricacy of EI development in each EI domain due to averaging of scores (Esnaola et al., 2017). The general consensus in the literature was that existing EI learning strategies were widely focused on improving specified EI domains with less emphasis on global EI (Bartz et al., 2018; Naseem, 2018; Mattingly & Kraiger, 2019; Suleman et al., 2019). This showed the importance to obtain and analyze EI domain scores for a meaningful interpretation of inter- and intrapersonal competencies in adult education.

In conclusion, EI training strategies in higher education with long-term development of inter- and intrapersonal competencies in students are feasible and are needed in technical disciplines and postsecondary engineering programs (Fakhar et al., 2019; Feijoo et al., 2019; Hirudayaraj et al, 2021; Skipper et al., 2017). As best practices in EI training followed integrated approaches that blended EI learning with existing content knowledge in the related field of study and, ideally, in conjunction with experiences in real-world applications (Kotsou et al., 2018), student internships in engineering industries seemed to align with addressing these professional learning outcomes. However, despite the understanding of the many benefits of student internships in engineering education, EI had not been assessed in interning students, and it remained unclear in the literature whether global or domain EI scores differed in undergraduate engineering students based on the participation in an internship in engineering industries.

Problem Statement

Contemporary engineering education has not adjusted to address the shifting demands on engineers (Skipper et al., 2017). Traditional engineering education has emphasized technical aptitude with little incentive to teach social-emotional skills (Goldberg et al., 2016), but the expectations on professional engineers have changed from individual contributions to solve isolated engineering problems to teamwork performances with high social values working with and for people (Boyatzis et al., 2017;

Gilar-Corbi et al., 2018; Hirudayaraj et al., 2021). Career success and effectiveness in engineering occupations have rapidly shifted to reward creativity, custom-design, and collaborative solutions developed in multidisciplinary teams (Boyatzis et al., 2017) or serving multicultural clients and customers (Miao et al., 2018), which necessitates strong social-emotional skills. Though EI competencies have been shown to positively relate to entrepreneurial thinking (Miao et al., 2018) and to be the leading predictor of professional success in engineering (Fakhar et al., 2019), contemporary engineering education remains focused on highly cognitive and technical competencies (Encinas & Chauca, 2020; Hirudayaraj et al., 2021; Lappalainen, 2017; Yong & Ashman, 2019).

In addition, Boyatzis et al. (2017), Fakhar et al. (2019), and Skipper et al. (2017) reported that the level of EI in engineering students needs improvement, although Skipper et al. (2017) found that longer work experiences in a professional engineering environment positively correlated with higher EI scores in undergraduate engineering students. Because real-world professional experiences can be attained in pregraduation internships, student internships in engineering industries were suggested as a potential strategy to enhance interpersonal and EI skills in engineering students (Bae et al., 2022; Feijoo et al., 2019; Skipper et al., 2017). Although researchers have investigated many benefits of internships in postsecondary education, I could not find any literature on internships in engineering education that included EI measures. To lay the ground for research on the role of internships regarding EI development in engineering students, it was essential to understand any differences between students with and without internships experiences. Comparing EI levels in undergraduate engineering students may assist to address this problem with today's postsecondary engineering education.

The specific research problem that was addressed through this study was the lack of understanding on whether undergraduate engineering students' levels of EI differ based on the participation in an internship in engineering industries or not. Internships in engineering industries have been shown to enhance self-development and professional competencies in engineering students (Marsono et al., 2017) and to impact undergraduate students' professional and personal growth in general (Anjum, 2020). Besides, students conceptualized internships as self-exploratory experiences, which led to clear differences in the complexity of student's perceptions of their own professional competencies and in working with others between students with and without an internship experience (Hora, Parrott, & Her, 2020). These findings indicated a connection between internships in professional industries and EI development in students, including factors of self-development and sociability, though, the authors did not examine EI scores. Vanhanen et al. (2018) pointed out issues with customer satisfaction when engineering students had to deal with client expectations that require social-emotional skills, whereas Feijoo et al. (2019) highlighted the gain of interpersonal skills from internships in engineering programs that led to improved employability in engineering industries. The opposing viewpoints on internships highlighted the need to understand whether EI differences exist between undergraduate engineering student who participated in internships in professional industries compared to those who did not.

Purpose of the Study

The purpose of this quantitative study was to determine whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries when controlled for gender and age. Age, as a measure of accumulated life experiences, and gender, as found as an influencing factor on EI scores in the literature (Petrides, 2009a), were controlled for to minimize confounding factors that impact EI scores independent of the internship experiences. To fulfill the purpose of this study, I obtained global and domain EI scores from undergraduate engineering students with and without participation in an internship in engineering industries during their postsecondary undergraduate engineering education. I compared the EI scores of the two student groups with and without internships in engineering industries to determine whether there were differences in EI scores based on the participation in the internship experience.

Research Question and Hypotheses

The research question was whether there was a difference between undergraduate engineering students' EI scores with and without participation in internships in engineering industries when controlled for age and gender. In this posttest-only-with-control-group design, I examined whether undergraduate engineering students, who did or did not participate in an internship in engineering industries, exhibited different global and domain scores of EI. The research question had five hypotheses in alignment with the theoretical framework according to Petrides's (2010) EI construct, which are outlined in Table 1.

Table 1

Research Hypotheses Breakdown for EI Domains Based on Petrides (2010)

H	H_0	H_a	Dependent Variable	Independent Variable	Covariates
1	There is no statistically significant difference in global EI scores of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	There is a statistically significant difference in global EI scores of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	Global EI scores		
2	There is no statistically significant difference in the EI domain scores for emotionality of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	There is a statistically significant difference in the EI domain scores for emotionality of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	EI domain scores for emotionality		
3	There is no statistically significant difference in the EI domain scores for sociability of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	There is a statistically significant difference in the EI domain scores for sociability of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	EI domain scores for sociability	With or without participation in an internship in engineering industries	1.Age 2.Gender
4	There is no statistically significant difference in the EI domain scores for wellbeing of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	There is a statistically significant difference in the EI domain scores for wellbeing of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	EI domain scores for wellbeing		
5	There is no statistically significant difference in the EI domain scores for self-control of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	There is a statistically significant difference in the EI domain scores for self-control of undergraduate engineering students with and without participation in internships in engineering industries when controlled for age and gender.	EI domain scores for self-control		

Note. H=Hypothesis, H_0=Null Hypothesis, Ha=Alternative Hypothesis

Theoretical Framework for the Study

The theoretical foundation for this study was Petrides's trait EI theory (Petrides, 2010) and Petrides's radix intelligence model (Petrides, 2021). Petrides (2010) conceptualized EI as a globally applied framework that integrates emotions, personality traits, and intelligence. Petrides (2010) described EI as emotional self-efficacy and utilized several existing EI constructs from the literature (Bar-On, 2006; Goleman, 1995; Salovey & Mayer, 1990) to develop global and four domain measures of EI consisting of 15 facets. Besides the global EI score with facets of adaptability and self-motivation, the four EI domains are (a) emotionality with facets of emotional expression and perception, empathy, and personal relationships; (b) sociability with facets of emotion management, assertiveness, and social awareness; (c) wellbeing with facets of optimism, happiness, and self-esteem; and (d) self-control including emotion regulation, low impulsiveness, and stress management (O'Connor et al., 2019). Petrides's (2010) EI model was based on self-perception of intra- and interpersonal skills that can be moderated by changes in one's self-construct due to life experiences.

Fluctuation of trait EI scores across diverse contexts was explained by the radix intelligence model (Petrides, 2019, 2021). The model presents radix intelligence as the inherited genetic ground that is shaped through an individual's self-construct when thinking begins in one's life. The self-construct is in constant change through lived experiences, which emerges in a manifold of major traits with adaptive values of emergence and intensity of trait EI facets and factors (Petrides, 2021). Based on this theoretical model, trait EI could be enhanced through experiences. An internship in the profession may provide the experiences that engineering students need to stimulate their self-construct to develop higher EI competencies.

Determining whether global or domain EI scores in undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries revealed some information whether internships were worthwhile to be further explored as interventions in engineering undergraduate education to address EI competencies in the curriculum. Furthermore, based on Petrides's (2010) four-EI-domain theory, the identification of differences in one or more EI-domains with or without internship participation may serve as a basis for further correlational investigations of social-emotional components that internships may affect in an engineering students' professional development.

Nature of the Study

This basic quantitative study was justified for several reasons. In the posttest-only-with-control-group design, I measured global and domain EI scores and collected demographic data of 206 undergraduate engineering students across U.S. universities at a single time point. Internships in engineering programs are conducted at different times during the academic education, usually within in the junior and senior year of a 4-year engineering degree program. Furthermore, not every educational institution offered student internships, and if so, they fall under a technical elective or voluntary extracurricular activity (see Kapoor & Gardner-McCune, 2020). Therefore, the posttest-only-with-control-group design was an appropriate approach when some students had and others had not participated in internships, and pretest data were not feasible nor practicable to collect (see Burkholder et al., 2016).

Petrides (2009b) developed an array of instruments that measure trait EI in a variety of circumstances. Besides a 153-item long version for adults, Petrides (2009b) also introduced a short form of the TEI questionnaire (TEIQue-SF), which contains 30 self-reported questions relating to the same four factors of EI as the long version. All answers in the TEI questionnaires were recorded on a continuous Likert scale, assessing the agreement with a given statement (Psychometric Lab, 2021b). The short form of the TEIQue was more feasible to collect survey responses from a large number of participants across the United States with less time commitment for each participant. The dependent variables were a global EI score and four EI domain scores. The independent variable was the membership in one of the two student groups, with and without the voluntary participation in an internship in engineering industries. Age and gender were controlled for as covariates. A possible relationship between internships in engineering industries and EI scores of engineering students have been suggested in the literature (Skipper et al., 2017) but lacked empirical evidence. Furthermore, engineering students have been reported to perceive their own social-emotional competencies differently based on the participation in an internship (Hora, Parrott, & Her, 2020), but actual EI scores had not been recorded. It had not yet been reported in the literature whether there was a difference in EI scores between engineering students who have or have not participated in an internship in engineering industries. Answering this question may be helpful to lay the groundwork for further research on how, why, and in what capacity internships may be useful in EI development in engineering students.

I statistically analyzed data from collected multidimensional TEIQue scores with ANCOVA (for global EI) and MANCOVA (for the four EI domains) procedures while controlling for other known factors that influence EI, such as gender and age (see Petrides, 2009b; Skipper et al., 2017). Comparing collected TEIQue scores of the two categorical groups provided information on whether there are statistically significant differences between EI scores of undergraduate engineering students with and without participation in an internship in engineering industries. The quality and length of internships in engineering industries was defined in the inclusion criteria for participants. By controlling for confounding variables as covariates, such as age and gender, the categorical internship experience was emphasized as the independent variable of interest. EI scores as dependent variables were continuous measures, which aligned with the use of ANCOVA family statistics (Frankfort-Nachmias & Leon-Guerrero, 2018).

Another reason for this quantitative study was related to the purpose of determining whether significant differences in EI scores existed based on group memberships in students with and without internships. Statistically significant differences in outcome variables based on categorical group membership in an intervention and control group can be used to evaluate influences of interventions when confounding variables are minimized (Warner, 2013). Although causal explanations could not be drawn from this basic quantitative study, differences found based on group membership may lead to further research on the reasons why and how emotional intelligence skills are impacted.

Definitions

Emotional intelligence (EI): A 21st-century construct involving "a cross-section of interrelated emotional and social competencies and skills that determine how effectively we understand and express ourselves, understand others and relate with them, and cope with daily demands" (Bar-On, 2006, p. 14).

Emotionality: A factor of EI related to the self-perception and expression of emotions (Petrides, Pita, & Kokkinaki, 2007).

Global EI: A broad index of measured EI related to general emotional functioning (Petrides, 2009b).

Internship: A minimum of 12 weeks of temporary student work in a field-related company on an engineering design project under the supervision of an engineer from the industries for educational benefits for the student (see Heatherfield, 2020; NACE, 2018; U.S. Department of Labor [Factsheet #71], n.d.).

Interpersonal skills: Essential skills involving dealing with and relating to other people (McConnell, 2004).

Intrapersonal skills: Various skills and attitudes involving dealing with yourself, such as self-reflection, self-care, and self-regulation (Lombardo et al., 2019).

Perception: To use the senses to construct understanding or interpret a situation (Bruner & Postman, 1949).

Radix-intelligence: Primal energy underpinning mind activity, which is shaped through one's experienced self-construct into various levels of cognitive and emotional intelligences (Petrides, 2021).

Self-construct: An individual's self-perception, which has a causal influence on their life by affecting cognition, emotion, perception, and action (Petrides, 2021).

Self-control: A factor of EI related to the regulation of emotions and impulses (Petrides, Pita, & Kokkinaki, 2007).

Sociability: A factor of EI related to the interpersonal utilization and management of emotions (Petrides, Pita, & Kokkinaki, 2007).

Trait emotional intelligence (TEI): A globally applied framework that integrates emotions, personality traits, and intelligence (Petrides, 2010).

Wellbeing: A factor of EI related to the reflection of dispositional moods (Petrides, Pita, & Kokkinaki, 2007).

Assumptions

This study was based on several assumptions. First, I assumed that participants were honest in answering the survey questions about their enrollment in engineering degree programs and their perceptions on emotional intelligence related questions. This assumption was important in lending credibility to the study. Second, I assumed that the findings in this study represent an objective nature of reality. Although I could not control the equality of non-measured population characteristics in the internship and control group in this quasi-experimental, post-test-only-with-control-group research design, I assumed that non-assessed population characteristics averaged out through the inclusion of diversity across various colleges in the United States, and relatively large numbers of participants to present a reality as close to objectivity as possible.

Scope and Delimitations

The scope of this study was based on certain study boundaries related to the purpose, methodology, and framework of this study. The purpose was to obtain information on EI scores in undergraduate engineering students across a wide range of students from various backgrounds. Short surveys completed by a large number of participants provided the best method to obtain this data and to perform statistical analysis. The EI questionnaire in the survey was directly related to the EI framework based on Petrides's EI model (Petrides, 2009a, 2010, 2021) and the author's EI instrument (Petrides, 2010). The framework was the best choice for this study since it allowed for the concept of trainability of EI, was used to assess multiple domains of the EI construct (Petrides, 2021), and it relied on an established assessment instrument (Petrides, 2009a). In turn, this decision on the framework shaped the scope of the study subsequently since hypotheses were aligned to the domains of the chosen EI framework.

There were three delimitations of this study. Though I could have collected data on many students, my focus was on postsecondary engineering education. Therefore, I only selected students as participants who were currently enrolled in a 4-year undergraduate engineering program in a postsecondary institution. Furthermore, I excluded students who already completed the current or another secondary postsecondary degree to minimize the influence of maturation. General life experiences or maturation are known to be influential on EI development in young adults (Skipper et al., 2017), and by targeting a short time window in the education of engineers, I minimized influences from other life experiences outside the engineering curriculum as much as possible. Further, 76% of all undergraduate postsecondary students in the United States enter college directly after high school (Miller, 2019) with little experience to work in engineering industries prior to entering college. Age, as confounding factor even within the delimited sample, was also controlled for as covariate.

Another delimitation was the definition of an internship in engineering industries. Internships in industry during postsecondary engineering education were offered as extra-curricular activities or as technical electives, were usually encouraged, but were not distinctly listed as graduation requirements in course catalogues of engineering colleges across the United States. The U.S. Department of Labor (n.d.) defined an internship as an activity in industry that is for the benefit of the students' development and entails certain criteria of length and professional engineering supervision. This definition was used as delimitation to separate students with and without internship experiences during their time in the undergraduate engineering program.

Lastly, I could have collected data from undergraduate students at all engineering colleges across the United States by addressing each university separately. However, my time in undertaking this study was a delimiting factor while I tried to reach a diverse student population across a wide geographical range of postsecondary institutions. Therefore, I decided to recruit participants through professional engineering societies and professional engineering groups and collected data at a single time point, which did not limit participants to specific partnering institutions. For time delimitations, I also stopped recruiting when I reached the targeted sample size number of 200–260 undergraduate engineering students. Overall generalizability of study results can be applied to undergraduate engineering students across the United States but not to students of other disciplines.

Limitations

The research design of a study often creates limitations. The posttest-only-with-control-group research design limited rigid randomization in group membership in comparison to truly experimental studies (Trochim, 2005). At the time of collecting survey answers from participants, however, the participation in an internship was already established, and group membership was not influenced by the participation in this study. Pre-internship data were not available to me since the internships had already taken place at different time points within the junior and senior years at different institutions. The trustworthiness of a study is based on a good balance between internal and external validity, but a posttest-only-with-control-group studies provides a solution when pretests are not available or not doable (Burkholder et al., 2016). Another limitation of this study was instrumentation threats since the EI questionnaire relied on self-reported answers only. However, the author of this EI instrument, Petrides (2009b), recognized this limitation as a desirable fact because the associated EI measure reflected the inherent subjectivity of emotions that should be part of the assessment strategy to produce valid and applicable data. Lastly, this study was limited in capturing confounding variables from various environmental influences in internship experiences. Although the test group without internships served as control group without the experience or activity, environmental nuances would need to be detailed in a qualitative approach (see Nguyen et al., 2019). This basic quantitative study was limited to reporting group differences and was not able to nor was intended to provide causal comparative conclusions on the findings (see Warner, 2013).

Significance

The significance of a study can be judged by the potential contributions made to advancing knowledge in postsecondary engineering education. This study was significant because it (a) adds basic knowledge about differences in engineering students to the body of literature, (b) helps inform stakeholders of engineering education whether further research on the reasons for potential differences in engineering students based on internship participation is needed, (c) helps to expand on what is understood about the benefits of internships for students in engineering industries, and (d) contributes to positive social change by evaluating the usefulness of internships to be further explored as practical interventions for EI competence building in postsecondary engineering students.

First, numerous studies have indicated that EI competencies in undergraduate engineering students needed to be improved (Boyatzis et al., 2017; Fakhar et al., 2019; Hirudayaraj et al., 2021; Skipper et al., 2017). Additionally, internships in engineering industries have been described to lead to clear differences in students' perceptions of their own professional competencies and capability to work with others (Hora, Parrott, & Her, 2020). These qualitative findings indicated possible differences in EI scores of engineering students based on the participation in an internship, including differences in domains of self-development and sociability, both factors of the utilized EI construct (Petrides, 2010). However, direct measures of EI scores with and without internship participation in engineering education had not been reported in the literature.

Second, observational results from this basic study indicated small differences in EI scores of undergraduate engineering students, leading to further investigations on how internships may impact engineering students' development related to their ability to deal with people and handle their own emotions, in addition to technical skills. Collective findings of this and follow-up studies may inform curriculum decisions in undergraduate engineering education to address a shortcoming of EI development for the successful 21st-century engineer (see Bae et al., 2022; Fakhar et al., 2019; Hirudayaraj et al., 2021). Providing future engineers with a holistic education that includes social-emotional (Vanhanen et al., 2018) and EI (Skipper et al., 2017) development may help meet the demands placed on engineers in today's highly technical, very collaborative environments (Goldberg et al., 2016). Ultimately, this study contributes to social change by helping to inform policy and decision making in engineering education on possibilities of future research and practice to improve the education of tomorrow's successful and holistic engineers.

Summary

In Chapter 1, I introduced this basic quantitative study on undergraduate engineering education based on the recent literature of students' EI development and internships in engineering industries. I defined the problem as the skill gap between EI competencies that engineering employers expect, and engineering students lack to develop in postsecondary engineering education. Although internships in engineering industries have a potential to fill this shortcoming, empirical evidence about the existence of differences in EI levels related to internship participation have not been reported in the literature. The purpose of this study was to determine whether EI scores of undergraduate engineering students differs based on the voluntary participation in an internship in engineering industries when controlled for gender and age. Based on Petrides's (2010) trait EI model, I developed the research question and related hypotheses in alignment with the theoretical framework, investigating the existence of differences in students' global and domain EI scores with and without the participation in internships in engineering industries. In this chapter, I also explained the nature of the study, the delimitations of the posttest-only-with-control-group design, population limitations, and the influences of confounding variables. Last, the justified study's significance lays in informing policy and decision makers to determine whether internships should be further investigated to improve students' EI in postsecondary engineering education.

Chapter 2 provides more details on related literature, includes a description of the literature search strategy, and a detailed discussion of Petrides's (2010) trait EI model and framework used in this study. I will present a thorough examination of related literature about internships in postsecondary engineering education, EI in postsecondary students of technical disciplines, and the trainability of EI skills through experiences. I will explain how this study will address a gap in the literature to understand whether the EI of undergraduate engineering students differs based on the participation in internships in engineering industries leading to further understanding of the usefulness of internships for a holistic education of tomorrow's successful engineers.

Chapter 2: Literature Review

The problem addressed in this study was the lack of understanding on whether undergraduate engineering students' levels of EI differed based on the participation in an internship in engineering industries. Internships in engineering industries have been identified as desirable activities in engineering education to prepare engineering graduates for the workforce, but their relationship to engineering students' EI remained undetermined. The first step in illuminating a connection between internships and EI development in engineers' higher education was to determine whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries. I reviewed literature on trait EI constructs that allowed for the learnability of EI through experiences. I chose Petrides' (2010) EI model and assessment instruments as the most appropriate and practical theoretical framework for the purpose of this study.

Chapter 2 includes information about the search strategies employed in locating research relevant to this study. The second section is devoted to describing the theoretical framework underlying the EI construct in alignment with the research question of this study. Finally, the remainder of the chapter is devoted to reviewing and synthesizing the relevant literature on internships and EI. This literature review is divided into three sections. First, I focus on internships in postsecondary engineering education. Second, I look at EI in postsecondary students of technical disciplines, including employers' and engineering alumni's perceptions of the need and value of EI in engineering education. Third, I review the trainability of EI skills through experiences, including discussions of existing strategies to develop EI in higher education, as well as gender and age influences on EI. Finally, I summarize major findings and the connections between the literature review topics to illuminate the research gap that this study has addressed.

Literature Search Strategy

The literature in this review was sourced from peer-reviewed academic journals, books, dissertations, conference proceedings, and research reports published within the last 5 years. A few seminal publications older than 5 years were included to underline applications of the theoretical framework most relevant to my topic. The databases used included Psycho Academic Search Complete, PsycTESTS, Health and Psychosocial Instruments, Business Search Complete, Education Source, ERIC, Sage Journals, Google Scholar, ScienceDirect, ProQuest, and Walden University's database, Thoreau. Table 2 shows the keywords used in various combinations in the search for the literature. The reference list of particularly relevant articles revealed additional authors and publications that deepened the review. The search for literature in this study was iterative, with many probes continuing until the same sources reappeared or the topics veered too far from my purpose, ensuring saturation.

Table 2

Research Topics and Search Terms

Research topic	Search term
Internships in engineering education	Definition of internships, engineering internships, real-world experiences in engineering, extracurricular experiences, CO-OP, parttime work in engineering, apprenticeship, effects of internships, professional engineering experiences, work experiences, benefits of student internships, challenges of student internships, internships learning outcomes
Emotional intelligence in technical disciplines	Emotional intelligence, socioemotional skill, emotional competence, intrapersonal skills, interpersonal skills, soft skills, assessment of emotional intelligence in higher education, ABET, outcomes, 21st-century skills in engineering, wholistic engineering education, EI effects, EI measures, EI training, EI development
Need for socioemotional skills and value in engineering	Communication skills in engineering students, Teamwork skills in engineering, wholistic engineering education, employability skills, employability in engineering, cognitive stressors in engineering, stress coping in engineering, conflict resolution and EI, diversity, socio-emotional competencies, professional competencies, leadership, entrepreneurship, innovation, creativity and EI
Alumni perspective	Engineering graduate perspective, engineering alumni view, perceptions or attitudes or opinions or views
Employer perspective	Employer or industry perspective on soft skills, social skill level, perceptions or attitudes or opinions or views, employability skills for engineers, entry-level engineer's attributes
Methodology	Quantitative, posttest-only-with-control-group, quasi-experimental

Initially, I sought to understand the literature on emotional intelligence in education. However, an overwhelming number of peer-reviewed articles surfaced. Narrowing the search terms only to *higher education* and to *technical disciplines* focused my literature searches substantially. Any publications with primary or secondary students and any EI child assessments were removed from my search lists and stored separately. Because I found diverse definitions of EI with varying understandings of EI constructs, I focused on articles that included trait EI models, which generally assessed typical performances with room to learn rather than maximal performances. I researched the development and trainability of EI through life experiences and examined existing strategies to include EI in higher education. I also looked at literature addressing gender and age influences on EI.

Furthermore, I investigated EI in postsecondary students of technical disciplines compared to non-technical disciplines and the value of EI in technical disciplines. The latter topic included research on contemporary stakeholders' perceptions on the need of EI in technical disciplines to illuminate the understanding that engineers mainly need to focus on highly cognitive competencies and technical skills to be successful and employable in engineering professions (see Hadgraft & Kolmos, 2020; Kolmos & Holgaard, 2018). I limited my literature review to the perceptions of employers of engineering graduates and engineering alumni because these two stakeholder groups were most competent to examine the needs of engineers in today's workforce. I also performed literature reviews on the characteristics and values of internships in engineering industries during the postsecondary education of engineering students. This review included benefits and challenges of internships as temporarily, short-term work experiences of engineering students in a professional, real-world environment in engineering industries. Finally, I looked at literature that addressed the effects of internships on student competencies in higher education to determine what is known about the kind of competencies that most likely will be improved through the internship experience and whether they are related to EI.

I organized all literature in topic groups using Google folders and literature review matrices in Microsoft Excel. I also used reference management software, Zotero and Citation Machine. Some references were connected to multiple topic groups, which I color coded to identify connections between the topics and findings. This strategy helped to identify the gaps in the literature and the need for further research related to my topic and research quest.

Theoretical Foundation

The theoretical framework underpinning this study was Petrides's trait EI model (Petrides, 2010). Based on intra- and interpersonal skills needed for engineers in the 21st century, I looked for EI domains that assess these skills. Petrides's EI model offers four domains of emotional intelligence: (a) emotionality with interpersonal skills of emotional expression and relationships, (b) sociability with intrapersonal skills of emotion management and social awareness, (c) wellbeing with intrapersonal skills of optimism and self-esteem, and (d) self-control with intrapersonal skill of emotion regulation, as well as an overall global EI which includes additional EI facets (Petrides, 2010). In this theoretical framework section, I discuss the four domains of Petrides's (2010) EI model, how EI skills can be developed, and a rationale for using this framework in my study.

Petrides's Emotional Intelligence Model

EI models have been around since the 1990s with the intend to create an ability-based construct similar to the IQ concept (O'Connor et al., 2019). However, in contrast to IQ measures that are intended to capture maximal abilities, emotion-focused models for EI failed to produce the expected predictive results for performance or success that could be scored with objective criteria (O'Connor et al., 2019). Second-generation EI models were developed emphasizing widely varying constructs of EI, which led to confusion and controversial reports in the literature (Conte, 2005), but this also initiated the acceptance of self-reported trait EI measures (Ashkanasy & Daus, 2005). Petrides, Pita, and Kokkinaki (2007) suggested a trait EI construct based on emotional self-efficacy that provided a comprehensive operationalization of emotion-related self-perceptions and dispositions.

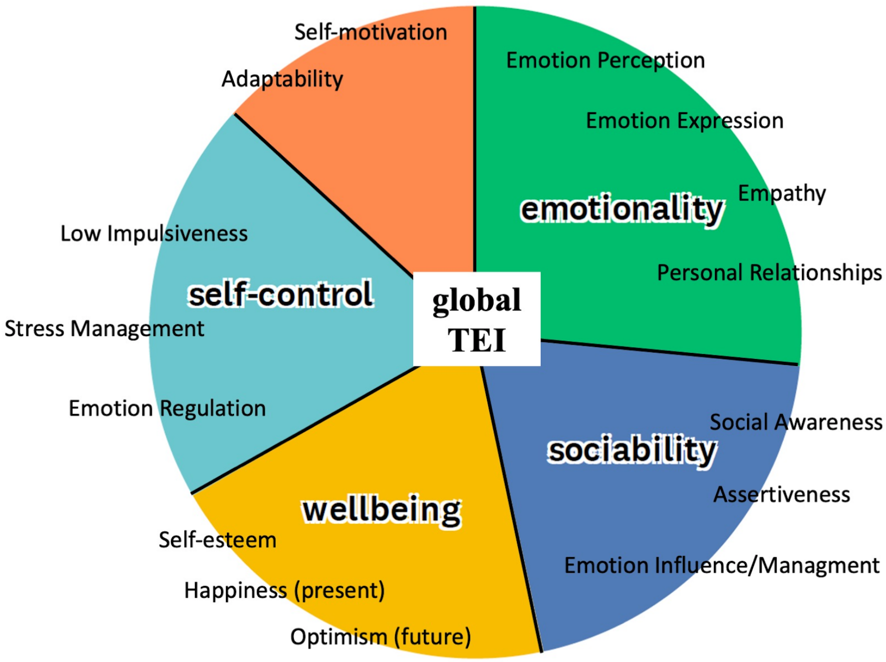
Petrides (2011) distinguished between ability and trait EI by the operationalization of emotions based on Gardner's (1983) work of multiple intelligences with intra- and interpersonal intelligences that focused on the abilities to understand people and act wisely in human relations. Petrides defined trait EI as emotional self-efficacy measured via emotion-related self-perceptions assessed in self-reported questionnaires avoiding right or wrong answers. Based on this understanding of trait EI, Petrides and Furnham (2001) investigated the psychometric properties of Petrides's EI model in reference to established trait taxonomies, combining consistent components from existing EI constructs developed by various EI scholars, such as Schutte et al. (1998), Salovey and Mayer (1990), and Goleman (1995). As a result, Petrides (2011) conceptualized EI as a globally applied framework that integrates emotions, personality traits, and intelligence.

Domains of Emotional Intelligence

Petrides (2011) conceptualized EI skills in a global EI index measuring general emotional functioning from 15 EI facets. However, Petrides also determined four EI domains besides the global EI index through weighing the answers to questions related to specified faucets in each EI domain. Two EI facets, self-motivation and adaptability, did not fall under any of the four determined EI domains and were utilized as additional facets in determining the global EI (Petrides, 2011). Therefore, the global EI provided a different measure than the additive combination of the four domain EI components. The four EI domains were detailed in (a) emotionality derived from four EI facets, (b) sociability derived from three EI facets, (c) wellbeing derived from three EI facets, and (d) self-control derived from three EI facets. A graphical representation based on Petrides (2009b) is presented in Figure 1.

Figure 1

Petrides's (2011) Trait Emotional Intelligence Framework



Note. The 15 facets of TEI are positioned with reference to their corresponding EI domains. Two facets do not relate to any domain and are referenced under the global EI only. Figure 1 was modified after graphics by Petrides (2009b) and was reprinted with permission from the London Psychometric Laboratory (www.psychometriclab.com) by K. V. Petrides. © Copyright K. V. Petrides 1998. All rights reserved (see Appendix G).

According to Petrides (2009a, 2009b), emotionality is related to the perception and expression of emotions. The level of perceiving one's own and other people's feelings as intrapersonal skills may lead to rewarding personal relationships and interpersonal skills expressed through empathy and in close relations to others. High scores in the emotionality factor, measured between 1 and 7 on a Likert scale, show good skills in recognizing one's own emotions and in decoding others' emotions and communicating emotions accurately and unambiguously to others. Emotionality also includes empathy, the skill to understand other people's needs and desires and to see the world from someone else's point of view. This leads to skillful conversations and negotiation skills in relationships with others as behavioral outcomes.

Sociability is defined by Petrides (2009a, 2009b) as interpersonal skills of social influence-building with a focus on positive behavior in social contexts. Good listening skills and feeling comfortable in diverse social interactions lead to higher scores in the sociability domain, measured on a Likert scale between 1 and 7. Sociability also includes emotion management concerning one's perceived skills to manage and influence other people's emotional states, such as "calm them down" or "motive them." Assertiveness in standing up for one's rights and beliefs is part of high sociability levels and aligns with certain leadership skills. Furthermore, sociability entails the facet of social awareness, which leads to good networking skills, even when confronted with unfamiliar social settings. The domain sociability differs from emotionality in that that it emphasizes behaviors in social relationships.

Wellbeing, as understood by Petrides (2009a, 2009b), reflects a generalized sense of intrapersonal wellbeing, extending from past achievements to future expectations. High levels of wellbeing scores, measured on a Likert scale between 1 and 7, relate to feeling happy, positive, and fulfilled with one's life. That includes the level of self-esteem or the overall self-evaluation of oneself and one's life in the past. Wellbeing also includes experienced optimism for the future and the ability to pursue new opportunities.

Finally, experiences in the present contribute to the facet of happiness. The wellbeing domain reflects the general psychological state at this moment in time in one's life.

Self-control is regarded as intrapersonal emotion regulation skill (Petrides, 2009a, 2009b). High levels of self-control, measured on a Likert scale between 1 and 7, present a healthy degree of control over one's urges and desires. In addition to controlling one's own impulsive behavior, the self-control domain includes the regulation of external pressures and stress. High emotion regulation skills can redirect unpleasant moods or prolong pleasant moods through conscious personal insights and effort. Actions, such as "thinking before doing" or "reflecting before making decisions" lead to low impulsiveness without being overly cautious. High levels of self-control also include the intrapersonal development of stress-coping strategies to deal with external tension.

Petrides (2009a, 2009b) also established a global EI index of general emotional functioning in addition to the four EI domains, which is different from a sum of measured EI facets. Instead, the global EI is determined by emphasizing certain aspects of the EI construct by placing different weights on individual facets and including two additional EI facets which are not embedded in any of the four subdomains: adaptability and self-motivation. Adaptability is reflecting the level of flexibility in the approach to one's work and life. It shows the level of comfort with change and adaptation to new environments and conditions. Self-motivation reflects the level of intrinsic motivation and perseverance and less reliance on external incentives or encouragement to produce high-quality work.

In summary, Petrides (2009a) four-domain trait EI model reflects the skills and behaviors that engineers of the 21st century seem to need: (a) understanding customer's needs (see Vanhanen et al., 2018) as addressed in the emotionality domain, (b) being effective communicators and feeling comfortable working in multicultural or unfamiliar team settings (see Miao et al., 2018) as reflected in the sociability domain, (c) projecting a confident and positive outlook on engineering solutions reflecting professional success (see Boyatzis et al., 2017; Fakhar et al., 2019) as mentioned in the psychological wellbeing domain, and (d) showing a healthy level of emotion regulations with low impulsiveness without being overly cautious to push innovation forward as reflected in the self-control domain. Furthermore, Petrides included perseverance, self-motivation, and adaptability in the global EI score, which are critical components to drive innovation, entrepreneurship, and engineering design forward to solve individual or global problems (see Boyatzis et al., 2017; Hirudayaraj et al., 2021). Besides, researchers have found a positive correlation between higher levels of EI and an increased likelihood of entrepreneurial career choices in undergraduate students (McLaughlin, 2019). Therefore, Petrides' (2011) EI model is an excellent theoretical foundation to assess social behaviors and skills that rely on internal and external awareness, emotional self-regulation, and positive relationship-building with others as needed for the collaborative and multidisciplinary environment of emerging engineers in the 21st century (see Goldberg et al., 2016).

Development of Emotional Intelligence Skills

Vernon et al. (2008), who conducted extensive research with twins on genetic associations with trait EI, found that 40% of the variability in global trait EI was due to genetic factors and 60% to environmental factors. However, Petrides (2009b) explicitly emphasized that the trait EI model he proposes represents EI as self-perceived emotions and skills that can be manipulated through conscious efforts and training as well as being developed through life experiences leading to changes in social behaviors. Other authors, such as Nelson et al. (2017) have taken the idea of learning EI through constant awareness and continuous practice to an even higher, transformational level applied in leadership theory. Many authors agreed that EI is generally understood as a learnable and teachable skill that impacts social behaviors (Boyatzis, 2018; Nelson et al., 2017; Nguyen et al., 2019; Petrides, 2021).

Petrides (2019) theorized about the initial development of one’s EI through interpreting of one’s own experiences of the phenomenal world, which gets progressively transmuted into thinking, feeling, perceiving, and finally acting in the world. Petrides (2021) introduced the Radix Intelligence model explaining how levels of various EI domains develop throughout one’s life based on changes in one’s perceived self-construct. In the Radix Intelligence model (Petrides, 2021), the self-construct serves as a refraction filter for the primal unitary energy of Radix Intelligence underpinning all mind activity. The assumption in the Radix Intelligence model (Petrides, 2021) is that multiple EI domains emerge and vary throughout life, based on experiences that influence one’s self-construct. Consequently, measurements of global and factorized domains of EI rely on self-perceived emotions and skills at that moment in time. Changes in one’s perceived self-construct, for example, through an array of intended or unintended lived experiences, may lead to the adaptation of values in the emergence and intensity of varying trait EI domains within the multiple EI construct (Petrides, 2021).

Petrides' (2021) EI model with the possibilities to consciously influence EI levels through experiences and training appealed to this study because internships may be regarded as desired life experiences that prepare engineering students for the social-emotional expectations in today's engineering professions (see Feijoo et al., 2019). Petrides' (2009a) instrument was used in this study to measure trait EI at a snapshot of a student's life to determine whether there are differences in undergraduate engineering students with and without the experience of an internship in engineering industries. It was unclear if students with higher EI levels choose to engage in an internship or if the internship itself contributed to higher EI levels in participating students. However, the first step to initiate further research about the reasons and implications of internships in engineering industries in postsecondary education for engineers was to determine whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries. This study was designed to answer that question based on Petrides' (2010) trait EI model and Radix Intelligence theory (Petrides, 2021).

Rationale for Using the Framework

Petrides' (2010) EI framework was developed to guide research on intelligence and personality traits in the field of psychology. The challenges in the field were to accurately assess emotions and the emotional mind, which had led to controversial commentaries on EI in the literature depending on various definitions of EI (Boyatzis, 2018). Petrides (2010) classified their trait EI model and instrument as assessment of personality trait, self-perception, and behavioral skills. Petrides and Furnham (2000) had stated in one of their earlier publications that, because their trait EI measures tend to measure typical behavior rather than maximal performance, they tend to provide a good prediction of actual behaviors in a range of situations. Because of Petrides' (2011) inclusion of behaviors, or in other words, EI competencies in social contexts, this EI approach was appealing to be applied to educational settings. Boyatzis and Cavanagh (2018) reported that EI approaches with focus on behavioral changes were used in many colleges and universities in undergraduate courses on leadership, business, management, among others.

In addition, Petrides (2010) rationalized the use of self-reported measures in trait EI assessment as intentional because of the inherent nature of emotions being based on experienced self-perceptions that can be revealed in snapshots of the physiological state of mind in time. Derksen et al. (2002) found that EI develops until age 35, peaks in the 35-44 age interval, and decreases in older age. Therefore, using self-reported measures in my study with university students in the developmental stage in early adulthood was a good fit for assessing undergraduate engineering students. Furthermore, Shipley et al. (2017), one of the first influential scholars in the field, used Petrides' EI instrument TEIQue-SF, the same instrument I used in this study, and reported a positive correlation between Petrides' (2009a) trait EI and longer work experiences in undergraduate business students. Shipley et al. (2017) mentioned that these study findings may apply to engineering students or similar technical disciplines as well. I have been building on this knowledge in the literature by applying the existing theory of Petrides' (2010) EI model to examine EI scores of undergraduate engineering students with and without internships in engineering industries. In the context of my study, I regarded internships as exposure to the professional engineering world that simulated first work experiences.

Furthermore, Petrides' (2010) EI theory has been widely established in the literature and applied to many circumstances by various scientific scholars. Related examples to my study were Finnigan and Maulding-Green (2018), who used Petrides'(2009a) TEIQue instrument to compare the EI of school administrators who had just started and who had had more than 10 years of work experience in their positions. Fakhar et al. (2019) utilized a self-reported questionnaire based on Petrides' (2009a) EI model to investigate the impact of EI on academic performance of engineering students, and Ahmed et al. (2019) used the TEIQue-SF for the prediction of academic achievement in the higher education of management students. Table 3 summarized examples of publications from the past four years alone, providing an overview of how widely Petrides' (2010) EI model was utilized. Various topic areas and disciplines that use Petrides' (2009a) TEIQue-SF instrument and EI model and theory were provided in part 1 (Table 3). Besides various topic areas, Petrides' (2009a) TEIQue instrument has been validated and applied in more than 20 languages, such as Bulgarian, Catalan, Chinese, Farsi, Georgian, German, Greek, Italian, Japanese, Lebanese, Persian, Polish, Portuguese (Brazil), Scottish, Serbian, Spanish, Chilean, Swedish, Urdu, Slovak, and Turkish, which was provided with example publications in part 2 (Table 3).

Table 3

Topic Areas and Languages of Publications Using Petrides's (2010) EI Model

Part 1: Topic Areas	Publications
Education	Ashouri et al. (2021), Dustman (2019), Fatin & Salim (2020), Gore et al. (2019), Ibrahim & Wah (2020), Khan et al. (2021), Marguerite et al. (2017), Mergal et al. (2019), Nwatu & Gana (2018), Revathy & Arasi (2021), Sanchez-Ruiz & El Khoury (2019), Stevens et al. (2019), Tariq et al. (2020), Wen & Wah (2018), Wilson et al. (2017, 2019), Zafar et al. (2019)
Healthcare, Nursing, Medical/Dental Students, Veterinarian	Al Hosani et al. (2020), Anjum et al. (2017), Compagnone (2019), Costa, Barberis, Larcan, & Cuzzocrea (2018), Crowley et al. (2019), El Boghdady et al. (2020), Montvilaitė & Antinienė (2020), Sharp et al. (2020), Snowden et al. (2018), Sokhi et al. (2019), Štiglic et al. (2018), Vasefi et al. (2018)
Marketing, Business, Professions: Loan Officers, Dancers, Gastronomy, Tourism, Social Workers, Sales	Anastasiadis (2020), Chartschlaa (2020), Farnia et al. (2018), Halkiopoulos et al. (2021), Lagrange et al. (2020), Oboh (2020), Samanta & Kallou (2020), Smith et al. (2020), Thompson et al. (2019), Tycoliz (2021)
Sports and Athletics	Akelaitis & Malinauskas (2018), Kopp et al. (2021), Laborde et al. (2017), Lobinger & Heisler (2018), Nateri et al. (2020), Slizik et al. (2020)
Human Resources	Awwad et al. (2020), Barreiro & Treglown (2020), Furnham et al. (2021), Quintana (2019), Treglown & Furnham (2020), Yadav & Lata (2019)
Psychology and Disease: Family Structure, Romantic Relationships, Mental Diseases, Disorders, Trauma, Diabetes, Obesity, Autoimmune Disease, Disability	Agnoli et al. (2019), Andrei et al. (2018), Aslanidou et al. (2018), Costa, Barberis, Gugliandolo, et al. (2018), Ganaprakasam (2018), Hussain et al. (2021), Kaden (2019), Ke & Barlas (2018), Lawal et al. (2018), Lawrence-Sidebottom et al. (2020), Lehman (2020), Lin et al. (2017), Octari et al. (2020), Persich et at. (2021), Rahmani & Ulu (2021), Rudenstine & Espinosa (2018), Ruggeri et al. (2021), Sanchez-Ruiz et al. (2017), Sesar et al. (2021), Smith et al. (2008), Tuck & Patlamazogloue (2019), Wollny et al. (2019)
Cultural Issues	Chiesi et al. (2020), Dierckx et al. (2021), Ghafoor et al. (2021), Pérez-Díaz, Perazzo, et al. (2021),
Military	Dugger & McCrory (2021), Garcia Zea et al. (2020)
Gaming Addiction, Internet Behavior, and Covid 19 Coping Strategies	Civai et al. (2021), Hazer-Rau et al. (2020), Kircaburun et al. (2020), Leutner et al. (2020), Rubaltelli et al. (2020), Sanchez-Ruiz et al. (2021), Sechi et al. (2020)

Part 2: Languages	Publications
Bulgarian	Kardesheva (2021)
Catalan	Aluja et al. (2016)
Chinese	Dong & Xu (2021), Feher et al. (2019), Wang et al. (2021)
Farsi	Ashouri et al. (2020)
French	Mikolajczak et al., 2007
Georgian	Martskvishvili et al. (2013)
German	Freudenthaler et al. (2008), Ghafoor et al. (2019), Jacobs et al. (2015), Lobinger & Heisler (2018), Wollny & Jacobs (2021)
Greek	Halkiopoulos et al. (2020, 2021), Kyriazopoulou (2021), Stamatopoulou et al. (2016, 2017)
Hindu	Singh et al. (2014)
Italian	Cabras et al. (2020), Chirumbolo et al. (2019), Di Fabio et al. (2016), Mancini et al. (2021)
Indonesian	Fatin & Salim (2020), Febriana (2021), Octari et al. (2020), Salim & Safitri (2020)
Japanese	Abe et al. (2018)
Lebanese	Sanchez-Ruiz et al. (2017), Sanchez-Ruiz et al. (2020)
Persian	Ashouri et al. (2021), Rahimi (2021)
Polish	Szczygiel et al. (2015)
Portuguese (Brazil)	Perazzo et al. (2020)
Scottish	Snowden et al. (2015)
Serbian	Dimitrijević et al. (2020), Marjanović et al. (2021)
Spanish Chilean	Pérez-Díaz & Pedrides (2021)
Swedish	Dåderman & Kajonius (2022), Geisler et al. (2020), Hjalmarsson & Dåderman (2020)
Urdu	Shahzad et al. (2014)
Slovak	Heinzova & Kaliska (2021), Kaliska & Nabelkova (2021), Paskova & Kaliska (2021), Slizik et al. (2020)
Turkish	Denz et al. (2013), Rahmani & Ulu (2021), Ulutas (2017; 2019)

Note. Publications in this list are intended as examples for the wide usage of Petrides's (2009a) TEIQue instrument.

In summary, Petrides's (2010) EI theory has been widely established in the literature, has extensively been used for assessment in higher education, and has shown measured changeable EI competencies in social contexts, which included trainability for desired intra- and interpersonal behaviors. The model has been used to measure four EI domains closely related to competencies that engineers in the 21st century need to be able to work in a collaborative and multidisciplinary environment (see Goldberg et al., 2016; Hirudayaraj et al., 2021). Petrides's (2010) EI model aligned with the five hypotheses of my research question to help determine whether global EI, which was a separate measurement than the sum of the four EI domain scores, and the four EI domain scores for emotionality, sociability, wellbeing, and self-control differ in undergraduate engineering students with and without the participation in an internship in engineering industries. Besides, the use of the short form of Petrides's (2009a) EI instrument was practical for recruitment of a large number of undergraduate engineering students, because its time burden on study participants was minimal as it consists of 30 questions that can be answered within 10 minutes time commitment.

Internships in Postsecondary Engineering Education

In the first section of the literature review, I will present findings on internships in postsecondary engineering education and on how internships in engineering industries are understood and characterized in the literature as an extension of postsecondary engineering training. In addition, I will discuss findings on the benefits and challenges of internships performed in engineering industries during engineering higher education.

Finally, I will synthesize empirical research on effects that internships may have on engineering students' competencies in higher education as reported in the literature.

Characteristics of Internships Performed in Engineering Industries

The mission of engineering education has changed throughout recent history. Engineering training has historically developed out of specific workforce needs around local or national industrial organizations based on the German higher educational model inspired by Humboldt (Schimank & Winnes, 2000). In accordance with the Humboldtian educational model, the traditional mission of engineering education was training for specified industry needs, therefore, requiring a close collaboration between industries and academic educational institutions (Kövesi & Kálmán, 2019). This was still practiced in France with a mandatory internship in engineering industries of nine months during postsecondary engineering education (Kövesi & Kálmán, 2019). However, many countries in Europe followed the Bologna Reform for Higher Education in 1999, which significantly altered the existing national systems of higher education to conform to an agreed-upon model for quality assurance of postsecondary education among university degrees (Johnson et al., 2021). Besides, the Bologna Reform attempted to minimize issues with comparisons of postsecondary degrees between international degree holders, for example between the United States, Canada, and European countries (Johnson et al., 2021). After the educational reform, successful postsecondary degree completion was changed to be based on the number of academic credit units in theoretical knowledge, taking practical experiences very minimal into account (see Johnson et al., 2021). This shift in higher education led progressively to a world-wide drastic weakening of the relationships between industry and academia in the beginning of the 21st century (Kövesi & Kálmán, 2019).

Particularly for undergraduate engineering education, the fundamental changes in the architecture of European higher education through the Bologna Reform started a separation of theoretical engineering education and practical application in the industries (Hedberg, 2003). In the United States and in most countries affiliated with the Bologna Declaration, practical work experiences in engineering industries were not required for an undergraduate engineering degree and only offered as extra-curricular activities or, at best, as technical electives in form of temporary internships, which were utilized by less than 50% of undergraduate engineering students (see Arrayan, 2020; Kapoor & Gardner-McCune, 2020; Laguador et al., 2020; Wolfgram et al., 2021). Very few higher educational institutions in the United States offered an organized integrative model, such as co-ops, between industry and academic experiences as mandatory degree requirement for undergraduate engineering education. As the co-op education represented a distinctly different kind of educational model (see Hora et al., 2017), findings based on co-op experiences were excluded in the literature review for this research study, as they did not apply to internships as specified in the context of this study. Internships in engineering industries, as defined in this research study, were considered experiential learning occasions in a professional environment of a minimum of twelve weeks or one quarter before graduation working in a field-related company on an engineering design project under the supervision of a professional engineer from the industries, intended for the educational benefit of the student and tied to the students' formal education

(Heatherfield, 2020; NACE, 2018;U.S. Department of Labor [Factsheet #71], n.d.). Such internships were usually offered as extra-curricular and volunteered experiences, that may or may not count towards a technical elective among other elective options in the curricula of undergraduate engineering degree programs (see Best Colleges, 2021; UW College of Engineering, 2021).

Characteristics of such internships in engineering industries before graduation followed the definition of the U.S. Department of Labor, as they can be paid or unpaid, and were regulated under the Fair Labor Standards Act (NACE, 2018; U.S. Department of Labor [Factsheet #71], n.d.;). The National Association of Colleges and Employers (NACE, 2018) developed a framework to define the internship experience and identified criteria for determining when internships can be offered ethically and legitimately without pay for the benefit of the students' education. For uniformity in its use and application, NACE (2018) defined internships as:

> A form of experiential learning that integrates knowledge and theory learned in the classroom with practical application and skills development in a professional setting. Internships give students the opportunity to gain valuable applied experiences and make connections in professional fields they are considering for career paths. (para. 6)

According to this definition, internships in engineering industries were heavily based on the interaction between the interning student, a professional company supervisor, and an academic career advisor to negotiate learning outcomes, assessment, and reflection opportunities of the internship experience (Rouvrais et al., 2018; Wolfgram et al., 2020).

Although the internship experience was taking place in the professional environment of engineering companies in the industry, ties to the formal education of the interning student and the application of learned topics in the classroom to professional practice were expected to be formalized and supervised by a professional engineer of the hosting company (see Heatherfield, 2020; U.S. Department of Labor [Factsheet #71], n.d.; UW College of Engineering, 2021). Generally, formative and summative assessment of learning outcomes in student internships were obtained in form of a project report, presentation, or formal feedback from the company supervisor, academic advisor, and the student, particularly when academic credit for a technical elective was granted (see Hora et al., 2017; Wolfgram et al., 2020). Therefore, constructive negotiation between the industrial supervisor and the academic institution was essential for knowledge transmission on the academic side and the logistics of operation, performance, and productivity on the company side to provide an enriching and coexisting experience for all stakeholders of the internship (Rouvrais et al., 2018).

Additional characteristics of internships in engineering education referred to the length of the experience in a work environment and the field of study. The internship in engineering industries during undergraduate engineering education was defined as of temporary nature, was intended for the educational benefit of the student, and must have been conducted in the associated field of study (Heatherfield, 2020; NACE, 2018; U.S. Department of Labor [Factsheet #71], n.d.). Internships in engineering education followed these guidelines, especially when they were tied to academic credit for technical electives. However, student internships in undergraduate engineering programs as an optional, short-term training element that was performed in industrial companies and contributed legitimately to the student's formal education was less rigorously contracted in comparison to other work-based learning models in engineering, such as co-op or apprenticeship models (Hora et al., 2017). Nevertheless, the internship model in engineering education was regulated under the U. S. Department of Labor (U.S. Department of Labor [Factsheet #71], n.d.) and, therefore, provided a comparable model to assess outcomes between various higher educational institutions and engineering disciplines. As the various internships under this regulation were expected to be performed in the relevant engineering discipline of the students' program (Ozek, 2018) and were related to the students' chosen career path (NACE, 2018), outcome measures for essential skill sets could be generally applied across all programs. Therefore, internships in undergraduate engineering education may not have had a uniform content topic across engineering disciplines or postsecondary educational institutions, but still contributed to comparable learning outcomes and professional skills in engineering education (see Laguador et al., 2020). As students were exposed to shared practices and the engineering culture of the work processes in their chosen field of engineering discipline, engineering internships had consistency in developing the skills of all future engineers (Laguador et al., 2020). Furthermore, internships in engineering industries have gained significant popularity in many colleges and universities in the 21st century (Baert et al., 2021; Hora, Parrott, & Her, 2020; Margaryan et al., 2020).

With increased popularity came the question of measures of success of internships in engineering education. In the literature, the success of internships in engineering industries was frequently reported based on qualitative feedback or surveys from interning students, hosting company representatives, or anecdotal input from institutional academic advisors (Lazarus, 2018; Marsono et al., 2017; Ozek, 2018; Powers et al., 2018; Wolfgram et al., 2020). Given the generally positive feedback from students, companies, and engineering educational institutions, industrial internships in engineering undergraduate education were often described as a win-win-win situation (NACE, 2018; Wolfgram et al., 2020). Furthermore, the internship had been designated as high impact practice in colleges, local governments, and workforce development boards to promote internship programs as a desirable solution to regional employment issues (Wolfgram et al., 2020). Yet, hard measures of internship successes were often referred to employment status after graduation missing direct links between learning outcomes of internships and employment probabilities (Hora et al., 2017; Wolfgram et al., 2020). Besides, Hora et al. (2018) and Wolfgram et al. (2020) pointed out that, in the enthusiasm of endorsing internships as general solution to increase employment, challenges with logistics and execution of internships may have been overlooked and that systematic analysis of outcomes and challenges of internships were missing in the literature due to terminology confusion and the lack of rigorous studies. These reports indicated the need to review the literature on benefits and challenges of student internships in more detail. Findings from this focused literature review part are presented in the following sections.

According to Wolfgram et al. (2020), the literature on internships in undergraduate education was simultaneously robust and inconsistent. As a rich body of practical knowledge existed on how to design and implement effective internships in engineering education (Hora et al., 2017; Kövesi & Kálmán, 2019; Rouvrais et al., 2018), reports of benefits and challenges of internships in engineering industries have been scattered, either based on a selected focus of the outcome of internships, or without consistency in causal relationships between outcomes and internship experiences (Wolfgram et al., 2020). Nevertheless, many findings in the literature encompassed evidence of the value of internships for students and employers (Arrayan, 2020; Bender, 2020; Chan & Luk, 2022; Chowdhury et al., 2020; Goller et al., 2020; Hora, Parrott, & Her, 2020; Huynh et al., 2020; Mikkonen et al., 2018; Minnes et al., 2021; Myint et al., 2021; Thomas et al., 2021). Some studies also identified challenges with internship programs in engineering education (Birhan & Merso, 2021; Craps et al., 2020; Hora et al., 2017; Kapoor & Gardner-McCune, 2020; Moss-Pech, 2021; Thomas et al., 2021; Yadav, Pandey, & Srivastava, 2020). Furthermore, results on the question whether and how internships may influence students' learning outcomes will be discussed in a separate section of this literature review. But, first, in the next part of this review, I remained focused on the benefits of internships performed in engineering industries.

Benefits of Student Internships in Engineering Industries

Numerous studies in the literature have documented benefits and positive influences of student internships in engineering undergraduate education on (a) students, (b) engineering educational institutions and their academic staff, and (c) internship-hosting companies. The most frequent reports about internships in the literature focused on the benefits for students and centered around two topic groups: longterm economic values of internships for engineering students and immediate effects on students while they were still in their educational program. Longterm economic values for engineering students included future employability (Bender, 2020; Chan & Luk, 2022; Margaryan et al., 2020; Myint et al., 2021; Thomas et al., 2021), better transition into the workforce (Kövesi & Kálmán, 2019; Wilson & Kaufmann, 2020; Wolfgram et al., 2020), employment rates (Baert et al., 2021; Rouvrais et al., 2018; Zuckerman, 2021), career crystallization (Hora et al., 2017; Ozek, 2018; Powers et al., 2018), and career adaptability (Marsono et al., 2017; Sharunova et al., 2019; Winberg et al., 2018). Reported immediate benefits of internships on engineering students were related to better grades (Arun Kumar, 2021; Ozek, 2018) and improved attitudes (Hoosain & Sinha, 2018; Lazarus, 2018; Mikkonen et al., 2018; Minnes et al., 2020). In the following paragraphs, I detail the findings of internships on student benefits with associated subtopics.

Economic Values of Internships for Engineering Students

Pregraduation internships in engineering industries were reported in the literature to benefit engineering students through several mechanism concerning their future employment. Topics in this area reached from findings on the transition into the work force, perceived or reported work readiness skills, opportunities for the first hire after graduation, employment rates and income, career crystallization, and career adaptability. Some of the topics blended into the level of motivation why engineering students engage temporarily in voluntary internships in engineering industries for little or no pay, which I will also address in the next paragraphs of this review.

Transitions Into the Workforce. As the transition from a structured academic environment into the workforce of engineering industries entails a substantial change for postsecondary engineering graduates (Myint et al., 2021; Wilson & Kaufmann, 2020; Wolfgram et al., 2021), internships in engineering industries have been identified to help smoothen this transition (Bender, 2020; Hora et al., 2017; Kolmos & Holgaard, 2018; Pardo-Garcia & Barac, 2020; Powers et al., 2018). Many studies assessed the influence of internships on a successful transition into the workforce by reporting students' perceived satisfaction levels with performed internships (Bender, 2020) or their self-evaluations on increased work readiness after their internship experiences (Myint et al., 2021). Although these results provided a strong indication on the effectiveness of internships on perceived work readiness among engineering students, provided data were based on students' perceptive values. However, Ozek (2018) concluded from a meta-analysis of publications assessing internships in engineering education, while utilizing students' and alumni feedback, that students gained engineering discipline-related work experiences by performing practical tasks in the field and experiencing professional work life prior to graduation. Alumni confirmed in these interviews that the internship experiences had prepared them better to enter the workforce (Ozek, 2018). Besides, Murtazin et al. (2020) concluded from a systematic literature review that internships have competitive advantages based on knowing the job market from discipline-specific practical experiences prior to graduation in engineering professions. In addition to work readiness, some authors discussed the importance of the first transition into work after graduation for the students' professional development.

As part of transitions between postsecondary education and workforce, students close to graduation start to develop their professional identity according to experiences and preferences in the engineering field they study (Rouvrais et al., 2018). According to Rouvrais et al.'s (2018) results, internships in engineering industries provided engineering students the chances they needed to learn about their own preferences in future jobs and to develop their professional identity along with the experiences. Furthermore, engineering graduates acknowledged pregraduation internships as an opportunity to apply their academic knowledge on concrete problems and to start understanding clients' needs, as determined in a large longitudinal study with surveys from all available engineering students in Denmark at three time points over six years (Kolmos & Holgaard, 2018). On a similar notion, Hora et al. (2017) found from a literature review that many studies identified internships as a strategy to fill the gap between employers' needs and graduates' actual professional skills. Bae et al. (2022) confirmed that internships were identified as strategies to bridge the gap between industry expectations and academic preparation for engineers from interviews with 13 civil engineering students. Besides degree-specific knowledge, the engineering students themed professional skills and EI as key elements for career success in engineering (Bae et al., 2022). In addition, the interviewed students named internships as the top experience to improve their professional skills and EI, while uncertain about the learning of these skill in class (Bae et al., 2022). Lastly, the students found internships to be instrumental to develop career motivation (see Bae et al., 2022). These findings in the literature underlined the importance of internships to develop engineering students' professional identity and employability skills.

In a more differentiated approach on identifying specific experiences in internships, Powers et al.'s (2018) collected data from semistructured interviews with 20 engineering students who had participated in internships and found that the most profound professional experiences were related to managing timelines of engineering design development and working in corporate culture. The interviewed students also confirmed that the internship experiences were very different to what they were used to from educational classroom tasks (Powers et al., 2018), aligning with Bae et al.'s (2022) findings on the uncertainty of learning professional skill in class. Another skill that may shape a students' professional identity is the acknowledgement of their entrepreneurial ideas. In this regard, Pardo-Garcia and Barac (2020) showed in a longitudinal study assessing entrepreneurial design competitions and internships with community-serving goals that not only the number of participating students increased over the years but also participating students reported how solving real-world problems with new ideas sparked finding their preferences for future work. This highlighted the importance of context learning in engineering internships with the opportunity of solving real-world problems. Besides assisting in identity finding and workforce transitions, internships in engineering education also have been reported to have a practical value in finding the first job.

When it comes to prepare for the work force after graduation, writing the first resume becomes an important step for this transition. Thomas et al. (2021) reported on this more pragmatic outcome of internships when added to the first resume, based on interviews and surveys with engineering alumni. According to Thomas et al.'s (2021) findings, the value of adding internships as work experiences to the first resume or curriculum vitae for entry-level engineering job applications may make the difference to get the first job after graduation when other work experiences are sparse in the applicant pool. Internships listed on resumes of entry-level engineers have been shown to lead to several competitive benefits in job seeking, as employment rate studies revealed. I will provide findings on employment rates related to internships in engineering industries in the next section of this review.

Employment Rates and Earnings. There was evidence in the literature about the positive correlation between engineering internships and increased employment rates, as numerous studies addressed this question. For example, comparative results with and without internships increased job offers for entry-level engineers by 16% (Zuckerman, 2021) or, in another study, internships led to 16% less unemployment rates in the first year after graduation (Silva et al., 2017). Qualitative feedback from engineering alumni interviews confirmed these data, as alumni comments about internships included that they were helping them to land a job right out of college (Mikkonen et al., 2018) and that a majority of graduates found their first job from their final-year internship (Kövesi & Kálmán, 2019). With an even more rigorous approach, Baert et al. (2021) conducted an experimental study, in which the authors analyzed 1248 fictitious, but realistic resume pairs with and without internships that were sent to job openings on the market. Baert et al. (2021) found, from bivariate and multivariate analyses, that the probability of being invited to a job interview was 12.6% higher with an internship on the resume compared to resumes without listing an internship, whereas other randomized applicant characteristics did not reveal a statistically significant difference in the number of interview invitations. Also, Wolfgram et al.'s (2020) and Ozek's (2018) results on employer feedback indicated that internships create higher resume attention leading to more interview offers and, therewith, significantly increase the probability of employment just after graduation. According to feedback from students and engineering alumni, part of the higher employment rate with internships may be explained by the opportunity to establish a professional network through pregraduate internships, which increased postgraduate interview opportunities (Hora et al., 2017; Ozek, 2018). Networking early in the career also enabled students to exchange resources with others, who can provide social support, and build trusted relationships for their future (Arrayan, 2020).

Beyond the first hire, some scholars examined the impact of internships on earnings after graduation. Margaryan et al. (2020) utilized regression analyses from longitudinal survey data of three cohorts of university students collected by the German Centre for Research on Higher Education and Science and found that graduates with internships faced a lower risk of unemployment during the first year of their career and earned 6% higher salaries in the short and medium terms of their employments. Bolli et al.'s (2021) study results on Swiss alumni confirmed that internships increased graduates' incomes. However, Margaryan et al.'s and Bolli et al.'s study only included engineering alumni in Europe. Besides the many reported positive economic values of pregraduation internships assisting the transition into engineering industries, internships may also influence career choices and adaptability.

Career Crystallization and Adaptability. Student internships in engineering industries during postsecondary engineering education were reported to assist students to explore potential careers in a short-term commitment prior to their graduation (Ozek, 2018). The variety of internship experiences that are offered in the industries may lead to progress in students' career crystallization and possible longterm job pursuits (Arrayan, 2020; Hora et al., 2017). When internships were viewed as test trials for future work, students had an early opportunity to explore and select the most suitable subarea of the engineering discipline that they are interested in and to acquire insights into associated engineering professions and up-to-date applied technologies (Ozek, 2018; Sulistiyono et al., 2020). Furthermore, engineering interns reported in semistructured interviews that the internship experience influenced their career decisions and broadened their thinking about the range of areas that can involve engineering (Powers et al., 2018). Many engineering students also recognized their internship supervising professional engineer as role model and mentor (Rouvrais et al., 2018), while they learned to survive in a different culture and in a result-oriented work environment common for effective engineering practice (Asplund & Flening, 2021; Ozek, 2018). In general, findings in the literature agreed upon the social and psychological goals for interning students in building engineering self-identity concepts, confidence, and resilience while developing common understanding and communication skills between all involved parties to help them choose a career path (Chowdhury et al., 2020; Ozek, 2018; Wolfgram et al., 2020). However, career exploration was not the only reason behind students' wanting to engage in internships prior to graduation. In the next section, I will present findings from the literature on the motivations of engineering students to participate in a voluntary internship in engineering industries.

Students' Motivation Behind the Participation in Engineering Internship

Supporting the findings of career path determination through internships as work trials, some authors examined the motivation behind engineering students wanting to engage in voluntary engineering internships with little or no pay (Bender, 2020; Chowdhury et al., 2020; Goller et al., 2020; Huynh et al., 2020). In mixed-method and qualitative comparative studies, results indicated that the most prominent reason behind participating in student internships were acquisition of new knowledge and learning opportunities on the technical and professional level (Chowdhury et al., 2020). Interestingly, results showed that job demand or job control exhibited much less power on why engineering students were eager to perform internships in the industries (Goller et al., 2020). Also, Huynh et al.'s (2020) study results showed a positive correlation between learning of engineering task self-efficacy and the drive to explore career goals, utilizing over 200 surveys of engineering students who had completed an internship. Supplementing the result of students' improved self-efficacy after internships with a qualitative study, Chowdhury et al.'s (2020) findings from semistructured interviews with engineering interns confirmed an increase in their self-efficacy after completing an internship. Specifically, participating students reported that the internships required them for the first time to plan their day on their own without a classroom structure, which demanded self-efficacy in time management skills and self-initiatives on communication and coordination with the supervisor in the company (Chowdhury et al., 2020).

Regarding pay, Bender's (2020) findings from 25 student interviews after a summer internship proposed that challenging and engaging tasks for engineering interns were more motivational than pay or job seeking demands. Therefore, perceived success of and satisfaction with internships in engineering industries were strongly dependent on given projects tasks and the mutual respect, communication, and collaboration efforts between the company supervisors and the interning students. According to Asplund and Flening's (2021) quantitative study results, collaboration efforts between the stakeholders of internships in engineering industries were moderated by the motivation of students and their company supervisors to successfully transfer knowledge on professional levels. Thus, the results of these studies indicated that career curiosity, motivation, and self-growth in professional skills were the leading reasons behind engineering students to engage in voluntary internships before graduation.

Professional skills were not only important during the transition into the workforce, but may also be crucial for future career changes, as adaptability was one of the highly desired criteria in employees while working in fast-changing industries when new engineering technologies, processes, and customs emerge in a rapid pace (see Hirudayaraj et al., 2021). Internships in engineering industries have been agreed upon in the literature to help engineering students to accustom to the new transdisciplinary nature of industrial design practice (Sharunova et al., 2019) and to work with others across diverse contexts leading to deeply understand engineering principles with a focus on real-world problems (Winberg et al., 2018). Also, internships assisted to gain hands-on experiences that complement academic learning by translating theory into problem-based, authentic practice (Hora et al., 2017), especially when it was executed in a multi-national environment (Tan & Umemoto, 2021). In terms of authentic problems, Burkholder et al. (2021) argued that the problems that engineering students are tasked with to solve in the classroom fall far short of the problem-solving processes that expert engineers practice. All authors agreed on the benefits of internships to prepare engineering students for the new demands of the labor market and engineering workforce of the 21st century.

Internships' Immediate Effects on Engineering Students

Besides career benefits, internships in engineering industries were also reported to have immediate positive impact on student's attitudes, motivation, and sometimes their grades (Mikkonen et al., 2018; Minnes et al., 2020; Ozek, 2018; Wolfgram et al., 2020). Ozek (2018) reported from a literature meta-analysis that grades improved after the completion of an internship primarily among weaker students, as interviewed students expressed better understanding of classroom theory through practical applications which enhanced both, engineering knowledge and skills. Additionally, Craps et al. (2020) and Arun Kumar (2021) mentioned grade improvement in engineering curricula through problem-based, authentic engineering experiences and the attainment of general program outcomes, such as communication, teamwork, and problem-solving in engineering design considering realistic constraints.

Yet, the stronger immediate impact of internships in engineering undergraduate education was attributed to improved attitudes among engineering students (Minnes et al., 2020, 2021). The realization of completing a product that will be of use to others was a strong motivational factor for positive attitude changes towards the engineering profession or the education, as Minnes et al. (2020) measured in responses from engineering students surveyed before, right after, and several months after an internship experience. In addition, Bae et al.'s (2022) study results from interviews with civil engineering interns highlighted the perception of engineering students that internships developed the understanding about the impact and meaning of their careers. Other authors found evidence supporting the positive role of internships on continued retention of students in engineering programs, using multivariate logistic regression analysis on student survey results (Robinson et al., 2020). Supplementary, in Powers et al.'s (2018) surveys and interviews, engineering students reported a boost in individual motivation and confidence by being able to choose the internship in an engineering field of their interest. Other authors agreed with findings of students' motivational improvement in internships through the feeling of meaningful applications for identifiable customers (Hadgraft & Kolmos, 2020), increased self-confidence in a realistic work environment (Kövesi & Kálmán, 2019; Ozek, 2018; Robinson et al., 2020), and a can-do spirit with strong optimism associated with a real-world engineering teamwork experiences (Mikkonen et al., 2018).

In addition to motivational boosts, Hoosain and Sinha (2018) noted that internships in the industries and community projects contributed to develop students' attitudes towards expected engineering ethics and professionalism in the workplace. In agreement, LeFrancois et al. (2021) proposed to combine engineering ethics education with engineering internships. Moreover, in Laguador et al.'s (2020) relational study, results showed a positive correlation between work ethics and internship skills.

Additionally, internships also were reported to foster students' self-management in taking charge of one's own career tasks (Wolfgram et al., 2020) and develop self-responsibility in real-life situations, as Lazarus (2018) reported from 1056 student and alumni feedback surveys launched in Indonesia. Rouvrais et al. (2018) confirmed these findings theoretically, using Kolb's learning framework to explain that the concrete internship experience may help to refrain abstract conceptualization of learned engineering concepts and may encourage the interning students to become more active actors of their own engineering training. Findings from Rouvrais et al.'s study included that engineering students developed a critical view of course content after they returned from practical experiences in the industries and started to reuse knowledge and criteria of performance evaluations that they had learned in companies to the classroom tasks. As better grades, motivational boosts, and ethical behavior was related to internship experiences in engineering industries, observations of bringing the learned back into the classroom (see Rouvrais et al., 2018) tied into secondary internship benefits for engineering institutions, programs, instructors, and classroom peers.

Benefits of Internships for Engineering Educational Institutions

The second group of stakeholders of pregraduation engineering internships were postsecondary engineering educational institutions and their academic staff. Engineering students may bring lived experiences from internships in the industries back into the classroom and, therewith, setting acquired skills in perspective for themselves and their peer students and for the academic staff (Rouvrais et al., 2018). Besides, engineering instructors may benefit from the exposure to up-to-date engineering practices in the field and current changes in practices and technologies in the engineering sector that they otherwise would not be familiar with in the fast-changing field (Ozek, 2018; Rouvrais et al., 2018). Additionally, industrial internships may be utilized as an excellent opportunity to develop academia-industry relations, which may lead to improved recognition and reputation of the engineering department and to increased talent exchange through collaborative projects and research (Ozek, 2018). Lastly, engineering programs often collected direct feedback on what employers want in engineering graduates for program accreditation purposes (see ABET, 2021) and industrial internships were an excellent opportunity to collaborate on the achievements of program learning outcomes that are common across engineering education (Laguador et al., 2020; Wolfgram et al., 2020). In the long term, internship offerings in engineering undergraduate education have the potential to increase the reputation of the university and attract more and better qualified incoming students (see Ozek, 2018). However, the institutional leadership and engineering instructors must be open for such collaborative efforts between industry and academia to become successful endeavors (see Hora et al., 2017; Rouvrais et al., 2018; Wolfgram et al., 2020). I will discuss this challenge of internships in more detail in later sections of the literature review.

Benefits of Internships for Engineering Companies

Before I will discuss challenges of internships in further literature review sections, in this paragraph, I will briefly address findings on benefits of student internships in engineering industries for hosting industrial companies, the third stakeholder group. The main reason behind companies wanting to host internships for undergraduate engineering students, according to employer survey data, was to screen upcoming talent for hire and to get better knowledge of the profile of young professionals that will soon enter the job market (Rouvrais et al., 2018). Ozek (2018) even named internships pregraduation recruiting devices for many companies. Additionally, Ozek reported from survey and interview data that companies were looking for help with routine tasks and minor projects, as well may benefit from new innovative ideas and outside-the-box thinking that a fresh mind may bring to the engineering design discussion table (see Pardo-Garcia & Barac, 2020). In a recent study, utilizing over 500 engineering company surveys and interview data, Hirudayaraj et al. (2021) pointed out that employers also using internships as a tool to assess professional skills of applicants outside the technical curriculum, as they are looking for well-rounded graduates as future employees, who have demonstrated to be able to manage timelines and work responsibilities and fit into the company's team environment. According to Zuckerman's (2021) statistics on internships in corporate America, tech companies hiring over 80% of new employees with pregraduation internship experiences, and about 90% of interns get offered a full-time job after graduation. Generally, it helped to boost a company's reputation by engaging with an academic institution and giving back to society by supporting future engineers and educational institutions; thus, the industry-academia collaboration may help with advertisement for the company (see Ozek, 2018). Summarily, the literature supported the statement brought forward by Wolfgram et al. (2020) that student internships are a win-win situation in postsecondary education.

Cumulative, it appears that internships in engineering education provided many benefits for engineering students, engineering institutions and their staff, and affiliated industrial companies. One may ask the question, why internships in industry have not been made mandatory for undergraduate engineering education at this point in time to optimize the education of future engineers. To answer this question, I will present findings from the literature on the obstacles of internships in engineering industries and the challenges that may come with implementing these internships as part of postsecondary engineering education in the next chapter of this literature review.

Challenges of Student Internships in Engineering Industries

As many authors in the 21st century literature glorified the internship experience in engineering education as a win-win-win situation for many aspects, some studies critically addressed challenges with the critical mass of internship offerings, the diversity of internship activities, and issues with execution, logistics, and equal access opportunities of internships in undergraduate engineering education. Hora (2018), Hora et al. (2017), and Zuckerman (2021) identified logistical barrier, limitation in time, costs, and administrative resources that it takes to properly offer and host internships, and the lack of capacities to guarantee a critical mass of external employers as hosts for short-term internships for all engineering students in an academic program. These challenges currently limit the possibility to make internships a requirement for engineering degree graduation. However, the compromise in most colleges to offset the administrative burden on the institution was to offer industrial internship experiences as extra-curricular activities or as technical electives that may count towards degree requirements in engineering (see Best Colleges, 2021; UW College of Engineering, 2021). Nevertheless, internships in engineering industries were widely encouraged and supported for undergraduate engineering students and about 40% to 50% of U.S. engineering college students engaged in at least one internship during their undergraduate education (Kapoor & Gardner-McCune, 2020; Laguador et al., 2020).

Another challenge with engineering internships was the diversity of activities. Since internship training activities has differed between institutions and engineering disciplines, it has been generally difficult to draw conclusions on what type of internship might be the most impactful in terms of benefits for individual students (Powers et al., 2018). Therefore, it has been challenging to standardize the internship experience across engineering educational institutions or across the wide variations of partner companies (Ozek, 2018). However, regulations under the U.S. Department of Labor (U.S. Department of Labor [Factsheet #71], n.d.) and the National Association of Colleges and Employers (NACE, 2018) has helped minimize challenges with variations in internships in engineering industries. Moreover, learning domains and student outcomes established by the Accreditation Board of Engineering and Technology (ABET) had been based on general and professional competencies that were common to every engineering program (ABET, 2021). Therewith, assessment of professional student learning outcomes in engineering programs had been consistent across various engineering disciplines and company training opportunities despite varying technical topic areas (Laguador et al., 2020).

The third set of challenges with student internships in engineering industries centered around the proper execution and logistics of these work-based learning opportunities. Findings in the literature showed that executive challenges with student internships in the industries can be grouped around five topics: (a) legal and ethical issues, (b) equality of accessibility, (c) standards for internship quality, (d) coordination between educators and employers, and (e) autonomy of interning students.

Legal and Ethical Considerations

Legal and ethical issues around pregraduation internships in postsecondary education have long been controversial issues in the field, especially when they were unpaid activities. An unpaid internship must demonstrate the educational quality of the experience (NACE, 2018) and pass a six-point test according to the U.S. Department of Labor to be legally unpaid (see Hora et al., 2017). However, Ozek (2018) reported, based on a meta-analysis of related literature, that internship hosting companies were sometimes unfamiliar with the official regulations guarding internship initiatives and hesitant to pay certain pocket money for students or their transportation to and from the internship location. In agreement, Margaryan et al. (2020) cautioned on the potential downside of internships as there was a risk that companies may exploit highly qualified students as cheap labor if the internships were not contractually regulated. Similarly, if the company had not legally agreed to a binding contract or memorandum of understanding, legal risks of disclosing intellectual properties and protected technical information may arise when a student worked on sensitive company products (Ozek, 2018). Therefore, the need for administrative resources on the company's as well as on the educational side has been a continuing challenge to properly oversee each internship's regulations and logistics. Christensen (2020) noted that this type of learning in internships could not be harvested without investment and costs.

Inequality of Accessibility

Similar thoughts in the literature addressed the view of students, who engaged in unpaid or poorly paid student internships. Concerns about the equality of accessibility for low-income students had been voiced (Hora et al., 2017; Moss-Pech, 2021; Robinson et al., 2020; Yadav, Pandey, & Srivastava, 2020). In particular, Hora et al. (2017) pointed to the ethical consequences, when students with economical disadvantages may struggle to afford unpaid work as interns and were less likely to receive the benefits associated with internship placements. Furthermore, issues with transportation or child-care needs may hinder the possibility to engage in a voluntary or elective internship experience (see Wolfgram et al., 2020). In addition, internships may carry a higher risk of extending the time-to-degree educational period, which would be particularly challenging for low-income students (Margaryan et al., 2020; Ozek, 2018). Confirming these concerns, Moss-Pech's (2021) longitudinal study, drawing from 176 interning student interviews and data from 91 tracked alumni through their graduation, indicated that privileged students from elite colleges had better access to internships and connections to prestigious employers than students who could not afford to participate in or could not find an internship in the industries. Results from Moss-Pech's study showed that students who could participate in such selected internships clearly had an advantage regarding immediate hires right after graduation. Consequently, Moss-Pech and Robinson et al. (2020) warned that the inequality of access, affordability, and participation in student internships in industry may produce unequal labor market outcomes between college graduates. Sharply, in terms of an equally gap, unpaid internships may pose a barrier to entry-level jobs when students cannot shoulder the educational opportunity costs of internship experiences before graduation (Arrayan, 2020; Margaryan et al., 2020; Moss-Pech, 2021; Zuckerman, 2021). However, according to NACE's 2019 Internship and CO-OP Survey Report (Koc et al., 2019), 61% of all internships in 2019 were paid with a higher percentage for engineering industries, and 84% of unpaid internships were subsidized by stipends, travel expenses, or paid social activities. This trend had improved from prior years (see Koc et al., 2019).

Internship Quality Measures

Another challenge for student internships in engineering industries were the lack of unified standards for internship quality. Although Rouvrais et al. (2018) stressed the importance of company supervision by a well-trained professional engineer or mentor and formative and summative assessment of student performances during the internship in engineering industries, the reality of internships was sometimes not ideal, based on feedback from student interns, collected and analyzed by Hora et al. (2017), Hora, Wolfgram, et al. (2020), Ozek (2018), and Birhan and Merso (2021). Starting with planning meaningful work for interns, clear instructions of expected tasks, and supportive job-site supervision, the company was expected to set aside time and resources of one of their employees, who often may not be trained in mentoring students, may be pressed for time to meet work deadlines, or may have little motivation or time available for interning students (Birhan & Merso, 2021; Hora et al., 2017; Ozek, 2018; Powers et al., 2018).

With similar findings, Craps et al. (2020) and Thomas et al. (2021) reported, based on critique from interviewed engineering students, that internship work tasks appeared not transparently linked to engineering knowledge in the classroom or authentic engineering experiences were hindered by the lack of effective facilitation or supervision in some cases. Powers et al. (2018), Silva et al. (2017), and Wolfgram et al. (2020) confirmed in their study reports that the execution and supervision of engineering interns largely differed across institutions and companies.

To investigate internship supervision in more detail, Hora, Wolfgram, et al. (2020) conducted a comprehensive mixed-method study on intern supervision, interpreting data from 435 interning students' surveys and 52 focus groups. Results of Hora, Wolfgram, et al.'s stepwise linear regression analysis indicated that the behavior of the company supervisor was significantly associated with intern satisfaction, career development, and the achievement of internship learning outcomes. When the intern-supervisor relationship was supportive and included aspects of personal mentorship, the interns' experiences became a positive representation of the company or even the profession and provided all the benefits of pregraduation internships regarding guidance, encouragement, and resources for the students' career plans (Hora, Wolfgram, et al., 2020). However, if the intern had an inattentive or even hostile company supervisor, the internship experience often led to disappointment and negative impact on the interning students, who then may develop a negative attitude to the hosts' industry, and therewith, influencing the students' career path (Hora, Wolfgram, et al., 2020). As this research suggested, the intern-supervisor relationship was a key factor in the success of student internships and pointed to the importance of effective job site supervision and mentoring in engineering industries (Lenihan et al., 2020). Unfortunately, some literature reports presented findings of a poor connection between academic learning and company supervision (see Hadgraft & Kolmos, 2020). The inconsistency of the internship experiences provided another challenge of internships in engineering industries.

Coordination Between Educators and Employers

Some reasons behind a lacking interaction between interning student, company supervisor, and academic coordinator may have been the time demanding logistics of planning and organizing the internship experience as joint projects between company and academia (Ozek, 2018) or difficulties of the company supervisors to accept theoretical learning objectives fixed by academic staff (Rouvrais et al., 2018). To minimize these challenges of internships in engineering industries, constructive negotiations between academic and company supervisor ahead of the implementation of the internship was essential for the establishment of learning and competency development as objectives on the academic side and company-specific needs on the industry side with the common goal to provide benefits and satisfaction for engineering students, companies, and the academic institution (Rouvrais et al., 2018). Thus, the academic coordinator position and collaboration with the company supervisor was crucially important for the quality of the internship and the adherence to internship descriptors and standards (Rouvrais et al., 2018). Consequently, ensuring enhanced experiential learning in engineering internships, an interdependence of academic staff, student, and company supervisor must prevail (see Lenihan et al., 2020; Rouvrais et al., 2018). As a possible solution and to help foster the connections between the three stakeholders of engineering internships in industry with its expectations on all parties, Al-Subaihi and Larsen (2021) introduced, in a case study in Denmark, a tie-in of industrial engineering internships with coursework, in which interning students were first prepared for internship expectations and later prompted to reflect on the effectiveness of the training in industry regarding project ownership, impact, and cooperation after the internship was completed. According to Powers et al. (2018) and Rouvrais et al. (2018), students' reflections on the internship experiences should be part of the assessment and improvement of pregraduation internships in engineering industries. Unfortunately, efforts on incorporating students' reflections on internship experiences were sometimes skipped due to inadequate support of administrators or missing guidance from mentors (see Birhan & Merso, 2021). According to Birhan and Merso (2021), the coordination between educators and employers was likely to remain a major challenge to facilitate well-performed internships in engineering industries until the need for adequate funding, personnel, and resources was universally accepted (see Birhan & Merso, 202).

Autonomy of Interning Students

Lastly, some challenges with student internships in engineering industries were reported in the literature around the level of autonomy given to interning students. Hora, Wolfgram, et al.'s (2020) study addressed this issue, and results from the analyses of 52 focus groups indicated that differences in how students experienced high levels of task autonomy was also highly correlated with the quality of their intern-supervisor relationship. The level and quality of instruction, supervision, risk-assessment, and trust between the company supervisor and the interning students greatly determined whether the task autonomy was experienced as ownership of the work or lack of supervision or interest in the student (Hora, Wolfgram, et al., 2020). Although autonomy in employees was generally a desired characteristic in the engineering workforce, there were conflicting findings in the literature whether high autonomy is a beneficial aspect of an internship experience (Hirudayaraj et al., 2021; Hora, Wolfgram, et al., 2020). For example, Hirudayaraj et al. (2021) found from employer interviews that internships in engineering companies were supposed to be just a glimpse on the demands of real-world engineering work experiences and that autonomy expectations were different on interns than they were on employees. Furthermore, some engineering employers experienced that some students may not be ready to handle the responsibilities and time managements skills to work autonomously, as they were, for example, viewing their cell phones at inappropriate times and did not understand procrastination issues when given task autonomy (see Hirudayaraj et al., 2021). Also, Hora et al. (2017) pointed out that too much autonomy can be a risk as many students are unaccustomed to professional workplace expectations. With conflicting findings on the level of appropriate autonomy of interning students in engineering industries, the decision whether autonomous work was desirable or not depends on individual students, the internship situation, and the intern-supervisor relationship (Hora, Wolfgram, et al., 2020). In the end, the company supervisor must make that determination in each case of interning student to provide maximal benefits for the students' education and the company's needs.

In summary, many challenges of internships in engineering industries were related to the execution and the logistics of internship initiatives. Communication between the stakeholder parties seemed to be the key for a successful internship experience (Birhan & Merso, 2021; Lenihan et al., 2020; Rouvrais et al., 2018). Generally, more research was demanded on the challenges of internships in engineering industries and how to best address them (Hadgraft & Kolmos, 2020; Hora, Wolfgram, et al., 2020; Wolfgram et al., 2020). However, economic and psychological benefits of internships in engineering industries seemed to outweigh the challenges and, although not mandatory for degree completion, many postsecondary engineering educational institutions promoted opportunities to engage in a student internship in engineering industries (see Best Colleges, 2021; UW College of Engineering, 2021). Besides the discussion of benefits and challenges of internships in engineering industries, few studies in the current literature evaluated direct effects of internships on students' professional competencies in higher engineering education. In the next section of this literature review, I will present further details on this topic.

Effects of Internships on Student Competencies in Higher Engineering Education

Internships in engineering industries in the 21st century were increasingly gaining popularity and importance in higher engineering education as changing expectations on the modern engineer demanded application of engineering solutions in social contexts and in real-world situations besides strong expertise in technical and theoretical knowledge (see Feijoo et al., 2019; Gilar-Corbi et al., 2018; Hirudayaraj et al, 2021; Kolmos & Holgaard, 2018; MacCann et al., 2020; Suleman et al., 2019). Although internships in engineering education were an old concept in new light, the assessment and systematic analysis of learning outcomes for students who perform an internship in engineering industries during their postsecondary education were sporadic and largely focused on outcomes of securing employment or transitioning into the workforce (see Wolfgram et al., 2021). Nevertheless, there was agreement in the literature on positive effects of student internships in engineering industries affecting students' employability and professional competence-building (Baert et al., 2021; Chan & Luk, 2022; Feijoo et al., 2019; Kövesi & Kálmán, 2019; Ozek, 2018; Rouvrais et al., 2018; Silva et al., 2017) as well as increased resilience and adaptability during work transitions (Asplund & Flening, 2021; Hadgraft & Kolmos, 2020; Kolmos & Holgaard, 2018; Rouvrais et al., 2018). In this section of the literature review, I focused on findings that discuss the impact of internships on professional and social-emotional competencies of postsecondary engineering students, as these skills were highlighted in the literature as professionally important for 21st century engineers.

Internships in engineering industries were often associated with the learning of interpersonal skills, such as team integration, clear communication, time-management, and professional behaviors in corporate cultures (Floyd et al., 2017; Rouvrais et al., 2018). Especially in the 2020's, many authors additionally called attention to the need to develop holistic competencies as workforce readiness or employability skills for engineers, as they need to be able to work in design teams and often in multidisciplinary and multicultural contexts (Chan & Luk, 2022; Laguador et al., 2020; Myint et al., 2021). Furthermore, authentic problem-solving skills with an innovative edge (Burkholder et al.,

2021) and geared towards human-centered design (Hoosain & Sinha, 2018) was considered a learning outcome particularly important for modern, emerging engineers, which could be demonstrated by mentors in industrial internships. Because, on the one hand, most non-technical competencies needed in the education of 21st century engineers were mentioned in the literature in conjunction with student internship experiences, and, on the one hand, Hirudayaraj et al. (2021) demonstrated, based on feedback from over 500 engineering employers, the existence of a skill gap regarding these professional skills in entry-level engineer hires, it was not surprising that there was an increased interest trying to understand if and how internships can improve non-technical student competencies in engineering education. Yet, the research on internships in engineering industries seemed to be still in its beginning stages, as few studies directly assessed the impact of internships on professional or holistic student competencies in postsecondary engineering education.

One of the rare studies that directly related skills from internship assessments to professional competencies in engineering education was conducted by Laguador et al. (2020) on 125 students from four engineering disciplines in baccalaureate degree programs of academic institutions in the Philippines. Laguador et al. compared internship performance ratings from industry hosts on four student competencies, categorized as technical knowledge, technical practical skills, attitude, and personality, to employability skills determined by an established and validated employability skill survey instrument that was given to the engineering students before the internships. Regression analysis results showed a statistically significant correlation between the internship assessment categories and students' professional skills of critical thinking, information literacy and numeracy, management skills, work ethics, and systems thinking (Laguador et al., 2020). Systems thinking was viewed as the interrelation of engineering design and organizational needs with a holistic perspective towards various elements of development in this study (see Laguador et al., 2020). Unfortunately, Laguador et al. utilized the pre-internship employability skill survey only as a mean to understand what students need to improve on before the internship and did not repeat the survey after the internship experience. This limited the study to correlational conclusions without evidence for internship effectiveness in improving assessed student competencies, which the inclusion of pre- and post-survey data could have provided. Nevertheless, the study findings established direct correlations between internship assessment data and employability skills.

Holistic Student Competencies

In the quest to determine learning outcomes from internships, a researcher group in Hong Kong developed and validated a work experience questionnaire, which was applicable to evaluate engineering students' perception on their internship experiences (Chan & Luk, 2020). In follow-up studies, Luk and Chan (2021) and Chan and Luk (2022) extricated six learning outcomes from internships in engineering industries with an emphasis on holistic competencies for the development of the whole person: (a) cultural sensitivity and global citizenship, (b) interpersonal and leadership competencies, (c) problem-solving and critical thinking skills, (d) self-understanding and resilience, (e) information literacy, and (f) moral values. Although the researcher did not perform assessment measurements on the identified learning outcomes, the qualitative results emphasized that the value of internships goes beyond the learning of technical and generic competencies, such as teamwork or presentation skills, and other benefits of internships in industry. Luk and Chan (2021) also called for more research on clear learning outcomes of student internships in engineering education to facilitate alignment with curriculum needs.

Most other studies addressing the impact of internships in engineering industries on students' learning outcomes explored student perceptions in qualitative research approaches. Similar to what Luk and Chan (2021) called holistic competencies, Myint et al. (2021) labeled interpersonal competencies, such as relationship-building, communication, diligence in being nice to clients, and teamwork, as well as intrapersonal competencies, such as personal effectiveness, creative problem-solving, time management, punctuality, and adaptability, as work readiness outcomes that could be gained in student internships in engineering industries. Myint et al.'s study with engineering students in Singapore indicated the impact of internships on work readiness outcomes by reporting high percentages of surveyed students that felt ready to enter the workforce post-internship and how much the internship contributed to that feeling. Along with some other qualitative studies addressing students' perceptions of learning outcomes in internships (Chowdhury et al., 2020; Sriram & Somu, 2020), Myint et al. did not provide details on the direct relationship between specified learning outcomes and internships experiences.

Other approaches provided anecdotal case study examples on learning outcomes that addressed multidisciplinary and multi-socio-cultural environments in internships, such as human-centered design skills and the understanding of social implications of technology in societal and culturally diverse contexts, for example, in South Africa (Hoosain & Sinha, 2018). In another example with focus on engineering students in the United States, Chowdhury et al. (2020) explored the experiences of undergraduate engineering students in internships in semistructured interviews to extract internship-impacted learning outcomes. Chowdhury et al. found that students experienced that the value of internships mostly centered around coordination with the team, customers, or work schedules and learning new things around professional and technical problem-solving skills. Almost all participants in this study discussed internships in engineering industries in a positive light, as it helped them to acquire competencies to solve contemporary problems with positive societal and economic impact (Chowdhury et al., 2020). Chowdhury et al. noted that part of the problem with current engineering education was the lack of opportunities in the classroom to replicate industry-like experiences. In general, qualitative results in the literature connected internships to intra- and interpersonal learning outcomes with social-emotional impact for engineering students.

Communication Competencies

A few research studies in the literature focused on single specified learning outcome regarding effects of internships on engineering students' competencies, for example, communication skills (Wilson, 2019), innovative thinking (Nachammai et al., 2020; Ranabahu et al., 2020; Sriram & Somu, 2020), and ethics (LeFrancois et al., 2021). In particular, communication competencies were detailed by Wilson and Kaufmann (2020) into technical and non-technical communication skills, as accreditation criteria for engineering programs required that students exhibit communication competencies with a wide range of audiences at the time of graduation (see ABET, 2021).

Wilson and Kaufmann's comparative study results established statistically significant differences between the perspectives of 178 engineering students on needed communication skills in the profession, based on what they learned in their engineering program, and the lived experiences of 55 postgraduate engineering employees. Strong differences were found in the frequency and type of non-technical communication in informal meetings and with clients and customers in comparison to official meeting presentations or technical reports. This showed a significant disconnect between engineering training in communication skills and actual communication needs in the industry (Wilson & Kaufmann, 2020). Wilson (2019) also showed that internships were significantly more effective at preparing engineering students for future communication needs than their college coursework, as determined from analyses of survey responses of 77 engineering students after they had performed an internship in engineering industries. The interning students in this study were asked to provide identification, frequency, and means of communication in their industrial internships as well as how effective their classroom training or internship experience were at preparing them for these forms of communication (Wilson, 2019). Comparatively, results showed a significantly greater impact of internships on needed communication skill-building than classroom work

(Wilson, 2019). Wilson (2019) reasoned that the shortfall of engineering curricula was related to that the majority of classroom communication practice was focused on formal lab reports and discussion with targeted expert audiences, such as instructors and peers, which differed from the reality in engineering companies. These studies with focus specifically on communication skills in engineering internships indicated strong evidence on the positive effects of internships in engineering industries on needed competencies in communication outcomes for postsecondary engineering students.

Entrepreneurial Competencies

Other researchers placed a focus on the need for innovative thinking or entrepreneurial skills in engineering professions. For example, Sriram and Somu (2020) reported that 90% of 107 surveyed undergraduate engineering students felt the need for an internship in their education and 95% felt that they benefited from an internship in engineering industries in the development of their interpersonal and, especially, entrepreneurial competencies. Furthermore, Ranabahu et al. (2020) illustrated, in a case study from an Australian university, that internships can be used to develop factors of innovative skills in designing and implementing technical solutions, particularly, when the learning outcomes were combined with innovation-related literature and in conjunction with entrepreneurial industry stakeholders. Innovative thinking has gained importance for engineering students as the uncertainty of future needs and the disruptions in production and distribution of goods and services had shifted the meaning of internship activities from application of knowledge to innovation of procedures that may work in unpredictable circumstances (see Ranabahu et al., 2020). Also, internship stakeholders may develop a common goal in shared entrepreneurial ideas, which may help foster the willingness to collaborate between academic institutions, industry members, and engineering students on internship efforts (Ranabahu et al., 2020). This aligned with Myint et al.'s (2021) findings that academic staff has otherwise a lack of industrial exposure. Although these studies underlined importance of internships on innovative competencies for engineering students, neither one of the authors provided learning outcome measures on entrepreneurial thinking.

However, one study identified learning outcomes from entrepreneurial internships. Nachammai et al. (2020) introduced the entrepreneurship internship program to deal with the fast rate of change and rapid development of technology and the need to generate new models to deal with arising challenges. In Nachammai et al.'s study, results from 75 surveyed and interviewed entrepreneurship internship participants identified five learning outcomes of internships in engineering industries: (a) new ways of thinking, (b) using new techniques to anticipate and handle risk, (c) ability to synthesize and present large amount of information, (d) motivation, and (e) the ability to learn and network with entrepreneurial professionals. Nachammai et al. stressed the understanding that entrepreneurship is more than just having an idea, it also entails the need to possess all necessary skills and knowledge associated with that idea, which students can learn by working with entrepreneurs in the industry. The participants in this study were also asked to rank the identified learning outcomes of their internship in order of importance towards innovative thinking and how much they had derived towards this competency from the internship experience (Nachammai et al., 2020). It was not surprising that new ways of thinking ranked high in the assessment of important internship outcomes among the internship participants (see Nachammai et al., 2020). Nevertheless, engineering students also acknowledged the importance of synthesizing a large amount of information and the necessary risk assessment around an innovative idea, which they felt may best be learned in a real-world environment with impact on human beings, but also may be laborious and often underestimated in classroom imitation models (Nachammai et al., 2020).

The findings on how important details were to take an idea to a realistic innovation went hand in hand with Burkholder et al.'s (2021) results on the authenticity of problems addressed in engineering educational curricula. Burkholder et al.'s study indicated that authentic problem-solving was not sufficiently taught in classroom exercises because the authentic part from realistic context, in which experts engineers engage in a set of 29 different decision steps to solve an authentic realistic problem, was missing in the classroom attempts. The realization of interning students on how important and, also, how laborious risk assessment and the collection of background information for engineering work, especially, around innovative ideas was, could be attributed to holistic competencies learned in authentic internships in engineering industries (see Nachammai et al., 2020). Innovative problem-solving appeared to be a far more complex learning outcome than can be addressed in classroom settings alone (Burkholder et al., 2021). Altogether, there were strong indications in the literature that internships in engineering industries have a substantial impact on innovative thinking competencies for engineering students.

Ethical Behavior

The latest learning outcome that was introduced in the literature in conjunction with internships was based on an ongoing study on ethics training for engineering students. LeFrancois et al. (2021) published preliminary results on an approach to merge engineering ethics training in academia with internships in engineering industries. This intervention approach was geared towards establishing ethical sensibility and reasoning skills in potential industrial ethical dilemmas as a core competency associated with forming the identity as an engineer and the role engineers play in responsibilities to society. According to LeFrancois et al., there was little explicit attention to ethical preparedness of engineering graduates for the exposure in the work force, although engineering program accreditation agency specified ethical behavior as one of the required student competencies at time of graduation (see ABET, 2021). LeFrancois et al. found, in the evaluation of student interviews about their internship experiences, that internships in engineering industries could inflict a constricting result on ethics and social responsibility by elevating the importance of company loyalty. However, with proper reflections on ethical experiences, engineering students could utilize internship experiences in the industries to gain awareness of ethical behaviors, their own attitudes, and showing greater self-confidence in conflict situations (LeFrancois et al., 2021).

Furthermore, LeFrancois et al. (2021) proposed in his study to include educational interventions of pre- and post-internship workshops that entail critical discussions of ethical challenges in engineering practice including self-reflection exercises. These interventions in conjunction with the real-world experiences in internships may assist in developing engineering students' development as a whole person with a strong sense of ethics, self-identity, and an understanding of impact on those around them (LeFrancois et al., 2021). As an engineer's identity comprises cognitive, affective, and performance variables, aspects of personal socio-emotional competencies, life experiences, and career-related learning opportunities, such as internships in engineering industries, may contribute to the development of the modern holistic engineer of the 21st century (Goldberg et al., 2016; LeFrancois et al., 2021). LeFrancois et al.'s proposed interventions of combining ethical reflection workshops with industrial internship experiences may help to prepare engineering students for potential arising ethical conflicts between academic and industrial experiences, either in internships settings or in the future workplace. Unfortunately, outcome measures of this intervention study were not available yet, since the study was still in progress (see LeFrancois et al., 2021). Nevertheless, this study adds to the notion that inter- and intrapersonal competencies in engineering education have become extremely relevant in the development of a holistic engineer and particularly in conjunction with internships in engineering industries. Inter- and intrapersonal competencies can be assessed by measurements of emotional intelligence and its domain scores according to Petrides (2010) and other authors in the field of EI theory. Therefore, I specifically searched for outcome assessment in internships related to EI in this literature review section but had no success in finding any EI measurements in interning engineering students.

Based on the current comprehensive literature review, direct student outcome assessment in internships in engineering industries in undergraduate engineering education was limited to defined communication competencies (Wilson, 2019), innovative thinking skills (Nachammai et al., 2020), and some holistic competencies around problem-solving for human and societal needs (Luk & Chan, 2021). Although mentioned in several studies, other professional outcomes or work readiness competencies were mostly broadly described in either case studies or in general terms of satisfaction levels or feedback on internship experiences without any details on whether and how the achievement of those competencies was related to the internships (Anjum, 2020; Feijoo et al., 2019; Marsono et al., 2017; Sriram & Somu, 2020). Besides, Hora et al. (2017) and Hora, Parrott, and Her (2020) mentioned industrial internships as high impact practices to achieve student competencies but fell short to provide data on details of specified student competencies. Instead, Hora et al. concentrated on the differences in the complexity of student accounts between students with and without internships and called for more rigorous studies that examine the impacts of specific internship characteristics on a variety of student outcomes.

Nonetheless of sparse literature findings that combined internships in engineering industries and student competencies, most of the assessed or mentioned student outcomes and professional competencies learned in internships centered around inter- and intrapersonal skill development. It was agreed upon in engineering education literature that inter- and intrapersonal competencies need to be developed in engineering students to face engineering workforce demands based on changes in the engineering profession in the 21st century, which I will detail in the next section of the literature review. Surprisingly, only few studies inferred a connection between the improvement of personal and professional competencies in engineering education and EI measures in engineering students with merely a suggestion to conduct more research on internships in engineering industries to boost students' EI (see Skipper et al., 2017).

Although EI inherently measures intra- and interpersonal competencies in its domain scores (see Petrides, 2010), only one recent study, that synthesized a literature review on psychosocial factors and outcomes of college internships, mentioned the interrelation of students' competencies in internships and EI (see Gillespie et al., 2020), Based on an integrative literature review on this topic, Gillespie et al. (2020) pointed out, that reports in the literature indicated positive relationships between internship participation and a number of psychosocial factors, such as EI, proactivity, self-efficacy, conscientiousness, emotional awareness and its display. However, Gillespie et al. did not report any data of EI measures in conjunction with internships nor distinguished between students' EI possibly being a reason for or the outcome of the participation in internships in engineering industries. Thus, the question whether there was a difference in EI between engineering students with and without the participation in an internship in engineering industries remained unresolved, although it seemed to be the foundation to asking more questions about competencies learned in industrial internships. Answering this question may bring new insights on the direction for further investigations whether and how internships may influence EI development as a basis of improving related inter- and intrapersonal competencies in undergraduate engineering students. Gillespie et al. also noted a long list of needs for more studies in the emerging field of student internships to better understand and align internships outcomes and student competencies in higher education. There is a notion to possibly promote internships as a mean to fill the skill gap between engineering education and changes in workforce requirement posed on the 21st-century engineer. In the next chapter of this literature review, I will present findings on changes in the engineering profession and how they relate to EI development in engineers.

Emotional Intelligence in Postsecondary Students of Technical Disciplines

In this section of the literature review, I compare findings on EI in postsecondary students of technical and engineering disciplines versus non-technical disciplines, such as in the medical field and the humanities. Furthermore, I synthesize empirical research that assessed the value of EI in technical disciplines. Within this topic, I will discuss changes in the engineering profession in the 21st century and how it relates to emotional intelligence. Lastly, I will present scientific findings on stakeholder's perceptions on the need for socioemotional skills, including EI, in postsecondary engineering graduates. I limited the stakeholders who's views I included in this literature review to employers of engineering graduates and engineering alumni since these two stakeholder groups were directly experiencing effects of EI, or the lack of thereof, in the workforce of engineering professions. Findings on the perceptions of engineering alumni and their employers may help to understand the need for and the value of EI in postsecondary engineering education.

Students' Emotional Intelligence in Technical Versus Non-Technical Disciplines

The inclusion of EI skills in education was not a new concept. However, professional fields that were historically interested in EI training were disciplines that typically rely heavily on direct human interaction as a measure for success, such as in nursing, healthcare, psychology, business, public management, and leadership (Kotsou et al., 2018). Conversely, higher education in STEM related, technical disciplines, such as in science, mathematics, technology, or engineering, focused primarily on highly cognitive and subject content knowledge lacking to address EI or other social-emotional competencies in students of such technical fields (Goldberg et al., 2016).

One of the greater challenges in higher education was to combine cognitive content matter knowledge and the acquisition of emotional competencies, particularly in technical disciplines (Gilar-Corbi et al., 2018). According to Gilar-Corbi et al. (2018), the inclusion of the assessment and teaching of social-emotional skills in the curriculum of technical disciplines was necessary to guide students towards technical productivity that was focused on high social values by solving realistic problems in the world. However, rigid curricula in technical disciplines have left little room to address emotions in technical postsecondary education, despite the understanding that emotions mediate the acquisition of knowledge itself (Gilar-Corbi et al., 2018) and enhance the communication with others in the future workforce, such as with clients or coworkers in multidisciplinary teams (Miao et al., 2018; Vanhanen et al., 2018). Therefore, noncognitive competencies, including EI, have increasingly become important in technical disciplines (Boyatzis et al., 2017; MacCann et al., 2020). In this section, I detail findings that compare students' EI in technical versus non-technical disciplines in higher education.

Emotional Intelligence in the Medical Field in Comparison to Technical Disciplines

The assessment of EI in students of non-technical disciplines, such as in medicine, nursing, psychology, or business had been frequently recorded in the literature. The largest number of studies with EI were conducted in helping professions of the medical sector, mostly including nurses or physicians. In the medical field, EI competencies were related to interpersonal skills associated with patient interaction (Ha et al., 2021), patient-centered care (Omid et al., 2018), high quality healthcare services (Srivastava et al., 2021), improved inpatient experiences (Mao et al., 2021), and leadership in hospital safety, conflict situations, and litigations due to medical mistakes (Coskun et al., 2018; Zaki et al., 2018). Furthermore, EI competencies in medical professions were linked to intrapersonal skills involving dealing with stressful situations and external pressures (Ha et al., 2021), emotional burnout (Di Lorenzo et al., 2019), compassion fatigue, high perceived stress levels (Foster et al., 2018), medical errors, and intuitive decision-making styles (Zaki et al., 2018). In most of these studies in the medical field, EI was found to be correlated with attributes of professional success and career trajectory due to the goal of providing maximal patient satisfaction. In some of the studies, EI training was perceived as a suggested intervention to build stronger resilience against the emotional demands in medical professions (Foster et al., 2018; Ha et al., 2021; Zaki et al., 2018). Yet, issues with the implementation of proper EI training in medical education or in the hospital work environment were attributed to lacking motivation of doctoral or nursing students and inconsistent EI training and mentorship approaches (Ha et al., 2021).

Although the definition of success in medical professions was heavily based on successful interpersonal relationship-building, some findings about EI in the medical field may be transferrable to technical disciplines. Technical professions in engineering or science used to define success primarily as technical or design accomplishments and only in recent years developed a focus on customer satisfaction or placement in multidisciplinary work teams, which required interpersonal skills (Boyatzis et al., 2017; Gilar-Corbi et al., 2018; Hirudayaraj et al., 2021; MacCann et al., 2020). Examples of knowledge from EI studies in the medical field that may be applicable to technical disciplines were findings on the importance of EI on leadership skills and on analytical versus intuitive decision-making strategies. Coskun et al. (2018), for example, reported results on statistically significant correlations between global and domain EI scores, measured with the TEIQue, and all subscores of leadership traits among 3947 family physicians in Turkey. This finding was confirmed by Wen et al. (2019) showing results of positive correlations between EI and leadership practices in 980 medical students in China. Furthermore, Zaki et al. (2018) investigated head nurses' leadership skills and decision-making scales in relation to EI scores. Results of Zaki et al.'s quasi-experimental studies with an EI training intervention on 57 head nurses showed a substantial increase in intuitive decision-making scales immediately after the EI intervention in comparison to before, followed by a slight decline of the use of intuitive decision-making strategies after three months past the EI intervention. Zaki et al. also showed a strong statistically significant correlation between global EI scores and intuitive decision-making in regression analyses. Unfortunately, Zaki et al. did not report domain

EI scores. Nevertheless, these results indicated a decline of gained EI skills from immediately after training to long term outcomes. It also showed the importance to investigate long term effects of EI training and application in real-world situations, which may be applicable to any discipline.

Additionally, the type of EI training may have contributed to the strength of long-term EI decline after an EI intervention. For example, Imperato and Strano-Paul (2021) addressed the previously documented long term EI erosion by using a different EI intervention model, which was based on reflection rounds with mentors in the hospital setting rather than on cognitive EI workshops. Imperato and Strano-Paul's study results on 285 third-year medical students showed a lasting improvement of EI skills and empathy on the job without signs of long-term erosion. These findings pointed to the significance of the appropriate circumstantial context for EI delivery models in real-world scenarios to achieve the maximum impact of EI training on students.

Besides, Hutchinson et al. (2018) reported that the separation of emotional decision-making and cognitive reasoning, a characteristic that equally applies to medical as well as technical disciplines, is counterproductive. Rather than ignoring or avoiding emotions in decision-making strategies, it may be more effective to consciously evaluate and include emotions in addition to analytical or technical reasoning (Hutchinson et al., 2018). Although Hutchinson et al. conducted qualitative research on 12 clinical nurses in Australia, the findings appeared to be relevant to technical disciplines as well as they touched the relationship between emotions and technical or analytical reasoning when dealing with customers, clients, or patients. Hutchinson et al. reported the emerging themes from semi-structured interviews, emphasizing the significance of the theme: “Incorporating emotional and technical perspectives in decision-making” (p. e603). This finding countered the engrained believe in science that emotions are harmful to the cognitive thought process (see Kumar et al., 2019), which became apparent in the applied engineering framework in most existing EI workshops or training as they tended to keep EI distinctly separated from cognitive reasoning (see Hutchinson et al., 2018). As in the medical sector the goal was to combine emotional and cognitive decision-making with the help of EI, engineering or technical disciplines were less susceptive to this constructivistic idea. Nevertheless, a common finding in EI research suggested that successful long term EI interventions have the most impact when incorporated in the real-world context of each situation or discipline.

Besides the type of EI training, the EI measures themselves seemed to reveal different EI learning outcomes. This has been shown by Di Lorenzo et al. (2019) who reported EI scores of 237 cross-sectional nursing students, comparing Schutte’s Self-Report EI Test (SSEIT), Jefferson Scale of Empathy (JSE), and Toronto Alexithymia Scale (TAS-20) to review dimensions of EI. Many other authors have commented on outcome differences underlying varying EI constructs independent of the discipline of application (Conte, 2005; O’Connor et al., 2019). Moreover, just reporting global EI scores did not seem to provide sufficient information on the precise situation to answer specified research questions in each case. For example, Snowden et al. (2018) pointed out that the interpersonal EI domain scores provided more useful information on significant relationships between EI and successful program completion in a three-year nursing and midwifery degree program than the global EI scores. In Snowden et al.'s longitudinal study with 876 nursing students in Scotland, the authors used the TEIQue to investigate the relationship between EI and students' retention in the program and did not find a significant relationship to the global EI scores but to EI domain scores. Regardless of the discipline of application, the choice of EI measures and the assessment of EI domain scores were agreed upon to be the leading factors to evaluate the outcomes of interest depending on the goals of specified research questions.

Another finding of EI research in the medical sector was its effect on stress coping. Education in medical professions as well as in technical or engineering professions with high demands on cognitive performances were both considered to have elevated risks of high stress levels on students due to cognitive (Nwatu & Gana, 2018) and interpersonal stressors (Enns et al., 2018). According to Lea et al.'s (2019) meta-analysis study, EI skills were effective to buffer acute stress. In addition, Enns et al. (2018) conducted a crossectional correlational study on 203 undergraduate students of helping professions majoring in psychology, nursing, and social work and reported a strong association between higher EI and lower perceived stress levels, which was mediated by greater use of adaptive stress coping strategies. Mao et al. (2021) agreed with these findings by reporting EI measures of 103 nursing students in China as being positively correlated with resilience and negatively correlated with stress. Expanding on high stress disciplines in higher education, Foster et al. (2018) investigated the stress levels of nursing, pharmaceutical, and dentistry students and identified significant inverse relationships between EI and perceived stress for nursing and pharmaceutical students, but not for dentistry students. Furthermore, the linear regression results in Foster et al.'s study indicated a moderate correlation between EI and perceived stress for nursing students and a strong correlation for pharmaceutical students. Pharmaceutical students were comparable with students of technical and other STEM disciplines, in which coping with academic anxiety was particularly important due to high academic pressures (see Jan et al., 2017). Jan et al. (2017) showed in a literature review on EI and academic anxieties that students' EI was a key element for handling stressful situations. In summary, studies in medical as well as technical disciplines have been reported to have high stress levels for students who may benefit greatly from EI training in learning to manage their perceived stresses.

Another essential outcome necessary for students in medical as well as in technical disciplines were creative problem-solving skills and flexibility in changing environments. Clinical teaching has been found to be more complex than classroom teaching due to unpredictable medical circumstances (Mosca, 2019). Problem-solving and creativity in developing solutions for new problems were both required learning outcomes for engineering education as well, as established by the Accreditation Board for Engineering and Technology (ABET, 2021). Thus, the accomplishment of these outcomes was very important in medical as well as in technical postsecondary education. EI was understood in the literature as being a predicting factor of creative problem-solving skills within a given context, as Mohammadi's (2019) statistically significant study results showed in a regressing analysis with 200 medical science students. In addition, Mohammadi's study indicated a positive correlation between EI and readiness for change leading to creativity in problem-solving. Likewise, Qutishat and Shdefat (2021) agreed with the influence of EI on change readiness by reporting a positive relationship between EI and academic adjustment in a study with 339 undergraduate nursing students as they successfully transitioned into the university life. Qutishat and Shdefat commented that EI not only benefited the students academically but also impacted them holistically. In the contrary, Mosca (2019) investigated clinical teaching faculty and did not find any statistically significant relationship between EI levels of nursing faculty and clinical teaching effectiveness in the global or any of the EI domain scores. Hence, with instructors having similar teaching effectiveness independent of EI levels, the significance of differences in EI skills in the postsecondary students was highlighted as being instrumental for their transition to college life and while engaging in stressful curricula. Therefore, training in EI would particularly benefit students in medical as well as in technical disciplines, although research on EI in technical disciplines was sparse compared to the medical or helping profession disciplines.

Few scientific authors directly compared EI levels in nursing and engineering students. Štiglic et al. (2018) conducted a study with 113 nursing and 104 engineering students at the start of their undergraduate degree programs at a university in Slovenia. Measuring the mean differences between groups using t-tests for independent samples, Štiglic et al. reported statistically significant higher EI scores in nursing students than in engineering students. The authors of this report confirmed the findings by using two EI measures simultaneously on the same population, Schutte’s Self-Reported EI Test (SSEIT) and the TEIQue, with the same results in both measures. Another study comparing EI scores in nursing and engineering students in Canada with a mixed-method approach was conducted by Lee et al. (2018) examining interprofessional education. In this study, they used a short EI intervention workshop to assess pre- and post- EI scores and used qualitative analysis of students' reflections on the intervention experience. The focus was on empathy and interpersonal interactions between professions in healthcare and engineering, which were not conventional topics taught in most STEM undergraduate programs (see Lee et al. 2018). Although Lee at al. did not report any quantitative changes in EI scores before and after the intervention workshop in either nursing or engineering students in the conducted MANCOVA analysis, qualitative feedback from students showed meaningful reflections about working with people of different professional training and backgrounds. However, the study results were limited by a small sample size and an uneven distribution between the groups, as only 8 nursing students and 34 engineering students participated. Nevertheless, awareness and positive reflections on EI in undergraduate programs of engineering disciplines and reported lower EI scores in engineering students compared to students of medical disciplines (Štiglic et al., 2018) emphasized the need to address EI in undergraduate technical education. Besides medical disciplines, other non-technical sectors utilized EI research in postsecondary education, which I will discuss in the next paragraph.

Emotional Intelligence in Psychology, Business, and Public Management Sectors

Although less than in the medical field, still, a substantial number of research studies have been published using EI measures in psychology, business, and the public management, or judicial sectors. Research topics with EI in these sectors were grouped around four clusters: (a) leadership and performance, (b) employee's or students' wellbeing, (c) organizational management and practices, and (d) self-development including entrepreneurship. Many of these topics can be transferred to technical disciplines including engineering, as expectations in the profession include leadership, management, and entrepreneurial competencies. In addition, the interconnectedness between engineering and business disciplines is reflected in the 2018 Harvard Business Review showing that 34% of the best performing Chief Executive Officers in the world have undergraduate or graduate degrees in engineering (Havard Business Review, 2020). In this section of the literature review I detail the results from EI research in psychology, business, management, and public sectors regarding findings that may apply to technical disciplines.

Leadership and Performance. A heavily discussed topic in the management sector was leadership and performance. The relationship between EI and leadership has been underscored in the past with the transformational leadership framework developed by Hammett et al. (2012), Nelson et al. (2015), Templeton et al. (2016), and Nelson et al. (2017). For a practical application, a recent example of the relationship between EI and leadership has been shown by Gilar-Corbi et al. (2019) who reported an increase in long-term EI scores after EI training of 54 senior business managers in a private company that resulted in better team management, work performance, conflict resolution, and organizational development. Besides a key role in optimal leadership, EI has become increasingly important in times of enhanced mobility and globalization in the business world, as leadership in culturally diversified organizations have become a topic on its own. Regarding diverse organizational cultures, Guang et al.'s (2019) study on 64 diversified management students emphasized EI as necessary preparation for culturally conscious managers leading heterogenous groups. In agreement with this notion, Oyewunmi (2018) reported a statistically significant relationship between EI and diversity management competencies in a regression analysis on 360 managers of a diverse workforce in Nigeria. The results of this study showed a positive correlation in global and all EI domain scores moderated by gender. Oyewunmi emphasized the need for learning and understanding of EI in globalized business endeavors to avoid possible discrimination, cultural conflict, and poor performance outcomes due to a deeply rooted natural lack of trust amidst people who are different. Working in multidisciplinary teams and with multicultural customers has become the norm in engineering professions as well (Boyatzis et al., 2017; Kolmos & Holgaard, 2018; Miao et al., 2018). Therefore, leading a diverse work environment using EI competencies has become equally important for technical professions as it is in the globalized management and business field.

Employees' Wellbeing. Besides business leaders, employees can also benefit from EI as it has shown to be related to workers' or students' wellbeing and success. Career success was defined by Urquijo et al. (2019) as job satisfaction on the intrinsic level and salary scale on the extrinsic level. The authors of this study assessed EI in 271 working alumni from various educational disciplines in Spain. Urquijo et al.'s findings from stepwise regression analysis revealed EI as a strong predictor of career success when the dependent variable was job satisfaction after controlling for personality traits and demographic variables. With a similar research quest, Monico et al. (2019)

determined with cluster analysis that the adaptive worker profile correlated with the highest levels of EI, whereas unhealthy worker profiles, for example, workaholics, corresponded with low EI levels. Regarding students in business and similar fields, effects of EI on students' wellbeing have been correlated with self-esteem building during the transition to university life (Fakaruddin & Tharbe, 2018), high self-efficacy and lower levels of perceived stress in psychology and educational students (Navarro-Mateu et al., 2020), and increased self-actualization in business students (Ordun & Akün, 2017) as well as in university managers (Gopinath, 2020). In addition, locus of control shifts from external blame to internal responsibility for own actions in MBA students (Thompson et al., 2019), citizenship behavior in management students (Dasgupta, 2020), and the understanding of own thinking style preferences to capitalize strengths of learning in art and science students (Margret & Levanya, 2017) have also been related to EI. In the field of psychology, EI has been positively related to the ability to adapt personally and socially to the increasing multicultural environment, as Mohammadiani and Home (2018) reported with a multiple regression analysis in 306 students in Iranian universities. Lastly, in the judicial sector, EI has been established as a requirement for legal intelligence for lawyers to best serve their clients and to develop trust and cooperation (Carrel, 2019). Through the different ways that EI skills fostered healthy attributes in students and employees leading to professional success in non-technical disciplines, the same or more pressures and expectations were posed on students or employees in technical disciplines. Thus, the findings of the discussed studies in the management, business, and public sectors were very relevant for technical disciplines as well.

Organizational Management. Another area in which EI was reported as strong influencer is the field of organizational management and practices. Instead of viewing individual wellbeing, this area examined outcomes in relation to an organization regarded as a whole. Ngwenya et al. (2019) conducted a meta-analysis on influences of EI on human research management on the organizational level analyzing the findings of 70 publications in the construction and engineering industry. The construction and engineering industry was considered a masculine environment which has been characterized by aggressive management styles and fierce competition, rewarding toughness, decisiveness, self-reliance, and control (Antoniadou et al., 2020). Emotionality has been viewed as a weakness in the past and studies addressing EI in the construction and engineering industries were sparce (Ngwenya et al., 2019). Ngwenya's meta-analysis results, using keyword cluster analysis, found four clusters of research in this area: (a) EI in relation to organizational human research management, (b) EI in relation to organizational leadership and performance, (c) EI in relation to an organizational healthy work environment with positive employers' wellbeing, and (d) EI's effects on changes in human research management practices. Ngwenya et al. suggested that organizational management could use EI to influence worker's job-related attitudes that are positively exhibited through job satisfaction, safety behavior, and readiness to identify with the organization and, ultimately, lead to higher workers' productivity. In agreement with this statement, Rahimi and Rostami (2018) had shown positive and statistically significant results of the influence of EI on job engagement and organizational performance in a quantitative study in Mexico. Although it was against the conventional stereotype of performers in the technical and engineering sector, organizations were starting to seek graduates with exceptional management and leadership skills to successfully complete projects (Antoniadou et al., 2020). Thus, EI skills are becoming increasingly important in organizations of technical and engineering professions, which currently occupy a unique place in the organizational management field, as they are in the process of undergoing a slow shift in professional expectations against a long history of engrained stereotypic behaviors.

Entrepreneurship. Another research topic that included EI in the business world is its relationship to self-development with attributes of entrepreneurship. Yitshaki (2021) examined EI regarding the growth of start-up companies, and study results showed EI as an essential factor in entrepreneurship and the perceived possession of the venture. EI was positively associated with the entrepreneurs' emotional stability, intentions, and performance as it greatly influenced the curvilinear relationship between the sense of territoriality and entrepreneurial psychological ownership (Yitshaki, 2021). Adding a view on the attributes of rising entrepreneurs, Nawaz et al. (2019, 2021) investigated the relationship between entrepreneurial intention, self-efficacy, and EI in students. The reason behind the quest for investigating this relationship was to stimulate the economy by focusing postsecondary education on creating job providers rather than job seekers.

Besides, EI was determined as trainable, which was in opposition to other personality attributes and had been shown to enhance entrepreneurship (Nawaz et al., 2019). Nawaz et al. (2019) surveyed 352 final-year business administration students on EI and entrepreneurial intention and reported a highly positive correlation between the two variables with higher EI levels corresponding with higher levels of entrepreneurial intention. In a follow-up study, Nawaz et al. (2021) showed results supporting the statistically significant correlation between EI and entrepreneurial intention with the addition of a mediating variable of self-regulation, defined and measured with an instrument independent from EI. Unfortunately, Nawaz et al. (2019, 2021) only reported global EI scores without any EI domain scores. It would have been informative to have added EI domain scores in Nawaz et al.'s studies, because they could have revealed interconnectedness of the variables for self-regulation and an intrapersonal EI domain variable, which would be statistically undesirable. Regardless of this small study design flaw, the relationship between EI and entrepreneurial intention was strong. Studies in engineering have confirmed this relationship as entrepreneurship was a skill highly emphasized in the education of the 21st century engineer (Miao et al., 2018). Conclusively, the field of technical and business education agreed on the necessity of including entrepreneurial thinking in their programs and acknowledged the impact of EI on entrepreneurship.

Direct Comparison between the Humanities and Technical Disciplines. Lastly, very few studies directly compared EI of students in management or humanities programs against students in engineering or related technical disciplines. A large comparative study was conducted on 448 students consisting of 176 students of the humanities and 223 engineering students in universities of Russia (Perikova et al., 2021).

Perikova et al. (2021) used stepwise multiple regression analyses to compare ten overlapping factors from surveys for EI scores, readiness for activity index, and innovativeness index. The study findings revealed only two out of the ten tested variables as statistically significant different between the two student groups. The EI domain scores for “recognizing emotions in others” were significantly higher in humanities students and the innovativeness index subscores for “taking risk for achievement” were significantly higher in engineering students (Perikova et al., 2021). The authors concluded that there are differences in the main predictors of intra- and interpersonal EI between engineering and humanities students. A similar study with less participants compared 57 technical students from the IT sector with 83 students of psychology in state universities in India, initiated due to observations of increased physical aggression among the technical and engineering students (Utami & Hitipeuw, 2019). The results of Utami and Hitipeuw’s (2019) study showed statistically significant higher means of interpersonal EI scores in psychology students compared to engineering students, but no statistically significant difference in intrapersonal EI scores. Low interpersonal EI skills among engineering students in India may be one of the reasons for the observed poor conflict resolution skills among students in technical disciplines, however, confounding or circumstantial factors were not discussed in Utami and Hitipeuw’s study, which limited the generalizability of the study results. In conclusion, from the few recent studies that compared EI in humanities versus technical disciplines, it may be indicated that interpersonal EI attributes in technical students were less developed than in students of other fields, whereas intrapersonal EI, in general, did not reveal significant differences between technical and non-technical student groups.

To the contrary, intrapersonal EI domains may show differences between students in technical and non-technical disciplines when EI domain scores were analyzed individually for each domain. Senthil et al. (2020) used the TEIQue as EI measure on a group of 141 MBA students entering the program either with an art and science or engineering undergraduate degree and found significant differences in self-control scores between the two student groups. Unexpectedly, Senthil et al.'s quantitative results showed that EI scores in the self-control domain were statistically significant higher in students with an engineering background compared to the art or science background students, whereas the other three EI domains of wellbeing, emotionality, and sociability did not reveal any significant differences. The authors expressed surprise by the results because generally students who pursue art or science degrees tended to spend more time in extracurricular activities that may develop higher self-control skills, such as sport activities, than highly stressed engineering students (see Senthil et al., 2020). This result also contradicted findings from other studies that generally showed lower EI skills in engineers in comparison to other student groups (see Perikova et al., 2021; Utami & Hitipeuw, 2019). However, a weakness of Senthil et al.'s study was the designation of group memberships with art and science in the same category. In the context of investigations for my study, I defined technical group membership as inclusive of science and engineering and separated students from non-technical majors, such as art. Senthil et al.'s study, however, combined the groups of art and science students, which may have disguised any differences in stress levels or other indicators that make technical disciplines unique. In Senthil et al.'s study, reported EI domain scores may have missed differences in results in the art and science group that may have averaged out within the group and when compared to the engineering group. Therefore, Senthil et al.'s results, unfortunately, had limited referencing weight for my study. Nevertheless, Senthil et al.'s study confirmed the importance of mastering EI skills in undergraduate education for students to become successful future leaders, independent of technical or nontechnical backgrounds.

The uniqueness of EI assessment in technical or engineering professions versus non-technical became further noticeable, when comparison within the non-technical discipline group did not reveal any EI differences. For example, Kant (2019) compared the EI scores of 200 students from the school of education and the school of law and governance and did not find any statistically significant differences in global EI scores. Furthermore, Jan et al. (2017) pointed out that STEM related disciplines have higher risks of anxiety and stress levels and may benefit more from the inclusion of EI skill training. Combined with the need to re-evaluate the unchanged, traditionally highly cognitive curricula for engineers and technical students, the inclusion of EI competencies in technical disciplines seemed to provide an extraordinary opportunity to demonstrate the trainability of EI despite masculine stereotypical thinking in the industry (see Antoniadou et al., 2020). Due to the increasing need for engineers to emotionally engage with a broad range of internal and external stakeholders, the technical field seemed to slowly be changing to position EI as critical addition to engineering education (Boyatzis et al., 2017). However, research with EI in technical disciplines was still hindered by the lack of conceptual understanding and the language of applying EI to engineering education (Antoniadou et al., 2020). Thus, although sparce in publications and stalled by stereotypical attitudes, EI research in technical disciplines offered a unique context and challenge, yet also opportunity, in comparison to other disciplines.

The comparison of EI findings in technical versus non-technical disciplines in this chapter summarized many applications that are equally important for both discipline groups. As EI implications were transferrable to technical education, it was plausible to add EI competencies to the list of necessities in engineering education in addition to technical knowledge. However, there was still a lack of acceptance of this need in engineering professions or engineering education. In the next section of this literature review, I will detail evidence for the value of and the need for EI training in technical postsecondary education.

Value of Emotional Intelligence in Technical Disciplines

After business majors, the second most popular discipline in higher education in the world was engineering and technology (Bhardwa, 2018; De Brey, 2021). Engineers have been around since 5500 BC, historically, as tool makers and inventors (Antoniadou et al., 2020). In the 21st century, technology has exploded to infiltrate every area of modern life, and the societal perception of the contemporary engineer has been transformed from a lonely tinkerer to a highly skilled technical expert with a narrow specialization (Antoniadou et al., 2020). Postsecondary education in technical disciplines, therefore, must cover an increasing amount of technical and highly cognitive content matter knowledge in major-specific curricula to educate highly specialized technical experts. Academic expectations, competition, and external pressures were high on students of technical and engineering disciplines (Nwatu & Gana, 2018). Additionally, engineering was still viewed as a masculine profession in which only the toughest can succeed (see Antoniadou et al., 2020) and emotions were perceived as weaknesses that hinder the cognitive thought process and technical progress (Kumar et al., 2019). With this engrained image of an engineer in modern society, it was understandable that there was little incentive or evidence that EI was part of the traditional engineering curriculum, in any country.

However, times of globalization, world-wide communication, global knowledge exchange, and a market of international businesses have changed the demands on the engineering profession from an independent inventor to an inter-dependent team member of the business world (Antoniadou et al., 2020; Jose et al., 2020). Employers of engineers now expect them to work comfortably in a diverse and multidisciplinary group environment and to successfully communicate with and serve a large group of technical and non-technical stakeholders (Boyatzis et al., 2017; Miao et al., 2018). Furthermore, engineers were often expected to additionally take on a leadership or management role in larger group projects (Vanhanen et al., 2018). Thus, to demonstrate expertise in specialized technical knowledge was no longer sufficient for success in technical and engineering professions (Boyatzis et al., 2017; Gilar-Corbi et al., 2018). In the next section of this literature review, I will present empirical evidence on changes in the engineering profession of the 21st century that may require EI skills to meet current professional expectations. I also examined the literature for information on the needs of employers regarding engineering graduates and the perspectives of alumni who graduated from engineering programs. These two stakeholder groups could directly report on the need and the value of EI in their technical fields, which may help to understand whether EI training is valuable and needed in postsecondary engineering education.

Changes in the Engineering Profession

The 21st century changes in the engineering profession that lead to the necessity to train in cognitive as well as in emotional intelligences have multiple causes. Historically, technical expertise has always been the basis and the desired outcome of engineering education. Therefore, EI skills in technical disciplines should not be considered as a replacement for technical knowledge, but instead as an enhancement to necessary work skills in the field that the shift in the engineering profession of the 21st century brought with it (Antoniadou et al., 2020). With changing expectations in the field came a different definition for job readiness and new employability skills that need to be developed during engineering education (Feijoo et al., 2019). As the technical field, as a whole, has adopted a fast-changing pace, career adaptability has become increasingly important as a major factor in workforce efficiency and graduates' employability (Hamzah et al., 2021). Career adaptability also has been shown to be substantially associated with EI, as Hamzah et al. (2021) reported in a correlational study with 205 university students. In engineering, adaptability to a fast-changing industry has become even more critical because expectations as well as technologies are constantly evolving.

Increasing Stress Levels. New technologies in the 21st century were developed faster and faster. Particularly in the engineering sector, radical digitalization, upsurge of artificial intelligence, new machine learning tools, and fast developing innovative technologies have created a need to be willing, motivated, and capable to constantly learn new things and develop a deep sense of quality, work ethics, and meaningfulness for societal advancements (Gilar-Corbi et al., 2018; Jose et al., 2020; Lappalainen, 2017; Warrier et al., 2021). In addition, technical solutions were supposed to be innovative (Miao et al., 2018), pleasing to the customer (Boyatzis et al., 2017), and incorporate a measure for social responsibility by including considerations of the impact of engineering solutions in global context and to the society at large (Lappalainen, 2017). To meet all needs of a customer-oriented, environmental-friendly engineering design in today's world, team-based models have become the norm in engineering organizations (Boyatzis et al., 2017). Some researchers believe that the perceived quality of relationships an engineer can built with others in internal teams or with external stakeholders will predict job engagement and effectiveness over and above cognitive intelligence. For example, Boyatzis et al.'s (2017) hierarchical multiple regression analysis on 40 professional engineers in the USA and Europe showed that EI, measured with self- and 168 peer-evaluations, was the only variable that significantly predicted engineering effectiveness. Besides, according to the World Economy Forum 2018, EI was considered one of the top ten skills that will lead to employability in future jobs (Schwab, 2018). Likewise, MacCann et al. (2020) noted that the attributes of successful engineering graduates built heavily on non-cognitive constructs, including EI. Consequently, success in the engineering profession relied on inter-relational competencies in a fast-developing field of new technologies. This new work environment came with a high level of pressures to stay competitive and stress on individuals to perform at their best at multiple and changing tasks. Thus, the engineering profession was considered to have higher risks of stress than other disciplines (Nwatu & Gana, 2018).

High stress levels in engineering industries were due to cognitive stressors from expected technical knowledge, on the one hand, and to the additional expectations on optimal performance in today's work environment, on the other hand (Jan et al., 2017). Cognitive stressors originated from the need to continuously develop better, faster, or more efficient technologies and the call for innovation and entrepreneurism to stimulate the economy in the technical sector (Antoniadou et al., 2020). Sometimes, the race against time or competition for the lead of who can engineer a new product first, was an influencing factor in the industries, as Khuroo et al. (2020) discussed in a publication of the COVID-19 vaccine development. These scenarios in a competitive environment may lead to a faster solution but created extraordinary stress levels on the engineering work teams. The real-world stress levels cannot be adequately simulated in the classroom environment of postsecondary engineering education to prepare graduates for the existing stressors in the workforce. Even before the pandemic, Gilar-Corbi et al. (2018) stated that the shift from acquiring theoretical knowledge in universities to practical application in the field with challenges in the workplace that require cognitive as well as emotional intelligences was often not properly addressed in postsecondary engineering education.

However, to develop strong emotional competencies to assist with stress coping or conflict resolution may help to smoothen the transition from the university environment to the industries. Conflict resolution as a part of leadership skills have already been discussed as being correlated to interpersonal EI domains (see Gilar-Corbi et al., 2019; Nelson et al., 2017). For stress coping strategies, Gilar-Corbi et al. (2018) highlighted the mediating role of EI on resilience, coping with stress, to work under pressure, and personal and professional well-being in engineering. Besides, Devis-Rozental (2018) discussed the effects of learning socio-emotional competencies in higher education as benefits beyond the classroom. In line with this notion, Zhoc et al.'s (2020) longitudinal study found that EI is positively associated with students' engagement, assessing 560 students from ten faculties in a Hong Kong university. In addition, Suleman et al. (2019) reported the EI domains of self-development, emotional stability, and relation management as the strongest predictors of success that represented 80% of the variance in academic excellence assessed in a multiple linear regression model with 186 science and technology students. Not only emotional stability, but also motivation to be an independent and innovative learner contributed to success, as Alsharari and Alshurideh's (2021) study showed. Alsharari and Alshurideh investigated the interaction between EI, creativity, and learner autonomy and found that there is a strong relationship between EI and learner autonomy indicating that autonomous learners are better equipped to persevere towards their goals. Conclusively these findings indicated that EI training may help to prepare students better to deal with their personal feelings and stress levels when they face the demands of the engineering workforce.

The New Normal. The first years of the COVID-19 pandemic has reframed the new normal for undergraduate students. In addition to already high expectations in the engineering industries in general, engineering students and graduates further faced challenges due to the pandemic. In addition to disturbances in their social, political, and economic lives, the sudden need for independent and asynchronous learning, in school as well as in the field, accelerated the necessity to become an autonomous learner and problem-solver, particularly in the biotechnology and bioengineering sectors. While focusing on global problems, a new urgency was to address individuals' emotional and psychological state of well-being. Warrier et al. (2021) explored the holistic development of students by leveraging EI to strategize practices that help in learning for the unforeseen future. In this qualitative study, Warrier et al. extracted themes from focus groups of campus counsellors and psychologists working directly with students during the pandemic, followed by the analyses of discussions on solutions from stakeholders' initiatives. Major themes for student challenges in the so-called "new normal" during and after the pandemic emerged as: "Fear of uncertainty" and "Impulse control" (p. 66). Fear of uncertainty is a stressor of high magnitude and impulse control can deal with reactions to unknown or uncomfortable situations (Warrier et al., 2021). Findings of Warrier et al.'s study further illustrated EI strategies, such as self-awareness, self-control, adaptability, stress management, and resilience-building, as successful tools to cope with adapting to an uncertain future. Resilience was defined as the ability to bounce back post adversity, which seemed to be mostly needed to adjust to the new normal (Warrier et al., 2021). Stakeholder perspectives on potential solutions included life skill training and improvement of EI development initiatives to provide much-needed awareness of emotional status and unhealthy stress impulse reaction habits among students (Warrier et al., 2021). As adaptability was the major attribute that helps to cope with the new social and work environment (see Warrier et al., 2021), the results of this study were easily applicable beyond students to individuals in the workforce, in particularly, in engineering industries as they experienced accelerated stress levels under the pandemic's pressure for solutions.

Readiness for Change. As social lives and work environment are facing an unknown future, readiness for change and self-initiatives are becoming an even stronger attribute in engineering professions. Supplementary to Warrier et al.'s (2021) study, Koç (2019) showed a strong correlation between EI and self-directed learning readiness in a relational study on 259 undergraduate students in mathematics, language, and education using the TEIQue. Koç (2019) highlighted the metacognitive, cognitive, and socio-emotional skills that related to autonomous learning and readiness for change. Readiness for change entails a high level of self-regulation and self-motivation competencies (see Koç, 2019), attributes that Sanchez-Ruiz et al. (2021) correlated to trait EI domain scores using regression analyses and structural equation modeling on 360 working Lebanese adults. Sanchez-Ruiz et al.'s study was special in current EI research because the authors added the component of "adaptive" to coping strategies and, therewith, reframed positive strategies in actively adjusting psychological reactivity to stressful situations. Adaptive coping strategies were shown to be related to less distress in times of the COVID-19 pandemic through meaning-centered coping (Sanchez-Ruiz et al., 2021). In summary of considerations for psychological well-being, engineering professions in the 21st century carried a high burden of stressors on various levels, which can be mediated by self-directed, adaptive, and healthy management of emotions based on the development of strong EI competencies.

Entrepreneurism. Besides personal well-being, EI also has been established to influence innovative thinking in engineering. Miao et al. (2018) reported in a meta-analysis study that EI was positively related to entrepreneurial intention with a stronger relationship in long-term-oriented cultures. Furthermore, Rodrigues et al. (2019) investigated the effect of EI on creativity in 345 university students, and results supported a direct positive effect between the variables, which fostered innovation and led to effective strategies of entrepreneurship. One skillset of entrepreneurs included effective leadership competencies, which could be applied to expectations in competitive engineering industries on the individual team-building level (see Oyewunmi, 2018) as well as on the organizational market-leading level (see Ngwenya et al., 2019). Besides, many authors already have established the relationship between transformational leadership and EI competencies in other fields (see Nelson et al., 2017). Leadership, transformation, and entrepreneurship as desired attributes in the engineering field became even more intricate when placed in the global workforce.

Diverse Thinking in Global Engineering. An interesting phenomenon of working in a global environment in engineering industries was the push to include diversity in problem-solving, as it has been shown to ensure innovative solutions and enhance the development of better products as well as organizational performance

(Triguero-Sánchez et al., 2018; Vaze, 2020). Special to engineering, however, was the extended understanding of diversity as it went beyond cultural, racial, and gender differences and relied heavily on the inclusion of the diversity of thought in design development. Benedict et al. (2018) examined in a qualitative study how 12 diverse engineering students perceived differences and enacted different ways of thinking. The semistructured interviews revealed that differences in engineering were defined primarily based on technical, creative, and interpersonal skillsets as well as different ways of thinking and interests. Benedict et al.'s study highlighted the need for the inclusion of diversity of thought in problem-solving in the engineering workforce as engineered design solutions must consider client or user perspectives, safety concerns, global impact, and marketing strategies, which may include non-technical considerations, such as appealing appearance without practical implication. Diversity of thought also included underlying latent attitudes, beliefs, and mindsets (Benedict et al., 2018), which may contribute to a feel of belongingness in the engineering world as corporate organizations have normed the perceived dominant way of engineering thinking. In essence, diversity of thought was extremely valuable for novel solutions, but also carried a danger of perceived failing to fit the parameters of the stereotypical engineering norm of thinking (see Benedict et al., 2018). Thus, emotional awareness and clarity in self-perception and use of emotions, as they can be trained by EI development, may be beneficial to ensure advantages of the conscious inclusion of diversity of thought in engineering designs without jeopardizing the feeling of belonging to the engineering crowd.

In conclusion, changes in the engineering profession were based on the drive for constantly improving technologies, shifting expectations on having multiple roles as a professional engineer, and higher levels of stress due to the pressing need for global engineering solutions. In these uncertain times, EI has become more important than ever to meet the challenges of the engineering professions in the future. However, it remained unclear if engineering education at its current state could meet the changing needs of the engineering industry. In the next paragraphs, I will examine the literature for perspectives of engineering graduates' employers and engineering alumni to discuss whether engineering graduates are prepared to face the new work expectations in the engineering field.

Engineering Employers' Needs

The perspectives of employers of engineering graduates were essential to understand the competencies that postsecondary engineering education needed to address in preparing its students for the workforce. Kolmos and Holgaard (2018) presented a comprehensive meta-analysis study of the literature on employability skills in engineering. Kolmos and Holgaard's analyses of 28 publications defining employability skills in multiple countries and from 1000 job advertisements revealed that the understanding of employability skills differed between employers' wishful thinking and students' perceptions of what they think employers are looking for. In fact, Kolmos and Holgaard's study pointed out that employers are regarding employability skills more as life skills. Motivation, teamwork, willingness to learn, communication, project management, and problem-solving were agreed upon in the literature to be the most often desired skills by employers (Kolmos & Holgaard, 2018). Likewise, De Campos et al. (2020) reported in his meta-analysis on soft skills for engineers that 85% of desirable skills for employability are related to soft skills and only 15% to technical skills. In contrary, engineering students expected that employers were mainly looking for technical subject matter expertise in their field of study, as it was projected by their engineering education focusing primarily on technical knowledge (Kolmos & Holgaard, 2018). As students tended to mirror the priorities of the curriculum in their perceptions of most wanted employability skills, Kolmos and Holgaard's meta-analysis indicated an incongruity in the believes of what engineering employers wanted and what engineering academic staff, who developed engineering curricula, thought employers wanted.

As the definition of employability skills may entail a broader societal perspective on global citizenship (see Kolmos & Holgaard, 2018), employers generally expected graduates from postsecondary engineering education to have a sense of contextual factors for engineering solutions, including business awareness, market leadership positioning, sustainability, global value, and awareness of environmental or social responsibility (Hadgraft & Kolmos, 2020; Kolmos & Holgaard, 2018; Nisha & Rajasekaran, 2018). Contextual understanding in engineering has become increasingly important because engineering was vital in humanitarian, social, and economic developments to face numerous global and sustainability challenges (Hadgraft & Kolmos, 2020). In particular, Nisha and Rajasekaran (2018) found, based on another meta-analysis study on engineering employability skills, that employers were looking for a blend of general and technical skills with great emphasis on motivation, self-management, adaptability, and positive attitudes ensuring continuous learning and informed judgement on contemporary topics. On the positive side, Pardo-Garcia and Barac (2020) mentioned that employers saw social benefits on hiring fresh university graduates because they can bring a new perspective to a problem. However, engineering graduates may be overwhelmed with the number of expectations noted in a job advertisement. For example, Dang et al. (2020) reported based on a mixed-method study using surveys and interviews with engineering employers and alumni, that corporate engineering organizations ideally were looking for interdisciplinary knowledge of technical and managerial skillsets, assuming applicants' familiarity with considerations of leadership, organizational performance, and risk management in engineering design solutions. Dang et al. pointed to the complexity of topics in this combination and suggested to clearly define separate engineering programs, such as engineering technology with an emphasis on practical engineering and engineering management with focus on planning and directing development of new engineering technologies. Due to the increasing complexity of emerging topics in engineering professions and a culture shift to focus on new technologies in a global business world, today's students may be faced with needing to prepare for unknown future positions that do not even exist yet in today's job market (Dang et al., 2020; Pardo-Garcia & Barac, 2020). Therefore, standard technical education in engineering has become less useful and attributes of motivation, inspiration to look for new opportunities, innovation, and entrepreneurship have become the most valued attributes in engineering industries.

However, current literature pointed to the discrepancies between employer expectations and engineering program graduates' proficiencies. Despite employer expectations on contextual factors for engineering designs, more than a third of surveyed engineering students in Kolmos and Holgaard's (2018) study felt not prepared at all in global and societal contexts, contemporary issues, impact of engineering solutions, ethics, or business knowledge at the time of graduation. Furthermore, many employers reported to have to train entry-level engineering hires in essential, soft, or professional skills, which were used as synonymous terms for the same group of non-technical skillsets (Kolmos & Holgaard, 2018). Specifically, employers reported a lack in newly hired graduates in professional skills regarding multidisciplinary teambuilding (Boyatzis et al., 2017), effective communication (Hirudayaraj et al, 2021; Yong & Ashman, 2019), customer-oriented behavior (Chand et al., 2019; Khan, 2019), knowledge of basic professional norms and work ethics (Hirudayaraj et al., 2021), the ability to work autonomous and under pressure (Khan, 2019, Pardo-Garcia & Barac, 2020), and the willingness to react to feedback and respond with behavioral changes upon reflection on prior experiences (Hirudayaraj et al., 2021; Pardo-Garcia & Barac, 2020). Furthermore, Chand et al. (2019), who focused in his study on three employability skills in young engineering graduates, reported a deficiency in EI, self-efficacy, and personal attributes, such as intrinsic motivation, by surveying 507 engineering employers in India. Unfortunately, Chand et al. did not collect employer feedback on any other non-technical attributes of young engineering hires. The lack of personal skills was also noted by Tejan and Sabil (2019) who surveyed 20 employers in Morocco specifying a lack in flexibility to cope with changing work environments, listening skills, accepting responsibility, and the willingness to learn new things in new entry-level hires. Together, these findings indicated a mismatch between the skills and qualifications of entry-level engineers and the abilities required by employers in the industries.

Most studies addressing engineering employability skills had chosen a few specific attributes of interest to investigate, which led to sporadic attempts in assessing this topic. Two recent studies filled this gap in literature by taking an organized and systematic approach on investigating the employability skills that engineering employers want and that entry-level engineering job seekers may lack. The first comprehensive study on engineers' employability skills was conducted by De Campos et al. (2020), who evaluated 2638 scientific publications on the importance of soft skills in engineering and classified the study's findings into six categories of necessary skills:

1. Problem solving, as it was the original nature of engineering.
2. Critical thinking, which involved making informed judgements.
3. Effective communication with technical and non-technical stakeholders, which included good listening skills.
4. Teamwork in domestically and international context, sometimes in unfamiliar fields, which required collaborative spirit, negotiation skills, and familiarity with multiculturalism.
5. Creative thinking, including leadership attributes that enabled the sense of ownership and responsibility of one's own actions, and divergent thinking.

6. Ethical perspectives, including personal accountability, morality, professionalism, effective work habits, and social responsibility.

In terms of skill ranking, De Campos et al.'s (2020) results showed that 83% of employers claimed professionalism, personal responsibility, and commitment to work to be the most important attributes in engineering job seekers. In the era of fast-developing engineering designs and technologies, creativity had a special meaning in employers' perspective, as it had both cognitive and soft skill elements (De Campos et al., 2020). Creativity resulted from a structured path of thinking based on (a) enough background information and repertoire of ideas, combined with a constant upkeeping on new developments in the outside world, and (b) the intrinsic motivation of opportunity seeking (De Campos et al., 2020). The term divergent thinking emerged as a new skill for engineers in De Campos et al.'s analysis. According to De Campos et al., divergent thinking produces results that are not only innovative, original, and unexpected, but also bold, critical on impact, and adaptive to contextual situation that are related to social needs. By re-defining new and historical essential professional skills for engineers from a systematic and comprehensive literature review laid ground to the assessment of what students need to learn in their engineering education and how to close the identified skill gap between the qualifications of engineering graduates and employers' expectations.

The second critical and comprehensive study on soft skills in engineers, conducted by Hirudayaraj et al. (2021), took a more practical approach by surveying and interviewing over 500 employers of entry-level engineers in a mixed-method design. The employers ranked 26 emerging key engineering skills by importance and, also, by the proficiency as they observed each skill in their entry-level engineering hires. Hirudayaraj et al., then, statistically compared the importance and the proficiency of each skill with ANOVA statistics by profile characteristic. A large positive difference indicated that the ratings for importance were greater than the proficiency of the newly hired engineers. This way, a statistically significant difference would indicate a gap in skills between employers' expectation and entry-level engineer's proficiency. Hirudayaraj et al. followed up with interviews of selected employers to illuminate some reasons for the ratings and proficiency findings and, also, to confirm the accuracy of the survey results post-pandemic. Hirudayaraj et al.'s quantitative study results highlighted reliability, teamwork, responsibility, self-motivation, and positive attitude as the top five attributes that engineers should have. The qualitative part of the study complemented these findings as one employer mentioned that the new hires need to demonstrate the ability to work with others already on the first day of work. Therefore, it was no surprise that employers indicated in their interviews, that effective communication, global and cultural awareness, reliability, work ethics, flexibility, willingness to learn, and curiosity or initiative contributed to the best cultural fit in their companies (Hirudayaraj et al., 2021). All 26 top attributes identified in this study fitted in one of the six categories established by De Campos et al. (2020) and aligned with prior findings in the literature on the most important soft skills for engineers.

Not surprising, but still alarming, were the results of Hirudayaraj et al.'s (2021) study regarding the statistically significant differences between the importance of each skill and the proficiency in entry-level engineers. Of the 26 identified professional skills for engineers, 24 showed significant differences between importance and proficiency, which related into the fact that entry-level engineers did not fulfil the expectations of their employers in 24 different soft skills. These findings strongly supported the existence of a skill gap in 24 attributes that employers deemed critical in engineering graduates. The attributes with the greatest skill gap were effective communication with a diverse group of people and time-management. The ability to deal with uncertainties in relating to people and situations were also significantly different between expectations and proficiency. Leadership skills were the least proficient on the list, but employers ranked leadership skills very low in importance for entry-level employees. Furthermore, Hirudayaraj et al.'s qualitative study results brought some deeper understanding on the type of skills lacking in engineering graduates. Some attributes seemed to be typical for millennials, such as the choice of preferred communication medium in digital form rather than in person. According to some employers' interviews, this created inter-generational conflicts within the company (Hirudayaraj et al., 2021). Some other skill gaps related to internal attributes, such as EI competencies, maintaining interpersonal professional relationships, persistence in problem solving, listening skills, or the ability to foresee the consequences of their actions. A more pressing issue was the lack of knowledge on basic workplace norms, such as dress codes, hours of work, and timely reporting as well as mentally engagement in the work (Hirudayaraj et al., 2021). All issues were related to professional or soft skills that appeared to be new to entry-level engineers who did not have a prior work experience. Hirudayaraj et al.'s findings confirmed the indicated inconsistency between expectations of employers and proficiency in professional skills in engineering graduates, as it was described in several other studies (see Boyatzis et al., 2017; Chand et al., 2019; Craps et al., 2020; De Campos et al., 2020; Hadgraft & Kolmos, 2020; Pardo-Garcia & Barac, 2020; Tejan & Sabil, 2019).

In the mindset of the fourth industrial revolution, which was driven by a change towards digital culture that relied on collaboration, innovation, data-driven insights, and customer centricity (see Maisiri & Van Dyk, 2021), employers' expectations on engineers have changed. Employers described soft skills as determining factors in the hiring or promotion process (Hirudayaraj et al., 2021). As they seemed to be satisfied with the level of the technical knowledge in entry-level engineers (De Campos et al., 2020; Hadgraft & Kolmos, 2020; Nisha & Rajasekaran, 2018; Tejan & Sabil, 2019), they identified gaps of professional skills in young engineers, lacking basic work ethics, engagement, customs of workplace norms, and communication skills. Especially in time of globalization, multicultural awareness and politeness in communication with diverse and wide-ranging audiences was rated high on the importance scale established by engineering employers; yet showed the largest gap in the comparison to young engineers' proficiencies (Hirudayaraj et al., 2021). The ability to work in multidisciplinary teams already had improved since 2015, as reported by Pardo-Garcia and Barac (2020) in a study comparing teams in sustainability contests in engineering designs between 2015 and 2019. However, teamwork proficiency and other professional competencies were in need of additional training for engineers as those skills still appeared on Hirudayaraj et al.'s (2021) list of 24 soft skills with statistically significant gaps between engineering employers' expectations and observed performance of young engineers. In general, there was an agreement among engineering employers in the literature that new-age engineers not only need technical knowledge, but also must be able to bridge this knowledge with multiple stakeholders and be adaptive to current social and societal needs in their approaches to solve a problem. The new list of employers' expectations on engineering graduates included many essential competencies, such as soft skills, EI, and people's skills.

Engineering Program Alumni's Perspective

In the same notion as engineering employers emphasized the importance of soft skills in entry-level employees, alumni of engineering programs widely agreed with the identified professional skillsets that helped to get employment in engineering industries (Alshehri et al., 2019; Nisha & Rajasekaran, 2018). Just as mentioned by employers, engineering alumni identified in alumni surveys the top competencies for employability in the engineering field to be effective communication, solving problems in a team, and managerial skills (Fletcher et al., 2017; Nisha & Rajasekaran, 2018; Watson & Blincoe, 2017). Some engineering alumni also highlighted motivation as an attribute that had a particular significant impact on the employability of engineering graduates (Nisha & Rajasekaran, 2018). In almost all studies, alumni were dissatisfied with the level they were trained regarding professional communication skills and business-oriented thinking (Alshehri et al., 2019; Fletcher et al., 2017; Pereira et al., 2019), whereas technical skills were perceived as taught more than sufficient in their engineering education (Fletcher et al., 2017). Kolmos and Holgaard, (2018) also pointed out, based on alumni feedback, that the transition from college into working in the industries was highly dependent on the individual's readiness to change. Adjusting to new situations and new contexts required reflective, transferrable, and metacognitive skills with the understanding and the willingness to adapt to new norms and customs that not only apply to the transition into the workforce, but also may continuously be needed in global and multicultural business relationships (Kolmos & Holgaard, 2018). In general, engineering employers and engineering alumni shared the same views on the importance of professional and soft skills and the lack of attention thereof in engineering education, as it was indicated by the findings of several studies analyzing engineering alumni perspectives on employability skills (Alshehri et al., 2019; Fletcher et al., 2017; Nisha & Rajasekaran, 2018; Pereira et al., 2019).

In contrast to the increasing awareness of the need for and lack of training in multicultural communication, collaborative teamwork, adaptability to change, and management competencies with others and self, engineering alumni were often not conscious of their opportunities to learn and that their future career progression was their individual responsibility. For example, in surveys with closed and open-ended questions on 930 engineering alumni, intercultural communication scored the lowest on the learning scale and respondents did not relate to this skill in their answers to the open-ended questions at all, as shown in a mixed-method study conducted by Lavi et al. (2021). In addition, Hirudayaraj et al. (2021) provided examples of non-professional behavior observed in entry-level engineers, such as staring at their phone, being absent-minded, or avoiding face-to-face communication, which not only showed lack of knowledge of professional etiquette or communication norms, but also projected an unwillingness to learn or to change habit. As this behavioral trend could be seen as a general issue among digitalized millennials, it created unwanted inter-generational problems in the workplace (Hirudayaraj et al., 2021). Similarly, Kövesi and Kálmán (2019) reported findings from 28 semistructured interviews with engineering alumni that time-management and self-organization was perceived as a problem when given autonomy and freedom to procrastinate, which may hinder proactive career development with long-term vision. However, all interviewed or surveyed alumni agreed upon, that today's engineers' qualities cannot just be grounded in technical knowledge, but must entail behavioral and emotional components, which include to be social, attentive, and, in particularly, knowing how to communicate.

Many authors also mentioned that personal and professional attributes can be learned and practiced outside the core educational curriculum by extracurricular activities, internships, and opportunities to gain real-world experiences in the industries. In fact, many authors who described the gap between employer expectations and engineering proficiency in professional skills and intrapersonal attitudes, suggested real-world experiences in design contests, industrial internships, collaborative projects with industry, or abroad exchanges as a way to bridge that gap (Alshehri et al., 2019; Hadgraft & Kolmos, 2020; Kolmos & Holgaard, 2018; Mikkonen et al., 2018; Pardo-Garcia & Barac, 2020; Sharunova et al., 2019; Winberg et al., 2018). For example, Pardo-Garcia and Barac (2020) noted that ideas for entrepreneurship arose from real-life problems that could be solved by putting professional and technical skills in a particular context with practical application solving certain needs in society. On the same note, Nisha and

Rajasekaran (2018) suggested individual placements of internships in multinational companies to enhance multicultural communication skills, and, in Kövesi and Kálmán's (2019) study, most alumni reported to have found their first job from an internship in their final year of their engineering program. In addition, alumni directly reflected on the significance of industrial internships for socio-behavioral interpersonal skills, such as teamwork and communication, as well as the learning advantages on intrapersonal attitudes, such as self-management, optimism, and motivation, as it was reported in the longitudinal study by Mikkonen et al. (2018). In this and other studies, the real-world aspect was mentioned frequently as a motivating component to learn and to bring theory into practice in a realistic and concrete context. Confirming that field experiences were crucial for success, recent engineering alumni reported first-hand, in reflections on their first job, to have been unprepared for the reality of how engineering design worked in industrial practice with expectations on deadlines, norms and regulations, timely communication, transdisciplinary feedback loops among several departments and with clients, and complex systems-thinking at every step of the design (Sharunova et al., 2019). Systems-thinking was important in engineering design because it increased awareness of the whole picture from beginning to end including marketing goals in designing a socially meaningful, useful, and optimized product with several iterations among multiple stakeholders (Sharunova et al., 2019). Lastly, Bae et al.'s (2022) qualitative study, illuminating the perspectives of engineering students on bridging the gap between industry expectations and academic preparation, confirmed not only the awareness of this gap but also highlighted the importance of internships to improve professional skills, EI, and the boost in understanding the meaning of their careers. Altogether, to offer industrial internships in engineering education seemed to be a possibility to address the gap in soft skills and work readiness in graduating engineers.

From the employers' view, internships served another purpose. Hirudayaraj et al.'s (2021) study findings confirmed in employer interviews that they looked in applicant's resumes primarily at internship experiences or activities outside of the degree requirements to find well-rounded hires. However, in Hirudayaraj et al.'s (2021) study findings, it was also noted that internships in engineering education were appropriate for just a glimpse of the real world of work, yet, interns were usually treated differently than employees because they were heavily supervised and not hold fully accountable for their own time management and professional responsibilities. Craps et al. (2020) also hinted to some flaws with internships being fully compared to engineering work experiences, as he pointed out in a focused smaller literature review. According to Craps et al., industrial internships were interventions meant to expose students to authentic engineering experiences, but the link to engineering practice was not always clear, possibly due to a lack of effective facilitation of the learned in the workplace. With the many questions about internships, Hadgraft and Kolmos (2020) expressed surprise in their meta-analysis study that internships were not yet well-researched in terms of learning outcomes, and the authors called for more studies on this topic. Nevertheless, and according to the general perception in the literature, internships were viewed as a possibility to partially fill the gap in engineering industry expectations and academic preparation of competent engineering graduates; however, research and empirical evidence on the details of learning outcomes from internships regarding employability skills were lacking.

In summary, the fourth industrial revolution with its digitalization and customer-centricity has brought changes to the engineering profession requiring soft skills as much as technical skills. In particular, multicultural communication was rated as the most important professional skill in today's engineering global work climate, followed by adaptation to change, collaboration, and entrepreneurship (Chand et al., 2019; Dang et al., 2020; Hirudayaraj et al., 2021; Kolmos & Holgaard; 2018; Pardo-Garcia & Barac, 2020; Yong & Ashman, 2019). Despite employer expectations on freshly hired engineers regarding these professional skills, many students and alumni felt that they had not been sufficiently prepared for the workforce in their engineering education (Alshehri et al., 2019; Bae et al., 2022; Fletcher et al., 2017; Pereira et al., 2019). Alumni and engineering employers alike identified multiple soft skills as the competencies that engineering graduates lacked the most. Communication skills, self-management, multicultural teamworking skills, professionalism, and innovative thinking stood out the most as gapping between engineers' proficiency and expectations in the engineering industry (Hirudayaraj et al., 2021). All mentioned employability skills required to understand and manage emotions in oneself and other people in a work relationship, which can be measured by EI domain scores (see Petrides, 2010).

With the change in expectations on today's engineers, EI gained importance in technical disciplines. Some publications mentioned EI directly as desirable employability skill, yet, deficient in engineering graduates (see Chand et al., 2019; Flores et al., 2020;

MacCann et al., 2020), whereas others highlighted the underlying or mediating role of EI on desired professional skills in young engineers. For example, Chand et al. (2019) verified the mediating role of EI on the relationship between employability skills and employer satisfaction through the analysis of employer surveys, Boyatzis et al. (2017) reported EI as a significant predictor of engineering effectiveness as observed in peer evaluations from fellow engineers, and Alsharari and Alshurideh (2021) detailed the interaction between EI, creativity, and learner autonomy. Additionally, Koç (2019) investigated the relationship between EI and self-directed learner readiness, Hamzah et al. (2021) provided data that supported the mediating role of EI on career decision self-efficacy and self-esteem with career adaptability, and De Campos et al. (2020) connected EI to emotional control, motivation, lifelong learning skills and self-management. Moreover, Liu and Boyatzis (2021) correlated EI with resilience and stress coping, and Craps et al. (2020) related EI skills to foundations of reflection and awareness of one's beliefs and values which were important to deal with a diverse collaboration or client population and were missing in engineering educational activities. Besides, EI has been shown to be the underlying competence for many of these outcomes in non-technical disciplines already. Since soft skills in engineers have become as important as technical skills, yet were addressed very little in current engineering education, which remained focused on specialized technical expertise, educational learning models that enhance professional skill development were widely suggested in the literature as desired program improvements in engineering education (Hadgraft & Kolmos, 2020; Kolmos & Holgaard, 2018; Mikkonen et al., 2018; Pardo-Garcia & Barac, 2020; Sharunova et al., 2019).

In summary, one of these suggestions to boost professional skills in engineering education was to place engineering students in real-world industrial settings, such as internships (see Bae et al., 2022; Boyatzis et al., 2017; Hadgraft & Kolmos, 2020; Mikkonen et al., 2018; Nisha and Rajasekaran, 2018). However, learning outcomes as results of internships have not been sufficiently researched in the literature, particularly regarding assessment of communication, teamwork, self-management, or EI competencies (Hadgraft & Kolmos, 2020). As EI was identified as underlying or direct skills needed for desired employability competencies in engineers (see Alsharari & Alshurideh, 2021; Chand et al., 2019; De Campos et al., 2020; Flores et al., 2020; Hamzah et al., 2021; Koç, 2019; MacCann et al., 2020), and internships were suggested as boosting activity in real-world scenarios and with real-life expectations in meaningful contexts (see Boyatzis et al., 2017; Hadgraft & Kolmos, 2020; Mikkonen et al., 2018), it made sense to investigate EI levels in engineering students with and without internship experiences. Hence, findings from such missing research in the literature may be the beginning to initiate a new field of research to fill the gap in understanding whether and how internships may impact professional skill building, including EI, in engineering students.

In this section of the literature review, I described EI in non-technical and technical disciplines in conjunction with changes and new expectations in engineering professions. I illuminated engineering employers' and alumni perspectives on employability skills of new-age engineers, and findings in the literature postulated agreement upon the pressing need to improve EI in engineering students as underlying or direct skill set related to success in engineering industries (see Alsharari & Alshurideh, 2021; Boyatzis et al., 2017; Chand et al., 2019; De Campos et al., 2020; MacCann et al., 2020). Many alumni and employers suggested real-world exposure, for example, in industrial internships, as possibilities to improve the engineering curriculum to address this need; however, solid understanding of the learning outcomes of internships and the trainability of EI in higher education was left undiscussed in these publications (see Hadgraft & Kolmos, 2020). Next, I examined empirical literature on the trainability of EI through experiences with a focus on higher education and I will present the findings in the next section of this literature review.

Trainability of Emotional Intelligence Skills through Experiences

In this section of the literature review, I present findings that illuminate the understanding of the trainability of EI. I will synthesize empirical research studies that provided evidence of how EI can be developed through life experiences, as it was indicated by Petrides's (2021) EI theory. Furthermore, I examine existing strategies to develop EI in students of higher education. Lastly, I will compare findings regarding gender and age differences on emotional intelligence in students of postsecondary education. In this portion of the literature review, I analyze existing knowledge on how EI has or has not been included in higher education, particularly, for technical disciplines. The findings presented in this section were limited to EI development in adults as it applies to higher education.

The second-generation of EI constructs defined EI as skills rather than abilities that were originally assessed with right or wrong answers (see O'Connor et al., 2019). EI regarded as skills implied that EI can be potentially improved through experiences, maturation, and training interventions (Lappalainen, 2017; Mattingly & Kraiger, 2019; Petrides, 2010). Mattingly and Kraiger (2019) conducted a comprehensive meta-analysis study on EI interventions and found statistically significant positive effects of EI training on EI score improvement. Therefore, the authors of this meta-analysis study agreed with Boyatzis (2018), Nelson et al. (2017), Nguyen et al. (2019), and Petrides (2021) that EI was a trainable construct. However, Mattingly and Kraiger's meta-analysis study was limited in assessing details of EI training modules and did not provide information on specific reasons for EI improvement. In Petrides's (2010) EI model, EI was shaped through one's self-construct influenced by life experiences, which I further examined in the literature for EI development in adults in the following section.

Life Experiences and the Development of Emotional Intelligence

EI was defined by Petrides (2010) as self-perceived skills that affect social behaviors and can be shaped through life experiences. Brackett and Cipriano (2020) suggested the development of the limbic system in the human brain as the place where emotional regulatory interactions can alter brain activity levels. The same authors theorized that EI is acquired through informal life experiences as well as formal instructions, such as learning of emotion-regulating strategies (Brackett & Cipriano, 2020). Espinosa and Rudenstine (2018) studied EI in clinical patients with personality disorders and found that unwanted adverse life experiences, such as traumatic events, were negatively related to EI, confirming that wanted or unwanted life experiences played an essential role in the development of EI.

However, there was no indication that the ability to learn EI skills was bound to a particular timeframe in a person's development. Unlike acquiring language skills more efficiently at certain developmental stages in childhood, Brackett and Cipriano's (2020) report on EI indicated that EI skills can be developed through life experiences at any time in one's life. Many scientific scholars agreed that EI was not a fixed quantity and can be improved at any age through opportunities to practice and gain EI skills (Bartz et al., 2018; Boyatzis, 2018; Goleman, 2018; Nelson et al., 2017). Particularly in adolescence, EI served protective and predictive functions in developing desirable behaviors for better physical and mental health regulating anxiety and stress that may negatively affect academic performance (Brackett & Cipriano, 2020). In addition, Naseem (2018) looked at the moderating role of EI on job stress and life satisfaction in 350 technical service employees from the telecommunication industry in Pakistan who dealt with customers daily. Naseem's study results showed a negative relationship between age and stress, and a positive relationship between age and EI, which led to his conclusion that job-related life experiences contributed to higher EI and lower stress levels in senior employees. In summary, findings in the analyses of literature utilizing medical, psychological, and educational studies that examined EI development showed agreement on the importance of intentional or unintentional life experiences, positive or negative, as a source for continuous shaping of EI in adults.

Results from studies in higher education in different disciplines, such as language, business, or engineering education, showed a relationship between higher EI scores and greater maturity of participants. Although few studies examined EI in language education, Dewaele et al. (2018) found that trait EI and teaching experiences in instructions of English as a foreign language were positively linked. Dewaele et al. concluded that teachers' EI can develop as a result of increased life experiences. Furthermore, studies with postsecondary business and engineering students showed positive correlations between higher EI and longer work experiences (Shipley et al., 2017; Skipper et al., 2017). Looking at more details, Esnaola et al. (2017) conducted a longitudinal "ex post facto" study in Spain, comparing EI scores of 484 students progressively between secondary and postsecondary education over 6 years. Results of this comprehensive, longitudinal study showed an increase in emotional competencies over time, based on summative EI scores (Esnaola et al., 2017). The findings were consistent with expectations that EI skills increase with age, greater maturity, and more life experiences, as indicated in the literature of the past 20 years and in the more recent meta-analysis studies by Khan and Minbashian (2017).

However, Esnaola et al.'s (2017) longitudinal study also indicated that summative EI scores alone may not detect differences in the development of each EI domains. Esnaola et al. reported that different EI domain scores fluctuated at varying times during the 6 years of their study depending on the developmental stages and gender of the participants. Results of specified EI domain measures over time showed an initial decline prior to a peak before consistent levels of EI domain development were achieved (Esnaola et al., 2017). Due to the general lack of consistent longitudinal patterns in the development of each EI domain during adolescence (Esnaola et al., 2017), the authors of this study interpreted their findings as contradictory to the general maturity hypothesis of

EI development as it was originally suggested in the literature (see Khan & Minbashian, 2017). To explain fluctuations of EI, Esnaola et al. concluded that the accumulation of life experiences contributes to each domain of EI development rather than the development of EI itself. Other authors confirmed the incremental development of EI domains assessed by self-rated or trait EI models depending on varying circumstances (MacCann et al., 2020). Comparing these findings in the literature underlined the understanding that EI can be learned at any time point in one's life, and unintended and intended life experiences may be learning events that are specific to related EI-domains. Therefore, planned strategies for intended EI learning events that may advance related EI domains were widely suggested in the literature to improve EI development in adults (Bartz et al., 2018; Boyatzis, 2018; Goleman, 2018; Naseem, 2018; Nelson et al., 2017; Mattingly & Kraiger, 2019, Petrides, 2009b; Suleman et al., 2019).

Emotional Intelligence Development Strategies in Higher Education

Although many scientific authors recommended focused EI learning strategies in higher education, few studies discussed the outcome of implemented EI learning events. Boyatzis et al. (2017), Fakhar et al. (2019), and Skipper et al. (2017) agreed that systematic opportunities for EI learning events in postsecondary education, particularly in technical disciplines with highly cognitive curricula, needed to be improved. However, these authors did not provide insights on practical solutions on how to improve students' EI skills in their reports. Strategies to improve EI skills in academic or professional education have been described as exploratory and unsystematic in the literature (Kotsou et al., 2018). In the following section of this literature review, I examine scientific publications that used existing EI development strategies and how they related to desired performance outcomes.

Emotional Intelligence Competencies and Academic Performance

Many scholars who applied EI research to higher education were asking how EI relates to academic achievement (Keefer et al., 2018; Lea et al., 2019; Nwatu & Gana, 2018; Petrides et al., 2018; Suleman et al., 2019; Zhoc et al., 2020). The target of these studies was to identify strategies that empower necessary EI skills for improved learning, particularly for primarily cognitive topics. For example, in a correlational study with 124 postsecondary students in physics, a subject demanding highly cognitive skills, Nwatu and Gana (2018) found a positive correlation between EI and academic performance in technical disciplines. From their EI domain analyses, Nwatu and Gana attributed a lack of stress management skills with academic challenging curricula in technical disciplines as the problem with retention in tertiary physics education. Suleman et al. (2019) also noted a direct relationship between students' EI and mathematics success from findings in a crossectional study with 186 undergraduate students in Pakistan. Statistical results of Suleman et al.'s study indicated that the EI domain addressing emotional stability was the leading factor in the relationship between EI and academic success. Findings from these studies indicated that stress management and emotional regulation, both factors of EI, directly related to success in highly cognitive educational topics.

Nevertheless, the ability to cope with new and stressful situations as a desirable EI skill has become a more significant topic in all areas of education. Sanchez-Ruiz et al.'s (2021) correlational data showed a mediating role of EI domains that address coping with stress and anxiety during the COVID-19 pandemic. These results were supported by the literature of positive psychology with findings that connected higher trait EI skills in individuals with a higher likelihood of engaging in adaptive coping strategies when confronted with stressful situations in higher education (Keefer et al., 2018). Therefore, a new need in higher education was to develop strategies to improve EI skills related to negative emotions around stress management that occur in unfamiliar situations (Keefer et al., 2018) or in curricula regarded as more stressful, such as in technical disciplines (Nwatu & Gana, 2018). In a meta-analysis study, Lea et al.'s (2019) findings indicated that trait EI was effective to buffer acute stress that could be initiated, among other stress factors, by cognitive stressors. With the increasing amount of online instruction in tertiary education and, in recent times, of pandemic-related remote learning, greater EI skills have become increasingly important to build relationships between peer students or between students and instructors in an online environment (MacCann et al., 2020). These findings underlined the new importance of EI skill-building strategies for students in higher education in recent times and, particularly, in technical disciplines with already high cognitive expectations and stressors.

However, Guil et al. (2021) pointed out that another EI domain, the awareness of emotions, may also contribute to negative effects on college students' performance. The authors presented a serial mediation model of trait EI domains on emotional affect and anxiety with a study of 467 undergraduate students. Increased negative emotions were related to the direct effect of enhanced emotional attention through learning about them, which may lead to increased anxiety (Guil et al., 2021). Study results showed that about

16% of variances in anxiety were attributed directly to the effects of trait EI levels. However, when emotional attention and emotional clarity in EI were connected, for example, through EI practical exercises, the potentially negative effect of higher EI awareness turned into a positive effect and lower anxiety in students (Guil et al., 2021). These findings further emphasized the intricacy of EI skills and their domains and the importance of the development of EI strategies relevant to each social situation or circumstance. Therefore, adding isolated, knowledge-based EI workshop intensives may not yield the long-term success in building EI skills as it had been originally suggested in the literature, and as it was presented in the meta-analysis review of EI-specific training modules by Hodzic et al. (2017).

Besides isolated intensives for EI skill building, blended EI learning strategies have shown more promising results. Suleman et al. (2019) proposed integrative programs for undergraduate education that blended instructional social-emotional learning in the curriculum. With this strategy, the authors reported to advance students' academic accomplishment by showing results of a strong positive correlation between EI and academic success in undergraduate students in Pakistan in a crossectional study. Furthermore, Majeski et al. (2017) suggested that even small EI learning strategies incorporated into existing discipline-based courses in online instruction, such as instructors raw modeling EI competencies through their behavior or the use of narratives of cognitive self-appraisals and emotional reflections on challenging topics, could make a difference in enhancing EI skills in adult learners. Lappalainen (2017) introduced an experimental integrative course design in an engineering curriculum that combined the learning of EI competencies in required classes without disrupting the remainder of the rigorous engineering program. The course included group projects and reflection on positive change, which was unusual for engineering curricula. Feedback from questionnaires from engineering students provided positive evaluations of the integrated EI intervention, although the students emphasized that this course was a completely new experience (Lappalainen, 2017). Results from qualitative analysis of student feedback included that engineering students started to think about making a difference in the lives of others and feeling positive and satisfied about working on practical group projects that brought impactful meaning to engineering problem solving (Lappalainen, 2017). In general, the discussion of integrative instructional strategies to enhance EI development in students of higher education has gained new popularity in recent literature. I further synthesized the literature on outcomes of existing EI intervention modules.

Modules of EI Development Strategies

Systematic reviews of existing EI interventions in the literature revealed widespread and mixed results depending on the various existing EI theories and measures, the specific goals of EI domain improvement, and the population and circumstance EI interventions were targeting. A general consent was that the field of EI interventions was relatively new and heterogeneous; therefore, intervention approaches' results from more than 20 different measures were not appropriately comparable due to lack of methodical consistency (Kotsou et al., 2018). Hodzic et al. (2017) and Kotsou et al. (2018) conducted meta-analyses studies comparing existing EI interventions in the literature and pointed out shortcomings of previous EI programs. The main concerns were generalizability because research with EI interventions was limited to specified fields, such as organizational leadership, medical professions, public managers in governmental entities, and the judicial sector (Kotsou et al., 2018). Furthermore, Kotsou et al. pointed out that many published EI intervention reports were missing control groups, which is a limitation to scientific methodology.

The execution of EI training programs also varied widely across literature reports. Most EI training programs aimed to improve a specified outcome related to an EI domain, such as the understanding of emotions to improve the quality of interpersonal relations, delivered by short, intensive workshops of a few days and specified for a targeted population group (Hodzic et al., 2017). The majority of short-term, EI-specific training modules were either theory-based through lectures or experience-based through reflection and role plays (Hodzic et al., 2017). Schoeps et al. (2019) reported issues with long-term stability of EI training from a study with 250 university students with 2-hour EI training sessions for eight weeks. Initially, students' EI scores increased at the endpoint of the training, but the effects disappeared at a later follow-up measure (Schoeps et al., 2019). Many other studies with short-term EI interventions did not provide long-term assessment data (Hodzic et al., 2017).

Besides direct EI training sessions, reports with other approaches utilizing indirect EI training through activities or online lessons were presented in the literature. Indirect approaches to EI training in higher education included drama activities (Alfonso-Benlliure et al., 2021), experiential psychotherapeutic self-esteem building exercises (Danciulescu, 2019), and various collegiate sports activities (Dobersek & Arellano, 2017;

Rodriguez-Romo et al., 2021). One group of researchers used vocational training to increase EI skills in students of health sciences in Spain (Perez-Fuentes et al., 2020). In another approach, a researcher group in Germany used a web based EI training program instead of face-to-face interactions to teach EI skills; however, comparative results in this study showed no statistically significant differences between the test and the control group immediately after the training and only some EI improvement after 6 weeks that were similar in both groups (Koeppe et al., 2019). In general, the definition of intervention success of these EI development strategies depended greatly on situational circumstances and improvement goals.

In summary, consistent findings from studies with EI interventions were that increasing length and duration of EI training, delivered over multiple weeks, were correlated to higher intervention success and that the intensity of EI improvement depended on situational factors and the theoretical foundation of the EI intervention (Hodzic et al., 2017; Kotsou et al., 2018). Kotsou et al. (2018) also noted that lower levels of baseline EI corresponded to greater EI improvement. Furthermore, Romosiou et al. (2019) confirmed the findings of positive effects of integrative, multiple weeks long EI interventions by showing ANOVA comparison statistics between a control group and an intervention group in the education of police officers. Romosiou et al.'s (2019) study was significant because it showed also long-term positive effects of integrated EI training modules through a follow-up questionnaire that included questions on how the learned skills were integrated into everyday life events. All authors agreed that, generally, EI training positively impacted EI skills and that more research was needed to improve EI interventions. In addition, many authors mentioned moderating and mediating factors on baseline EI levels and EI development, such as gender and age. In the next section, I synthesize literature that examined findings on the influences of gender and age on EI.

Gender and Age Influences on Emotional Intelligence in Postsecondary Students

Historically, gender and age differences on EI have been discussed in the literature since the beginning of EI research. Aloiseghe (2018) pointed out that most studies in the past from original EI theorists, such as Salovey, Goleman, Bar-On, Nelson and Low, Boyatzis, and Wong, found higher EI to be positively correlated with the female gender and increasing age of the participants. However, recent literature showed that the relationships between age or gender to EI was more complex with contradictory study findings regarding age and gender differences on EI (Aloiseghe, 2018). Particularly, when EI differences, based on gender and age, were measured for specified EI domains and compared to global EI scores, the literature revealed contradictory study results (Meshkat & Nejati, 2017). In the following sections, I will separately discuss research that examined age influences and gender influences on EI.

Age and Emotional Intelligence

Although age has been shown to be significantly positively correlated with EI in recent meta-analysis studies (Khan & Minbashian, 2017; Kotsou et al., 2018), the connection between social influences from the surrounding world at any time point in one’s life were considered instrumental in shaping emotion management and other domains of EI skills (Lappalainen, 2017). The finding of a global EI increase among older age groups seemed to be consistent with the expectation that EI should progress with further life experiences (Esnaola et al., 2017); however, when Esnaola et al. (2017) detailed EI domain development over time in a longitudinal study, the authors found that EI domain scores fluctuated across the time of the 6-year study without an ascertainable pattern and not linear to the increasing ages of the participants. Esnaola et al.'s longitudinal study results with 484 students showed that none of the assessed dimensions of EI underwent substantial changes in relation to age. Furthermore, Costa et al. (2021) concluded from their study with 1066 adolescents that age was weakly negatively associated with the EI domain addressing the use of emotions, whereas the EI domain of emotion appraisal of others was positively correlated with age. These studies with EI domain analyses confirmed that, generally, the relationship between age and EI scores of EI domains were more complex than the global EI score alone could reveal (Meshkat & Nejati, 2017), even when measured over a longer period in one's life (see Esnaola et al., 2017).

In addition, studies with students in postsecondary education were generally limited to the specific ages that students commonly attended college. Aloiseghe (2018) specifically examined the EI of 291 university students in technical disciplines and study results showed no correlation between EI and age. The author pointed out that college students have a limited range of time when they attending college, which cannot be generalized to changes in a full lifetime with a greater array of different experiences (Aloiseghe, 2018). Aloiseghe and MacCann et al. (2020) agreed that emotional maturity depended on experience levels and only secondary on age itself, particularly in adults. Guil et al. (2021) used age as a covariate in their EI study on 467 undergraduate students to account for students' maturity levels. All authors confirmed the relevance of age for the development and evolution of EI domains, not only as a secondary influence on maturity, but also as a potential mediator of other factors for EI development. In summary, existing literature provided controversial findings of the direct influence of age on EI development. Emotional maturity as an accumulation of experiences (see Khan & Minbashian, 2017) was generally found to be intertwined with age, but age and emotional maturity did not seem to automatically develop linearly.

Gender and Emotional Intelligence

Such as age, gender also had a complex relationship to EI. However, in the past decade, gender as survey question had undergone a shift from a binary variable to a more fluent category (Sullivan, 2020). Most surveys or censuses prior to 2011 reported gender as a fundamental demographic variable in binary form (Medeiros et al., 2019; Sullivan, 2020). As previously defined by the American Psychological Association's council of representatives in 2011 (APA Annual Report, 2011), gender referred to the attitudes, feelings, and behaviors that a given culture associated with a person's biological sex. According to Medeiros et al. (2019), the debate of gender as a non-binary category in surveys or censuses started through movements in the political arena around 2010. Sullivan (2020) pointed out that 2021 census advisories confused the three distinct categories of sex as a biological classification, gender as a social construct, and gender identity as an individual self-perception by combining these terms interchangeably in surveys. Furthermore, the existence of biological intersex conditions was estimated to apply to 0.018% of birth, a minuscule number of minorities, which questioned the usefulness of the non-binary variable choices in censuses (Sullivan, 2020).

Although non-binary gender categories have become more popular in recent years, the consequences for survey research have not been satisfactorily examined (Medeiros et al., 2019). Therefore, gender as non-binary category in quantitative social sciences has received limited attention due to difficulties in comparing research results with historical data (Medeiros et al., 2019). Furthermore, in quantitative terms, surveys with more than male and female classification, were unlikely to produce enough responses for statistically meaningful analysis in additional categories, particularly when the survey did not rely on relevant associations to gender outside the health and medical fields (Medeiros et al., 2019). Medeiros et al. conducted a study on surveys with binary gender questions compared to non-binary gender questions in the United States, Canada, and Sweden to examine methodological differences and possible survey priming effects based on political biases of the survey participants. The authors found no methodological differences between the two questionnaires and reported that of the three countries only for the United States a political affiliation made a statistically significant difference in the survey evaluation. Nevertheless, the difference between surveys with binary or non-binary gender questions could significantly alter survey results and participation rates when politicized (Medeiros et al., 2019). However, since literature studies in EI research referred to gender in terms of social roles associated with the biological sex of male or female and the expectations on typical male and female behaviors in society, rather than political affiliations, I adhered in my discussion of gender influences to the existing EI literature with binary gender classification. Gender influences on EI were commonly reported according to the historically male and female gender categories. All examined literature reports followed the definition of gender as a social construct as determined by Sullivan (2020) and in the newest APA manual (American Psychological Association, 2020).

Gender as socially defined construct introduced the meaning of society as a responsible force for socializing behavior of males and females differently (Aloiseghe, 2018). Findings in international literature concerning gender and EI supported this understanding by reporting different and sometimes controversial results about the correlation between EI and gender depending on the culture of participants in the study. For example, Esnaola et al. (2017) reported statistically significant differences in EI of male and female participants in their longitudinal study with students in Spain, explaining the gender difference as mostly caused by the socialization in different roles and emotional education of boys and girls in Spain. Controversially, Meshkat and Nejati (2017) showed results from 455 undergraduate students in Iran with no significant difference in global EI of male and female participants, explaining the findings in conjunction with a relatively recent equalization attempt of women in the Iranian workforce. These studies may indicate a cultural component on gender differences in EI.

Other authors confirmed possible cultural influences on gender-specific EI variations by showing inconsistency in the results of gender-related EI differences in various parts of the world. For example, in India, female college students were reported to have higher EI scores than males (Chandra et al., 2017; Soni & Bhalla, 2020); in Sri

Lanka, female medical undergraduate students showed higher mean EI scores than males (Ranasinghe et al., 2017); in Nigeria, gender differences in the strength of the relationship between EI and performance in physics were significant (Nwatu & Gana, 2018); and in Pakistan, EI gender differences in undergraduate students were significant in all domains of EI (Saeed & Ahmad, 2020). Contrarily, in Delhi, dental undergraduate students showed no significant differences in EI among both genders (Yadav, Mohanty, et al., 2020), and, in Ghana, medical university students did not display significant gender differences in EI in all assessed EI domains (Lawson et al., 2021). In the United States of America, Mattingly and Kraiger (2019) reported no gender differences in EI in their meta-analysis study, whereas Keefer et al. (2018) indicated in their longitudinal study that females scored significantly higher in the interpersonal dimension of EI. In summary, there was no consensus in the literature about gender influences on EI in adults. However, many authors of recent literature started to focus on male and female gender differences in specified EI domains instead of global EI measures.

Systematic analyses of gender differences in various EI domains indicated that global EI scores as summative measures may average out any details that gender-specific strengths and weaknesses in specified EI domains may reveal (Aloiseghe, 2018). Abdullah et al. (2019) conducted a systematic meta-analysis on EI domains among women. The analysis' results showed that, generally, higher interpersonal EI skills utilized in building relationships with others were associated with females and higher intrapersonal skills, such as assertiveness and stress management, were associated with males (Abdullah et al., 2019). Other authors confirmed similar findings, for example, results from a study with 1066 adolescents reported that males had higher levels of self-emotion appraisals, whereas females had higher levels of emotion appraisals of others (Costa et al., 2021). In addition, Milena and Ginszt (2017) assessed EI levels in male and female sport climbers, a high-stress sports activity that demanded the highest physical and psychological performance to succeed, and his EI measurements from questionnaires showed that male climbers had significantly higher EI in the domains of realizing, acknowledging, and judging their own emotions. In other EI domains, such as empathy or interpersonal skills, the male and female athletes did not show a difference (Milena & Ginszt, 2017). Generally, stronger male EI skills, compared to females, were dominantly found in intrapersonal domains of EI and stronger female EI skills in interpersonal domains of EI.

In students of higher education in technical disciplines, however, the general gender related strengths in intra- or interpersonal EI domain competencies did not seem to be consistent. Higher levels of EI in areas of stress management skills were associated with males in a study by Nwatu and Gana (2018) on physics students and by Aloiseghe (2018) on technical students. Another study with a competence-based EI model utilizing 313 postsecondary engineering students showed statistically significant gender differences in two domains of EI: self-emotion appraisal and regulation of emotions with males scoring higher than females (Encinas & Chauca, 2020). On the contrary, in Meshkat and Nejati’s (2017) study, female undergraduate students scored higher in EI domains related to self-regard as compared to males, which matched the findings of Soni and Bhalla (2020) in colleges students, that females managed their emotions more competently than their male counterparts. Furthermore, a study on the fear of missing out among 339 undergraduate students by Qutishat (2020) confirmed with linear regression results, that females possessed higher competencies in EI related to self-management and academic adjustment in college than males. As another outcome possibility, Bibi et al. (2020) reported in their study no EI gender differences in 100 university students in Pakistan but showed a negative association between EI and aggression, in which male students scored higher on the aggression subscale. Although most authors agreed on gender-specific differences in students of postsecondary education in certain EI domains, findings showed contradictory outcomes concerning males or females scoring higher in specified EI domains, particularly in students of technical disciplines.

In summary, studies addressing gender differences in EI scores were categorized into three groups: (a) studies that showed no differences in global EI and EI domains between males and females (Lawson et al., 2021; Mattingly & Kraiger, 2019; Yadav, Mohanty, et al., 2020), (b) studies that found no gender differences in global EI but found significant differences in specified EI domains between males and females (Bibi et al., 2020; Meshkat & Nejati, 2017; Milena & Ginszt, 2017), and (c) studies that showed gender differences in all EI scores including global EI (Abdullah et al., 2019; Costa et al., 2021; Encinas & Chauca, 2020; Esnaola et al., 2017; Keefer et al., 2018; Saeed & Ahmad, 2020; Soni & Bhalla, 2020). The controversial findings in the literature on gender influences on EI levels may have depended on many factors, such as the type of EI measurement, or external components, such as cultural upbringing, environmental factors, or other external circumstances of each study. Petrides's (2010) trait EI model acknowledged gender specific EI differences, and many studies that used Petrides's EI instrument controlled for gender differences in the male and female distinction (see Petrides, 2009b).

In conclusion of this literature review section on the trainability of EI, EI has been established as learnable skills that can be developed through training experiences for adult learners, either exclusively focused on EI development or incorporated in other learning situations. Many authors acknowledged the need to include EI skills in the curriculum of higher education, particularly in technical disciplines, but strategies to deliver EI training in postsecondary education were exploratory and in need of further investigation. Generally, multiple weeks of EI training incorporated in other activities revealed better long-term outcomes of EI skill development than short EI training intensives that added to an already tiresome curriculum in technical disciplines (Hodzic et al., 2017; Kotsou et al., 2018). A face-to-face EI training component to enhance practical interpersonal skills was found superior to remote training modules (Koeppe et al., 2019). Furthermore, differences in EI development depended on each learning situation (Guil et al., 2021), the baseline levels of EI in individuals, and the type of EI measurement. In some cases, gender and age contributed to EI baseline and development differences. The synthesis of a combination of explored EI learning strategies in the literature and their reported effects in adult education discovered specifics of an optimized version of EI training in higher education. However, no existing EI learning strategy had been reported or tested that included all criteria of an optimized EI learning strategy as synthesized from the literature.

Although the literature provided the specifics of an ideal EI learning situation in postsecondary education, existing EI intervention strategies lacked one or more of these attributes to be successful in the development of long-term EI skills and were mostly removed from real-world applications (Schoeps et al., 2019). Therefore, there was a need to examine more EI learning strategies in higher education that had interpersonal, practical, individualized components and were incorporated in content-specific activities of the existing curricula. In the education of engineers, an internship in affiliated engineering industries may fulfill many of these characteristics of a long-term EI training strategy; however, it was unknown if engineering internships may have an influence on EI development in students or even whether students with and without the internship experience differed in their global or domain EI scores. This knowledge would greatly improve the notion to further examine internships as possible EI development strategies in undergraduate engineering education.

Summary and Conclusions

In this literature review, I examined existing knowledge on internships in engineering education and how they may relate to student outcomes, EI development in postsecondary engineering students, and strategies in higher education concerning the trainability of EI through experiences.

The first topic that I exhausted in the literature was on existing knowledge on internships in undergraduate engineering education. Student internships in engineering industries fell under a specialized work-based learning model that was regulated under the U.S. Department of Labor (U.S. Department of Labor [Factsheet #71], n.d.) and follows criteria developed by the National Association of Colleges and Employers (NACE, 2018). Pregraduation internships in engineering industries were defined as temporary learning experiences in professional settings that are tied to the students' formal education by providing a practical application for knowledge acquired in the classroom; thus, must be executed in industries of the students' field of study considered for their career paths (Heatherfield, 2020; NACE, 2018). However, student internships were not as formally contracted as other work-based learning models (Hora et al., 2017) and, therefore, relied heavily on the cooperation between the academic coordinator of the educational institution, the company supervisor, and the interning student to establish and evaluate set learning outcomes (Rouvrais et al., 2018). Although outcomes may be different in topic areas, internships in engineering industries targeted to expose interning students to the shared practices and work procedures in their chosen field and, therefore, contributed to the achievement of comparable professional skills in engineering across disciplines or institutions (Laguador et al., 2020).

Next, I synthesized findings in the literature on benefits and challenges of student internships in engineering industries. Due to many reported benefits of pregraduation internships for students regarding their transition into the workforce (Bender, 2020; Kövesi & Kálmán, 2019; Myint et al., 2021), employment opportunities (Baert et al., 2021), better career crystallization (Arrayan, 2020; Ozek, 2018), and attitude improvement (Minnes et al., 2020), internships in engineering industries have gained strong popularity in engineering education for students, educators, and hosting companies alike (Hora, Parrott, & Her, 2020; Margaryan et al., 2020, Wolfgram et al., 2020).

Companies benefited from student internships in engineering education by screening emerging talent and being able to advertise their company or products through increased academic-industry collaborations, which also may have benefited the reputation of the educational institutions (Ozek, 2018). Despite all benefits of student internships in the industries, challenges with a critical mass and equal access of internship opportunities for all students (Moss-Pech, 2021; Robinson et al., 2020), logistical obstacles (Birhan & Merso, 2021), and differences in the execution of internships (Powers et al., 2018; Silva et al., 2017) have hindered to include internships in engineering industries as mandatory curriculum component (Zuckerman, 2021). Thus, industrial internships were primarily offered as extracurricular activities or as a choice for technical elective credits in engineering education (Best Colleges, 2021), and only about 50% of engineering students participated in an internship in the industries while enrolled in the degree program (Kapoor & Gardner-McCune, 2020; Laguador et al., 2020).

Furthermore, I researched knowledge on the effects of internships on student outcomes in engineering education. There were few studies in the literature on the effects of internships on student competencies in higher engineering education, and mostly either based on student data from perceived satisfaction levels with internships (Bender, 2020) or without evidence of direct relationships between student outcomes and internship activities (Wolfgram et al., 2020). However, a handful reports focused on the development of specified student competencies through internship activities, such as communication skills (Wilson & Kaufmann, 2020), entrepreneurial competencies (Nachammai et al., 2020; Ranabahu et al., 2020), ethical behavior (LeFrancois et al., 2021), or holistic and people-centered competencies (Luk & Chan, 2021; Chowdhury et al., 2020; Hoosain & Sinha, 2018; Myint et al., 2021). All assessed or mentioned student outcomes in internships had in common that they required underlying inter- and intrapersonal skills, which could be measured with EI instruments (see Petrides, 2010). Furthermore, Gillespie et al. (2020) pointed out that reports in the literature indicated positive relationships between internship participation and a number of psychosocial factors, such as EI. Yet, the literature was lacking reports that combine EI measures with student internship participation in engineering industries.

The second topic that I discussed in my literature review was focused on what was known about EI in postsecondary engineering students. EI was historically studied in non-technical disciplines that rely primarily on direct human interactions, such as in psychology, business, public management, and healthcare professions (Kotsou et al., 2018). In the healthcare field, EI training was related to improved interpersonal skills associated with patient experiences (Ha et al., 2021; Mao et al., 2021; Omid et al., 2018; Srivastava et al., 2021) and intrapersonal skills associated with stress-coping and burnout (Di Lorenzo et al., 2019; Foster et al., 2018; Ha et al., 2021). Furthermore, in the business and public management sector, EI was shown to be influential on leadership and performance characteristics (Gilar-Corbi et al., 2019; Nelson et al., 2017), diversity consciousness (Guang et al., 2019), employee's well-being (Monico et al., 2019), high self-efficacy and lower stress levels (Navarro-Mateu et al., 2020), as well as organizational management in competitive markets (Ngwenya et al., 2019). Besides, EI in the business world was attributed with successful entrepreneurship (Nawaz et al., 2019, 2021; Yitshaki, 2021). Most of the benefits from EI training in healthcare and business applied to 21st century engineering professions as well because changes in the engineering field led to increased stress, the need for interaction with clients, global competition, and multicultural collaborations (Antoniadou et al., 2020), which require inter- and intrapersonal EI competencies. However, comparative studies between engineering students versus nursing students or engineering students versus students of the humanities showed significant differences in EI between students of technical versus non-technical disciplines (Perikova et al., 2021; Štiglic et al., 2018; Utami & Hitipeuw, 2019), sometimes depending on the assessed EI domains or varying definitions of group memberships (see Senthil et al., 2020).

In the contrary to healthcare, business, or psychology fields, STEM- and technical disciplines in higher education focused on technical expertise to meet workforce demands, widely disregarding EI training in engineering education due to rigid curricula emphasizing technical content matter knowledge (Antoniadou et al., 2020; Gilar-Corbi et al., 2018, Goldberg et al., 2016). However, in the 21st century and particularly during the 4th industrial revolution (see Maisiri & Van Dyk, 2021), expectations on the modern engineer have drastically changed to meet new needs that globalization, multicultural and collaborative work environments, digitalization, the development of fast-changing technologies, and customer centricity brought with it (Gilar-Corbi et al., 2018; Jose et al., 2020; Lappalainen, 2017). Job readiness in engineering professions could no longer be defined by technical knowledge alone (Feijoo et al., 2019), but needed to include professional, collaborative, and soft skills to be successful as an engineer in modern engineering industries (Boyatzis et al., 2017; Kolmos & Holgaard, 2018; MacCann et al., 2020; Suleman et al., 2019). Engineering employers' feedback (see De Campos et al., 2020; Hirudayaraj et al., 2021) and engineering alumni perspectives (see Alshehri et al., 2019; Fletcher et al., 2017; Pereira et al., 2019) confirmed the notion that new expectations in engineering professions included attributes, such as the ability to communicate with multiple technical and non-technical stakeholders of engineering solutions (Benedict et al., 2018; Hirudayaraj et al., 2021; Yong & Ashman, 2019), entrepreneurship (Miao et al., 2018), readiness for change (Koç, 2019; Kolmos & Holgaard, 2018; Warrier et al., 2021), and self-efficacy (Chand et al., 2019), and were among the most desired competencies in the engineering field. All new desired competencies of a successful engineer were either directly related to EI (Chand et al., 2019; Flores et al., 2020; MacCann et al., 2020) or EI was the underlying or mediating factor for desired professional and employability skills (Alsharari & Alshurideh, 2021; Hamzah et al., 2021; Koç, 2019; Liu & Boyatzis, 2021). Therefore, the inclusion of EI competencies in technical disciplines seemed to provide an extraordinary opportunity to demonstrate the trainability of EI despite masculine stereotypical thinking in the industry (see Antoniadou et al., 2020). However, while many alumni and engineering employers suggested internships as a real-world experience that may enhance EI in engineering students (Bae et al., 2022; Boyatzis et al., 2017; Hadgraft & Kolmos, 2020; Mikkonen et al., 2018), empirical evidence of EI assessment in interning students was lacking in the literature (Hadgraft & Kolmos, 2020).

To understand existing approaches on whether and how EI could be enhanced in postsecondary students, I examined a third topic in the literature on the trainability of EI through experiences in higher education. The second generation of EI constructs defined EI as skills rather than fixed inherited abilities (O'Connor et al., 2019). Therefore, many authors agreed on EI as a trainable construct and that EI skills could be improved through life experiences or intentional training strategies (Boyatzis, 2018; Goleman, 2018; Mattingly & Kraiger, 2019; Nelson et al., 2017; Nguyen et al., 2019; Petrides, 2010, 2021). However, Esnaola et al. (2017) pointed out that global EI scores alone missed the intricacy of EI development in each EI domain and a general consent in the literature was that EI learning strategies were widely focused on improving specified EI domains with less emphasis on the global EI scores (Bartz et al., 2018; Boyatzis, 2018; Goleman, 2018; Mattingly & Kraiger, 2019; Naseem, 2018; Nelson et al., 2017; Petrides, 2009b; Suleman et al., 2019).

In higher education, particularly for technical disciplines which required higher stress coping abilities (Keefer et al., 2018; Lea et al., 2019), EI learning strategies have been described as exploratory and unsystematic in the literature (Kotsou et al., 2018) and reports often missed to state learning outcomes of the described EI learning events or had limitations to scientific methodology such as missing control groups (Hodzic et al., 2017; Kotsou et al., 2018). Besides, gender and age differences as influencing factors on EI scores have been controversial in the literature (Bibi et al., 2020; Costa et al., 2021; Encinas & Chauca, 2020; Lawson et al., 2021; Mattingly & Kraiger, 2019), connected to cultural differences in upbringing experiences (Esnaola et al., 2017; Meshkat & Nejati, 2017), and depended on the applied EI measures (Aloiseghe, 2018). Generally, synthesis of EI learning strategies in the literature revealed that in-course integrated and multiple weeklong EI development events showed better long-term outcomes of EI skill development than isolated EI intensive training sessions in adult education (Hodzic et al., 2017; Kotsou et al., 2018; Schoeps et al., 2019). In summary, long-term EI training in higher education was feasible, was needed in technical disciplines, and should be following an integrated approach that blends in with existing content knowledge in the field and relates to real-world experiences.

In conclusion, internships in engineering industries may be the intervention in engineering postsecondary education that may fit the criteria that best practices in EI training modules revealed. Furthermore, there was consent in the literature about a skill gap in social-emotional competencies between engineering program graduates and expectations of engineering employers in today's environment (Hirudayaraj et al., 2021) and that EI training in postsecondary engineering education was strongly needed (Boyatzis et al., 2017; Fakhar et al., 2019; Skipper et al., 2017). Supplementary, the studies from Anjum (2020), Feijoo et al. (2019), Gillespie et al. (2020), Hora, Parrott, and Her (2020), and Marsono et al. (2017) indicated a connection between internships in professional industries and EI development in students. Yet, I could not find any literature that examined internships in relation with EI measures in engineering students. As a first step in the research on internships as EI development tool in postsecondary engineering education, the question whether the EI scores of engineering students differed based on the voluntary participation in an internship needed to be answered to further advance the knowledge in the field of postsecondary engineering education. Ultimately, such research may contribute to a holistic education of tomorrow's successful engineers (see Goldberg et al., 2016).

Chapter 3: Research Method

The purpose of this study was to determine whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries when controlled for age and gender. EI is considered essential to succeed in the engineering profession with the shift of expectations on future engineers to work in teams and with customers of engineering designs (Boyatzis et al., 2017; Goldberg et al., 2016, Hirudayaraj et al., 2021). To understand differences in EI levels of engineering students who have or have not experienced an internship in engineering industries, I compared global and four domain scores of EI in undergraduate engineering students by collecting data from surveys assessing snapshots of EI scores.

In Chapter 3, I describe the rationale of the research design and the methodology that I used in this study. I include descriptions of the study population, sampling procedures and sample size calculations, participant recruitment, data collection, and a data analysis plan. Lastly, I will address threats to validity and ethical considerations of this study.

Research Design and Rationale

The research question was whether undergraduate engineering students' EI scores differed based on the participation in internships in engineering industries when controlled for age and gender. In this posttest-only-with-control-group design, I examined whether undergraduate engineering students, who did or did not participate in an internship in engineering industries, exhibited different global and domain scores of EI. The research question had five hypotheses as presented in Table 1.

The posttest-only-with-control-group research design related to the research question by comparing the EI scores of two existing groups of undergraduate engineering students, with and without internship participation in engineering industries during their time in their undergraduate engineering education. To minimize the influences of confounding factors that impact EI scores independent of internships, I controlled for age, as a measure of accumulated life experiences, and gender, as recommended by the literature using Petrides's (2009b) EI framework. With age and gender as covariates, this research study focused on internship experiences as the independent variable of interest. Internships in the engineering work environment during engineering education may qualify as life experiences for intra- and interpersonal EI development, in particular for emerging engineers. Petrides (2021) projected EI skill development through experiences that shape one's self-construct as the basis for their EI model. According to Petrides (2009b), snapshots in the development of fluctuating levels of EI can be measured in global and domain EI scores.

To control for additional work-related experiences from possible times before entering college, advanced ages of undergraduate engineering students served as reflection on additional life experiences, which was controlled for as covariate. However, it was expected that most undergraduate engineering students did not have significant life or work experiences in engineering industries prior to entering their postsecondary engineering degree. An analysis of college graduation statistics by Miller (2019), based on data from the U.S. Department of Education and the National Center for Education Statistics (NCES), showed that more than 76% of college students enrolled in a 4-year bachelors' degree program as teenagers right after high school graduation. Therefore, engineering internships during college most likely have the greatest benefit for students coming directly from high school. By controlling for age, I attempted to highlight the importance of college internships in engineering industries for the typical undergraduate engineering student by minimizing confounding explanations from experiences that older students may have had before they entered college. In essence, this research study had one independent variable based on college internship participation, while at least two other influences on EI scores were controlled for through age and gender-related adjustments.

Variables in the Research Question

The research question was whether undergraduate engineering students' EI scores differed based on the participation in internships in engineering industries when controlled for age and gender. The research question had five outcome variables, one independent variable with two categories, and two covariates. The outcome or dependent variables were global EI scores and four domain EI scores, each one focusing on a different EI domain as presented by Petrides (2010). The EI domains were (a) emotionality with facets of emotional expression and perception, empathy, and personal relationships; (b) sociability with facets of emotion management, assertiveness, and social awareness; (c) wellbeing with facets of optimism, happiness, and self-esteem; and (d) self-control including emotion regulation, low impulsiveness, and stress management. The global EI score was an independent measure determining general emotional functioning (Petrides, 2009b) and was based on weighted scores from individual survey questions with the addition of two additional facets: adaptability and self-motivation. All five EI measures in Petrides (2009b) EI model—global EI scores and four EI domain scores—were measured on a continuous scale between 1 and 7 determined from participants' answers in the self-reported TEIQue-SF questionnaire (Petrides, 2009a).

The independent variable was the categorical group membership, in which students either had or had not participated in an internship in engineering industries during their undergraduate postsecondary engineering education. An internship in engineering industries during undergraduate engineering education was defined as a minimum of 12 weeks working temporarily, part time or full time, in a field-related company on an engineering design project under the supervision of an engineering professional from the industries, intended for the educational benefit of the student and tied to the students' formal education (see Heatherfield, 2020; U.S. Department of Labor [Factsheet #71], n.d.). Many undergraduate engineering degree programs offered technical internships in professional engineering industries as electives but did not require them for graduation.

Although the inclusion of technical internships in undergraduate engineering education as a mandatory component in engineering curricula had been suggested in the past (Sirinterlikci & Kerzmann, 2013), the logistical barriers, including time and cost limitations, as well as lack of resources to guarantee a critical mass of external employers as hosts for short-term internships serving all enrolled undergraduate engineering students had not been sufficiently solved (Hora, 2018; Zuckerman, 2021). To balance the burden on the educational institution and academic staff in offering internships to undergraduate engineering students (see Ozek, 2018), the tendency was to allow engineering students to apply elective internship credit to their degree requirements (see Best Colleges, 2021; UW College of Engineering, 2021). For students to learn about the steps to secure an internship was considered part of the experience with guidance from the educational institution (see Best Colleges, 2021); however, the initiative to participate in an internship in engineering industries remained a voluntary choice among other technical elective choices and was too challenging to be made mandatory for graduation from an undergraduate engineering program (Zuckerman, 2021).

Some engineering colleges required a co-op course in industry for graduation, which was distinctly different from internships in such, that a co-op or an apprenticeship engineering education, as applied in European models (see Rouvrais et al., 2018), entailed a longer student commitment time and a formal agreement on an integrated curriculum between company and educational institution (see Ozek, 2018; UT Cockrell School of Engineering, n.d.). I have not found an undergraduate engineering program at a college or university in the United States that distinctly listed an internship as graduation requirement in their course catalogue. The internship experiences as defined in the context of this study (see Heatherfield, 2020; U.S. Department of Labor, [Factsheet #71], n.d.) were offered as electives or extracurricular activities organized by engineering student organizations or career centers of the related educational institution (see UT Cockrell School of Engineering, n.d.) and were based on voluntary participation (see Best Colleges, 2021). Therefore, a random distribution between the group membership of students with and without internships occurred naturally and prior of this study.

Influences on EI scores based on gender, measured as a nominal variable for male and female, and age in years was controlled for as covariates.

The Research Design and Justification

The posttest-only-with-control group design is used to compare dependent variables of at least two population groups at a single time point after an intervention or activity has been completed (Burkholder et al., 2016). The control group is typically intended as a neutral comparison group, usually without the activity (Pam, 2015), when pretests of the dependent variable were not recorded. Resulting data from comparing an intervention group to a control group at the posttest time point can be used to indicate whether the intervention or activity may have been effective when pretest data are not available (Insights Association, n.d.). However, a causal relationship cannot be concluded from the results of a posttest-only-with-control group study alone because competing confounding variables cannot be sufficiently excluded with this research design (Warner, 2013). In the case of this basic quantitative study, results may highlight the importance of engineering internships by providing observations and indications on differences in EI domains between students who participated in internships and those who did not. Findings may lead to further questions and additional research in this field.

The posttest-only-with-control-group design was used for this research study because the undergraduate engineering students had already completed the internship at the time of survey participation. Because not every participating student had the opportunity to participate in an internship due to limited availability of internships in engineering industries or lack of support of internship programs at various universities, the student group who had not performed an internship at the same time point in their postsecondary education served as control group. Therefore, the posttest-only-with-control-group design participants fell into one of the two groups established before study participation. A larger number of numbers of participants can help to assure that the two groups are comparable in terms of characteristic, therewith, minimizing any observed differences in posttest scores due to baseline differences (Gribbons & Herman, 1997). Although a pretest-posttest research design could have been used to assess the baseline of EI scores and whether the two groups were initially similar, a pretest is likely unnecessary when large numbers of students are involved (Trochim, 2020). Furthermore, due to the nature and characteristics of the study population in my study, obtaining a pretest was not practical in terms of length of the internships and varying time points when each student was engaged in the internship experience.

Due to the nature of the independent variable with or without an internship, group membership of the participants was mutually exclusive, which led to independent groups and fulfilled one of the posttest-only research design requirements (see Frankfort-Nachmias & Leon-Guerrero, 2018; Warner, 2013). Because existing groups were utilized, this quasi-experimental design varied in the rigidness of randomization in comparison to truly experimental designs, and other factors may have influenced the natural formation of my population groups. However, an assumption of entirely equal groups in real-life scenarios can only be met to a limited extent in any study design (Cook & Campbell, 1979), and a balance between external and internal validity can be achieved by a sensitive evaluation of rival explanations for differences in the outcome variables

(Warner, 2013). Therefore, age and gender, which influenced the outcome variables (Petrides, 2009b; Skipper et al., 2017) and as an attempt to limit known rival explanations for EI differences, were controlled for in this posttest-only-with-control-group study design.

Despite efforts to select equivalent groups as much as possible, differences in other group characteristics may have been present. Additionally, changes within the groups were not assessed with this posttest-only research design, so only measures of the differences in the outcome variables and covariates were recorded (Trochim, 2005). Lastly, findings of differences between the test and control group were not sufficient to conclude a causal inference (see Warner, 2013), because they were carrying the risk of influences of unknown confounding variables, such as students' maturation due to non-age-related influences. Nevertheless, the posttest-only-with-control-group design had a moderate level of control over study procedures (see Trochim, 2020) and provided an effective solution because pretests were not doable due to data collection time constraints and unpredictable variations in times when internships were offered at different institutions.

In conclusion, the posttest-only-with-control-group design carried a sufficient trade-off to answer the research question. To determine whether there were differences in EI scores in engineering students with and without internships, advanced the knowledge in the field of higher engineering education by understanding the baselines of college internship experiences in relation to EI skills in undergraduate engineering students. Findings of this study may become the first step in this line of research to understand whether internships should be further explored as a reason for potential differences in engineering students' EI, as suggested by Skipper et al. (2017). Ultimately, knowledge gained from this research study may help inform decisions about the education of tomorrow's holistic engineers.

Methodology

In this section, I describe details of the methodology of this study. Specifically, I will include descriptions of the study population, sampling and sampling procedures, sample size calculations, procedures for recruitment and study participation, data collection, and a data analysis plan. In addition, I will discuss threats to validity and ethical considerations of this study.

My role as researcher did not conflict with my present position as a bioengineer in a large research university because this research study focused not on engineering design application but instead on engineering education. Specifically, I looked at students' practical experiences in internships in conjunction with engineering students' emotional intelligence levels. I did not ask students from my department to participate in this research study. Instead, I surveyed engineering students from other engineering colleges across the United States whom I did not know personally or had any other connection besides shared professional memberships in engineering societies or LinkedIn engineering groups.

Study Population

The target population for this study included undergraduate engineering students from engineering colleges across the United States who were enrolled in a 4-year undergraduate degree program in engineering. The targeted sample size was approximately 200 engineering students. Because not all universities supported internship programs, and an internship in engineering industries was generally a technical elective choice but not required to graduate from an undergraduate engineering degree program (Zuckerman, 2021), not all participating students have completed an internship in engineering industries at their time of graduation. Therefore, I expected a similar percentage of participating students who had completed an engineering internship in their college years as the ones who had not.

Sampling and Sampling Procedures

Potential participants were selected using non-probabilistic stratified sampling. In this method, a heterogenous population is divided into smaller groups by selected exclusive characteristics with the samples representing the entire population (QuestionPro, 2021). The stratified sampling method was justified because the extensive population group of engineering students in postsecondary education across the United States could be divided into two subgroups, with and without the voluntarily completion of an engineering internship in their undergraduate engineering education. Group membership was mutually exclusive, but all population members fell into one or the other group without exception. The samples were drawn with the assistance of gatekeepers across the U.S., which helped to maximize student participant diversification from a wide range of demographics. The advantages of stratified sampling across numerous U.S. engineering programs were to reduce biases in the selection of the study participants, particularly in the case of a diverse and geographically dispersed study population consisting of undergraduate engineering students across U.S. engineering colleges.

The procedures for how the sample was drawn included voluntary participation in an online survey, which was advertised through announcements in student chapters of professional engineering societies, LinkedIn engineering student groups, and through gatekeepers of my personal learning network around engineering education. Interested engineering students participated anonymously on a voluntary basis and self-selected whether they had or had not completed a college engineering internship as part of the questions in the survey. Group membership was determined from the students' answers in the survey. Since professional engineering societies had student members from diverse societal and geographical backgrounds, I recruited as many, diversely located samples of the undergraduate engineering student population as possible.

The sampling procedure included both inclusion and exclusion criteria. To be included, participants (a) must have been currently enrolled in a 4-year engineering undergraduate degree program at a postsecondary institution and (b) must not have earned or engaged in more than one postsecondary degree. Participants could not (a) have been an alumnus of a postsecondary degree or (b) have been a graduate student in an engineering degree program.

Population Sample Size Calculation

Obtaining statistical power for a quantitative study that compared two population groups needed to meet a specified minimum sample size (Warner, 2013). A power analysis was used to determine sample sizes based on tests for an Analysis of Covariance

(ANCOVA). The error probability alpha was set to .05, a conventionally used level of error probability (Warner, 2013). Pooled effect sizes from meta-analyses were considered as robust tests of theory and valid estimates of otherwise unknown effect sizes (Baribault et al., 2018). Andrei et al. (2015) conducted a meta-analysis study using the TEIQue instrument developed by Petrides (2009a) to assess EI in adults, the same instrument I employed in this study. In the meta-analysis by Andrei et al. (2015), the authors evaluated 18 studies providing 105 effect sizes for EI measures with the TEIQue and concluded that a pooled medium effect size ($r^2 = .06$) was practical and statistically significant. Measures of effect size in ANOVA-family statistics examined the degree of association between the dependent variables and their main and interaction effects (Becker, 2000). If the values of association measures were squared, they could be interpreted as the proportion of variance in the dependent variable attributed to each effect (Becker, 2000). A medium effect size reported as r^2 can be translated into Cohen's *d* standard of .05 and $f = .25$ (Becker, 2000). Therefore, the medium effect size was adapted to $f =.25$ for the population sample size estimates in G*power for this study. Finally, the power level was plotted as a range in G*power (UC Regents, 2021) and evaluated between .80 to .95 (Appendix A). The minimum total sample size for ANCOVA test statistics at a power level between .80 and .95 ranged between 128 (see Appendix B) and 200 participants (Appendix A).

The minimum total participant sample size of 128 was sufficient for the global EI score as directly measured with the TEIQue instrument; however, the multivariate approach of several EI domain scores may have had errors due to unknown correlations between the multiple dependent variables that represented domain scores and covariates (Cole et al., 1994). Power calculation tools, such as G*Power, do not offer estimates for a Multivariate Analysis of Covariates (MANCOVA) test due to the inability to account for the strength of correlations between the response and covariate variables. Shieh (2019) explained that the strength of correlations between variables was population specific, and, therefore, MANCOVA test sample sizes cannot easily be calculated with a generalizing power calculation tool. However, a MANOVA calculation in G*power was used to calculate an estimated sample size for the four EI domain scores as dependent variables, which incorporated adjustments for more than one dependent variable, but did not account for any covariates. The calculation for the MANOVA test in G*power showed a minimum sample size of 196 participants at the .80 power level (Appendix C).

Armstrong (2014) mentioned that many researchers apply the Bonferroni correction to the error probability alpha in power calculation models for MANCOVA analyses to adjust for the increased risk of a type I error when combining multiple statistical tests. The Bonferroni correction controls for the familywise error by dividing the unadjusted *p* value by the number of tests (Armstrong, 2014). For example, the error probability of .05 for each ANCOVA test of four EI domain scores would be equal to the overall MANCOVA test with an error probability adjustment of .05 divided by 4. Using this formula and adjusting the error probability alpha to .0125, a G*power analysis for MANOVA provided a minimum sample size of 266 participants (Appendix D). Although it was recommended to underestimate the power level for unknown correlations in a power analysis (Grace-Martin, 2020), the Bonferroni correction was considered to adjust for the worst-case scenario, when all tests are independent of one another, and each test would have a 5% chance of yielding the wrong answer that the null hypothesis is false (Coppock, 2015). This assumption was too extreme for the MANCOVA test with the four EI domain scores that measured moderately correlated constructs of EI concepts (see Petrides, 2009b). Therefore, a sample of 266 participants would "withstand" Bonferroni correction but was not necessary to reach an acceptable level of power in this study. Instead, an overall targeted number of approximately 200 participants was estimated as sufficient and targeted for my study.

Alternatively, Coppock (2015) suggested using the Holm correction instead of the Bonferroni correction once the *p* values for each dependent variable in a multivariate test were established. The Holm correction is considered more powerful than the Bonferroni correction because it accounts for the different levels of dependencies of outcomes and their Type I errors (Coppock, 2015). By ordering the outcome *p* values from smallest to largest and applying a correcting formula, the Holm correction moves the significance threshold of alpha for each outcome variable sequentially up instead of keeping a constant alpha of .05 for each outcome. The Holm correction was applied to the four outcome variables of the MANCOVA test for EI domain scores in the analyses of my study to correct for familywise statistical errors.

In summary, 200 undergraduate engineering students were the targeted minimum population sample size for my study. For the ANCOVA test with global EI, which is directly and independently measured by the TEIQue instrument, the participant number of 200 was expected to yield a high-power level (approximately .95). For the

MANCOVA tests of the four EI domain scores, the participant number was expected to be sufficient for a .80 power level. The power of statistics for each statistical test was confirmed in Chapter 4.

Procedures for Recruitment and Study Participation

The recruiting procedures included a number of steps. First, I approached members of student chapters of professional engineering societies, such as the Biomedical Engineering Society (BMES), of which I am a fellow. The Biomedical Engineering Society has large student chapters with engineering students from colleges and universities across the United States, and many student members are very active in the society and engaged in annual society meetings (BMES, n.d.). Through the professional engineering societies and the American Society of Engineering Education (ASEE, n.d.), I had access to student emails and annual society meetings' participants, who could serve as gatekeepers for the distribution of my study invitation. I asked the BMES annual meeting's organizer (BMES Annual Meeting, 2021) for permission to use their list of contacts to reach out to gatekeepers that were interested in assisting to distribute my study invitation. I have also participated virtually in the annual BMES meeting 2021 (BMES Annual Meeting, 2021) and had created an interest in my study among gatekeepers from engineering colleges across the United States to help disseminate my invitations once I were ready to launch the survey for undergraduate engineering students. Approximately 100 engineering schools and colleges had participated in the BMES annual meeting, and I talked to more than 60 gatekeepers. I followed up with interested gatekeepers from several engineering colleges and stayed in contact until I received IRB approval in spring 2022.

Next, I contacted organizers of engineering student groups, such as the Biomedical Engineering Facebook Group and engineering professional LinkedIn groups, which serve diverse engineering student populations. I asked for permission to post invitations to participate in my study to their professional engineering groups. Then, I reached out to engineering professional societies that support a specified group of engineers, such as National Society of Black Engineers (NSBE, n.d.), Society of Women Engineers (SWE, n.d.), or the Society of Hispanic Professional Engineers (SHPE, n.d.). Furthermore, I approached discipline-specific engineering societies, such as the American Association for Engineering Education (ASEE, n.d.), the International Society for Pharmaceutical Engineering (ISPE, n.d.), and the Institute of Electrical and Electronics Engineers (IEEE, n.d.). I contacted the student chapter's officers and asked for permission to post my study invitation in their group or other networking platforms, such as Discord and Slack. A list of targeted engineering societies is available in Appendix E. Lastly, I researched any publicly available contact information of undergraduate engineering students on the internet and social media with focus on engineering groups, such as the Biocom Life Science group (Biocom, n.d.).

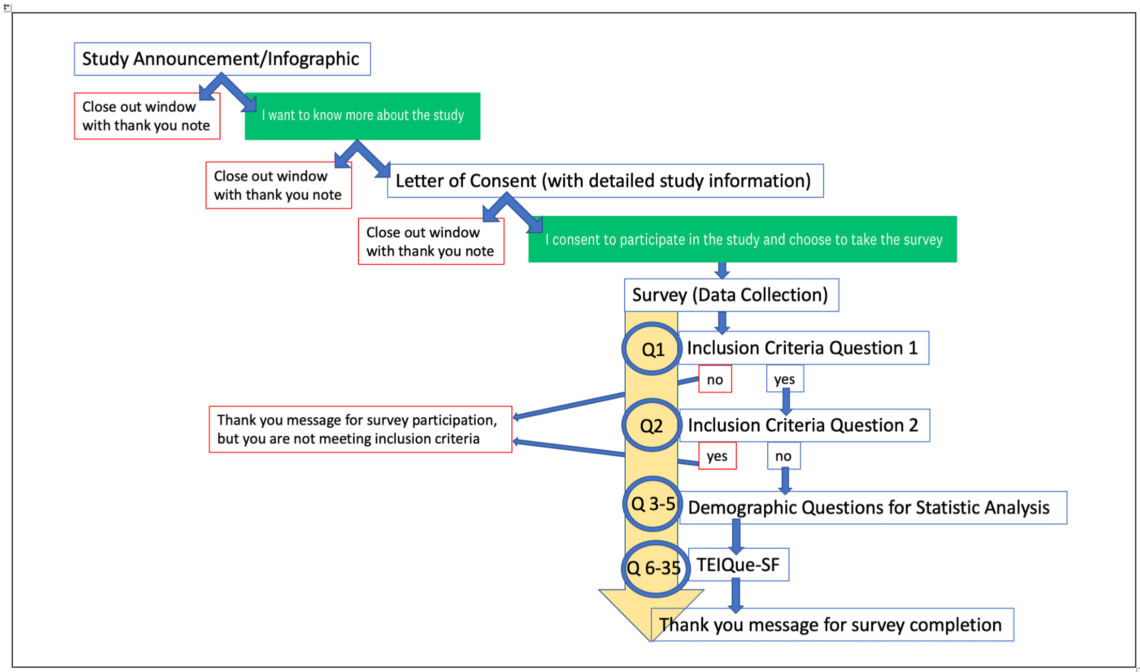
The procedures for study participation included three steps. To raise awareness of the possibility to participate in my study while keeping the burden of reading text with information to a minimum, I first used a short invitation or study announcement flyer as my initial contact with potential participants. The announcement flyer is displayed in

Appendix F. I sent the study invitation flyer in emails or direct messages within the social media's site to student members of specified professional societies and gatekeepers from the BMES national meeting (BMES Annual Meeting, 2021). The same invitation flyer was also posted in all mentioned professional groups and social media sites as an infographic. The infographic contained a link and quick response (QR) code to the first page of my survey, briefly explaining the study details and the inclusion criteria with a prompt to continue by clicking on the button at the end of the page if students were interested to participate in the study.

The second step was to lead continuing participants to the letter of consent posted online in the survey with explanations of the potential risks to participate in this study, the purpose of the study, and expectations to complete 35 questions in an anonymous and voluntary online questionnaire. At the end of the consent letter page was a green button with the clear wording: "I consent to participate in the study and choose to take the anonymous and voluntary survey." Consent was implied anonymously through the action of clicking on the embedded consent link, which provided greater privacy for study participants than signing a form with their name. Consenting participants were further guided from that green-highlighted consent link to the actual study questionnaire with its five demographic and 30 EI-instrument questions. Those who did not want to participate in the study were instructed to simply close out of the window. The first two demographic questions verified study inclusion criteria for participating students as part of the questionnaire. If answers to the first two questions did not meet the inclusion criteria, the participants were thanked and closed out of the survey. Therefore, the burden of non-qualified students was kept to a minimum. Figure 2 shows the flowchart how participants moved through the process.

Figure 2

Flowchart of Survey Participation



The purpose of the five demographic questions was to (a) provide an opportunity for the participants to self-select that they fit the study inclusion criteria and (b) collect the covariates and independent variables to be used in the statistical analysis. Question 1 of the demographic questions verified that students were enrolled in 4-year undergraduate engineering degree program, and question 2 confirmed that they had not completed another postsecondary degree. If a participant answered any of the two questions in a way that indicated they did not meet the inclusion criteria, they were immediately directed to a different page and received a thank you note for their willingness to participate while informing them that they did not meet the study's participation requirements. Therefore, through the study logistics, only participants verifying the inclusion criteria were prompted to read the internship definition and following demographic and EI-related questions. Once participants had completed all sections of the survey, they had to click on the submit button at the end of the questionnaire and received a thank you note on another survey page, which closed the survey for them. There were no follow-up procedures after the survey was completed and responses were anonymous, so I could not contact any particular survey participant. Participants who had started the survey and did not complete the survey by clicking submit at the end of all answered questions were closed out of the survey. This ensured that if participants changed their mind about participating during the survey, they could simply stop answering questions and no partial responses were recorded. The anonymous survey was housed in SurveyMonkey (SurveyMonkey, n.d.). The total time commitment was less than 10 minutes.

Data Collection

Once a participant had consented to be part of the study, survey data were recorded via SurveyMonkey (SurveyMonkey, n.d.). SurveyMonkey was an extremely popular and capable online survey tool and was set up to collect answers from study participants anonymously adding timestamps to their responses (see Graw, 2020). I did not record any private information, such as name or email of the participants, and I, as the researcher, was only able to download survey responses labeled by given timestamps. Nevertheless, I was able to see how many engineering students had started or completed the survey at any timepoint.

The survey collected the answers to the five demographic questions about the students' age, gender, and self-reported participation in an internship in engineering industries by multiple-choice questions and a simple number for age. The remaining two questions were answered with yes or no confirming the study inclusion criteria that students were currently enrolled in a 4-year undergraduate engineering degree program at a postsecondary institution and that they had not completed or were engaged in more than one postsecondary degree. After the five demographic questions were completed, the participants were directed to the EI survey part, which included the 30 Likert-scale questions from Petrides's established TEIQue-SF instrument (Psychometic Lab, 2021b). The survey was completed with a total of 35 questions, mostly in multiple-choice style. I have obtained permission from Petrides (2021a) to use the TEIQue-SF instrument for research purposes (see Appendix G).

Once I had collected the targeted number of 226 survey responses, I closed the SurveyMonkey survey. All recorded data were exported from SurveyMonkey to an Excel file for data analysis. Downloaded data and scores were stored on a password-protected file on my hard drive and backup hard drive. The raw data were scored according to a scoring key provided by Petrides (Psychometric Lab, 2021a). Single domain scores did not simply add up to the global EI score but had weighted influences from different questions for each EI score. Furthermore, the global EI score included two additional facets of EI measures that were not addressed or used in the key for any of the domain scores. Therefore, global EI scores were treated as an independent EI measure and were analyzed with an ANCOVA test separately from the other scores. To gain summative analyses for the four EI domain scores addressing (a) emotionality, (b) sociability, (c) wellbeing, and (d) self-control MANCOVA test analyses were used to account for correlations between the variables for each outcome. The software for analytical statistics was SPSS 28.0 (Wagner, 2016). Results and SPSS output were stored on my secured and password protected hard drives.

Operationalization of Variables

The independent variable was a categorical membership in the group of engineering students who did or did not participate in an internship in engineering industries while enrolled in a 4-year undergraduate engineering degree program. Because students either had or had not performed an internship, the independent variable had two categories based on the internship participation. The membership exclusively in one or the other group was self-reported by the participants in the survey as a multiple-choice question answered with yes or no.

The dependent variables included five recorded EI scores in alignment with the five study hypotheses:

1. Global EI score,
2. EI domain score for emotionality,
3. EI domain score for sociability,
4. EI domain score for wellbeing,
5. EI domain score for self-control.

All five EI scores were measured on a continuous scale between 1 and 7. Higher scores represented higher levels of reported EI skills. All scores were derived from self-reported measures in the TEI questionnaire developed by Petrides (2009a). A score represented the level of agreement or disagreement with a given statement on a 7-point Likert scale. Each domain score was obtained by a weighted formula of two or three survey questions according to the scoring key provided by Petrides (2021a). The global EI score, however, incorporated two facets of EI as reported by separate survey questions that had not been used to determine any of the domain scores (Petrides, 2009b). Therefore, the global EI score was treated as a separate EI value directly derived from the questionnaire and different than a summative value of the four EI domain scores. Table 4 shows an alignment of the dependent variables to the research question hypotheses.

Table 4

Dependent Variables Alignment with the Research Question Hypotheses

DV	HP1	HP2	HP3	HP4	HP5
Global EI score (with additional facets of EI)	X				
Emotionality EI domain score		X			
Sociability EI domain score			X		
Wellbeing EI domain score				X	
Self-control EI domain score					X

Note. DV = Dependent Variable; HP = Hypothesis of the Research Question

The covariates in my study were gender and age. Gender was measured as a nominal variable for male or female. Age was measured as a continuous number. Both covariates were self-reported by the participants in the demographic survey questions.

Instrumentation and Operationalization of the EI Construct

The instrument to measure EI scores was based on Petrides's TEIQue (Petrides, 2009a). Petrides developed a short form of the original TEIQue instrument, labeled with SF for short form (Petrides, 2009b). Although the full version of the TEI-Que would be a more comprehensive measure, it was not practical for the recruitment of 200 participants due to the length of the survey and the time commitment needed from each participant. Petrides (2009b) stated in his EI manual that the TEI-Que instrument provided comprehensive coverage of individual differences in emotion-related self-perceptions that influenced behaviors in social contexts. Petrides's (2009b) EI construct was appropriate for this study because it illuminated personal differences in EI, based on life experiences that may have influenced emotional self-perception and social behaviors. There were no right or wrong answers to the survey questions, and the goal was to simply measure levels of global EI and EI domain scores that may or may not have been seen as beneficial in a wide range of situations or circumstances.

Applied to engineering students, the change in expectations on the profession to work in teams and understand customer needs may benefit individuals who function better in social group situations. This may be accounted to higher EI levels in some domains, but not in others, for example, as a result of too many emotions (see Petrides, 2009b). Life experiences, such as internships in the industries, may be beneficial to balance EI levels as measured by the TEI-Que (see Petrides, 2009a). Therefore, the TEIQue-SF was the best suited instrument to determine and compare TEI levels in students with and without internships with minimal time commitment for participants.

Although Petrides (2009b) labeled his construct as trait EI, the authors caution in their manual that "trait" should not be understood as inherited skill that may not be changeable. Petrides and Furnham (2001) argued that the operationalization through self-reporting in Petrides's trait EI model was straightforward because it explicitly recognized the inherent subjectivity of emotions and their changeability through relating to one's experiences, life changes, and conscious development efforts to achieve behavioral modifications. Petrides (2009a) referred to the label "trait" as a distinguisher of how answers were collected: for the TEIQue in a self-reported fashion as one sees him- or herself. Furthermore, Vernon et al. (2008) established a genetic and an environmental part of the EI model, which allowed modification of behaviors through the conscious shaping of EI. Petrides (2021) presented a model of genetic Radix-Intelligence as the basis of intelligence, which was shaped through one's experienced self-construct into different levels of EI domains. Petrides and Furnham (2001) derived at consistent EI elements by sampling EI domains through content analysis across established EI taxonomies. Incremental domain validity and construct comparisons with the Giant Three and the Big Five have been demonstrated in several independent studies (Kluemper, 2008; Petrides, Pérez-González, & Furnham, 2007; Saklofske et al., 2003; Van der Zee & Wabeke, 2004; Vernon et al., 2008).

Instrument Validity and Reliability

Petrides's (2009a) trait EI model captured four interrelated domains of emotion-related self-perceptions. According to Petrides, Pita, and Kokkinaki (2007), (a) emotionality is related to the perception and expression of emotions, (b) sociability is the interpersonal utilization and management of emotions, (c) wellbeing is reflecting dispositional moods, and (d) self-control is the regulation of emotions and impulses. Furthermore, the TEIQue instrument captured a global EI score as a broad index of general emotional functioning, which included additional items not related to one of the four EI domains. Petrides (2009b) used a standardizing sample of 1721 individuals across 15 different countries in Europe, Africa, and Asia to determine validity and reliability of the TEIQue instrument. He reported a robust internal consistency of global EI scores with Cronbach's alpha of .90, as well as for the four EI domains with Cronbach's alphas between .78 and .83. Petrides (2009b) stated that reliability of measurements was confirmed in four dozen datasets from various countries and can be applied to a wide range of circumstances.

Costa et al. (2001) and Petrides (2009b) reported differences between male and female in the use of the TEIQue; therefore, gender was controlled for in this study. Petrides (2009b) observed normal distribution patterns for the global and the four domain EI scores using the standardized sample population. Test-retest reliability analysis showed stable temporal EI scores with significant test-retest correlations (Petrides, 2009b). The reported overall attenuated stability coefficient for the TEIQue was .78, $p < .01$ in the standardized sample population (Petrides, 2009b). Translation of the TEIQue in more than 20 languages had generated cross-cultural data published in Greek (Petrides, Pita, & Kokkinaki, 2007), French (Mikolajczak et al., 2007), Croatian (Vernon et al., 2008), German (Freudenthaler et al., 2008), and Chinese (Petrides, 2009b) with great consistency.

The shorter version of the TEIQue, the TEIQue-SF, consisted of 30 selected questions, ensuring broad coverage of each sampling domain of the EI construct. Each domain was measured by including two items from each EI facet, represented by between six to eight questions in the questionnaire (see Appendix H). Items were selected on the basis of their correlations with corresponding total facet scores in the long version of the TEI-Que (Petrides, 2009b). The TEIQue-SF was validated to be able to derive the four EI domain scores, in addition to the global EI score (Petrides, 2009b). Cronbach's alpha for the short version of the TEIQue-SF instrument was reported in the literature at .88 for global trait EI, at .73 for emotionality, at .69 for sociability, .80 for wellbeing, and .65 for self-control (Petrides & Furnham, 2006) (see Appendix H). For practical purposes, the TEIQue-SF was the best workable trade-off between participants' time constraints and instrument reliability.

Data Analysis Plan

For this quantitative, posttest-only-with-control-group study, I conducted Analysis of Covariance (ANCOVA) and Multivariate Analysis of Covariance (MANCOVA) statistical tests. These tests assessed statistical differences on multiple continuous dependent variables by an independent grouping variable while controlling for other variables to reduce error terms. ANCOVA family analyses eliminated covariates' effects on the relationship between the independent grouping variable and the continuous dependent variables (Warner, 2013). The research question of whether there were differences between undergraduate engineering students' EI scores with and without participation in internships in engineering industries when controlled for age and gender was addressed in five hypotheses. The first hypothesis was looking at a statistical difference in the global EI scores of engineering students with and without internships in engineering industries when controlled for gender and age. Since the global EI score was an independent direct measurement of EI in this context, ANCOVA statistics was used to assess group differences for hypothesis 1. However, the second to fifth study hypotheses related to EI domains for (a) emotionality, (b) sociability, (c) wellbeing, and (d) self-control measured by the four EI domain scores. The EI domain scores were expected to have a moderate interaction effect with each other, which needed to be adjusted in a multivariate approach to target summative outcomes of the four EI domain scores. Therefore, I used MANCOVA to assess hypotheses 2-5 for EI domain scores.

I used SPSS 28.0 software for the data analysis (Wagner, 2016). Before the statistical analysis was executed, I screened the collected raw data for group membership to one or the other group, or, in other words, with and without participation in an internship in engineering industries, which was the answer to one of the demographic survey questions. Any participant, who did not answer this question, was excluded from the data analysis because I could not determine group membership. All other data with completed questionnaires were used. Raw data from TEIQue-SF survey answers were scored with Petrides's weighted scoring key via their online scoring tool (see Psychometric Lab, 2021a) and final EI scores were imported to SPSS 28.0 for statistical analyses. Once I had the five EI scores (one global and four domain scores) for each participant uploaded in SPSS, I started the data analysis process.

The data analysis plan included several steps. First, I determined if ANCOVA family test assumptions were met in the data set. ANCOVA and MANCOVA statistical analytics can be applied when the data fulfill specified test requirements to produce meaningful outcomes (Warner, 2013). In MANCOVA, all test assumptions were the same as in ANCOVA tests, but one additional assumption was related to covariates

(Statistics Solution, 2020). The ANCOVA and MANCOVA family tests assumptions were (Laerd Statistics, 2018):

1. Independence of observations,
2. Multivariate normality,
3. Homogeneity of variances,
4. Homoscedasticity,
5. Absence of multicollinearity,
6. Linear relationship between covariates and dependent variable,
7. Homogeneity of covariate regression coefficients,
8. Absence of significant unusual points (for example, extreme outliers).

Since my data set dealt with two mutually exclusive groups, the observations were independent, and criterion 1 was met. A normal distribution was expected since I have a relatively large population size with more than 50 participants in each group and across a wide range of demographical backgrounds. According to the central limit theorem, a population size larger than 50 can be assumed to have normal distribution (Frankfort-Nachmias, & Leon-Guerrero, 2018). Furthermore, Petrides (2009b) showed multivariate normality in standardized sample populations for all five EI scores. I had similar findings in my data set; however, histogram for data distribution were additionally plotted for each EI score to confirm normality.

Homogeneity of variances was tested with Levene's test to verify equal variances of residuals across the groups. Because the Levene's test generated non-statistically significant results above the conventional $p > .05$ level, the null hypothesis was failed to be rejected, and equal variances between groups were indicated (Field, 2013). Only when Levene's tests are statistically significant, the Sidak test or other post-hoc tests could be performed to determine the severity of test violations and how to adjust for them. However, my data set showed non-statistically significant results in the Levene's test and other tests were not necessary. Sometimes unequal sample sizes between groups may affect the variance assumptions (Lehigh University, n.d.). However, ANCOVA or MANCOVA are considered robust towards moderate departures from equal group sample sizes as long as equal error variances were present (Laerd Statistics, 2018).

Equality of covariances between groups was tested with Box's M test of equality of covariance matrices (Field, 2016). Non-statistical results at the $p > .001$ level in Box's M tests are usually considered an indication of equality of covariances because the test is highly sensitive (Statistics Solutions, 2020). Homoscedasticity was addressed by residual scatter plots. Multicollinearity between dependent variables was tested with correlation analysis. According to Tabachnick and Fidell (2012), no correlation should be above $r = .90$. The four domain scores of EI were moderately correlated in the EI construct but were measured in four independent EI domains represented by a different array of questions in the TEIQue-SF (Petrides, 2009b). Therefore, correlations between dependent variables representing EI domain scores were expected to be moderate, but not above the suggested level due to the nature of the variable construct in this model. Interaction tests between covariates and dependent variables were generated with univariate analyses in SPSS 28.0 (see Wagner, 2016). However, the covariates' effects (age and gender) on EI were not expected to relate to the choice of participating in an engineering internship.

Additionally, the relationship between the covariates and the dependent variables must be linear and similar across all groups (Grace-Martin, 2019). The homogeneity of regression slopes was a strict assumption of ANCOVA family tests to allow the interpretation of an overall relationship or regression line applied to the entire data set, which ignored in which group a participant belonged, therewith widening the target of a statistically significant result. The interaction tests in SPSS 28.0 were used to verify that the assumption of the homogeneity of regression lines was not violated. In addition, grouped scatter plots were used to visualize the homogeneity of regression slopes (Miller & Chapman, 2001). Lastly, the existence of extreme outliers was tested by generating box plots for each group. My dataset only showed mild outliers in the non-internship group for one EI domain score. Therefore, no extreme outliers or unusual point were found in my dataset. Further discussion of excluding the outliers and what it may mean for the data analysis were optional for the interpretation of my results because the few outliers I found were not extreme (Statistics Solutions, 2020).

After I evaluated test assumptions, I performed ANCOVA tests on the global EI score and MANCOVA tests on the four EI domain scores in two independent procedures. The Holm correction on the alpha levels was considered the most reliable procedure to account for multiple statistical tests for MANCOVA (Coppock, 2015), and was applied to determine statistical significance for each of the four EI domain scores in this analysis using the correction function in SPSS 28.0. Because I did not find statistical significance in my tests, I did not run post hoc tests or in between group analyses in the corrected model, as was originally suggested by Warner (2013). Influences from confounding variables, as reported in the literature by Petrides and Furnham (2006) and Skipper et al. (2017) as gender and age, were controlled for in the ANCOVA and MANCOVA tests. Partial eta square values were provided in the display of statistical results in tables and used to show how much variance was explained by the independent variable. Partial eta square values can also be used as the effect size measure for MANCOVA models (Statistics Solutions, 2020). Results were interpreted as the lack of or existence of a statistically significant difference in EI scores between the engineering group that did or did not participate in an internship in engineering industries during their postsecondary engineering education. SPSS output was interpreted as statistically significant according to conventional *p*-values for group differences to answer the research question for each of the five hypotheses. Output data showed within and between group differences in the corrected statistical model for group mean comparisons with covariates (Wagner, 2016). Individual nuances of EI domain scores were interpreted using observations and trends of the direction of score differences in addition to statistical significance. These observations may reveal which EI domain may be useful in the context of future research on EI assessment and internship participation. The global EI score provided an insight into general emotional functioning as a separate single measure (see Petrides, 2009b) to respond to hypothesis 1, whereas the EI domain scores provided a more detailed look at each of the four EI domains while adjusting for interaction effects between domain scores to respond to hypotheses 2 to 5. Therefore, ANCOVA was the appropriate test statistic for the global EI, and MANCOVA was the appropriate test statistic for the four EI domain scores, adjusting for a moderate level of intercorrelation effects in a multivariate approach among the domain scores.

Threats to Validity

Addressing threats to validity referred to finding a balance between the ideal study design and available resources for the study to increase trustworthiness (Frankfort-Nachmias & Leon-Guerrero, 2018). Some threats were inherent to the nature of quasi-experimental studies, particularly in posttest-only designs, because I, as the researcher, had limited control over the randomization of naturally formed population groups (Cook & Campbell, 1979). Threats were discussed in this quantitative research to disclose limitations of the study and to find a balance between internal and external validity.

External Validity

External validity referred to the applicability of study results to other populations, also called generalizability (Burkholder et al., 2016). Some external validity issues were present in this study. Mainly, my targeted population group was limited to undergraduate engineering students. Study results were not applicable to any other disciplines or graduate student programs. However, I was assessing differences in students who will be working in the engineering profession, so looking at undergraduate engineering students was an appropriate sample population for the given context. Furthermore, I recruited study participants from colleges and universities across the United States, as well as from all engineering disciplines, which was a strategy that increased the diversity of population characteristics in my sample. With increased diversity, variations in the dependent variables due to varying baseline participants' characteristics may be minimized (Stronks et al., 2013). Therefore, applications of my study results to a wide range of undergraduate engineering students may be possible but not beyond.

Another threat to external validity was the reality in which measured relationships or differences can be applied to uninvolved people or settings (Insights Association, n.d.). Under no circumstances observed differences in this study may be explained by the sole participation in an engineering internship as a program intervention. Instead, observed differences in this study can be utilized to ask deeper questions and may lead to additional research. Therefore, this study has limited external validity regarding causal explanations of the findings. Nevertheless, the multiple external settings in real-world internship conditions added to the external validity and the ability to apply study findings to various settings (see Trochim, 2020).

Internal Validity

Internal validity referred to the extent to which competing explanations for the results could be minimized. There were several issues of internal validity in this study. This posttest-only study design was based on existing group membership to either with or without participation in an internship in engineering industries. Therefore, a selection bias for group membership existed (Glen, 2015). Alternative explanations could include a higher motivation in students who participated in an internship or the fact that the college did or did not support internship programs. At the time of the survey, however, group membership had already been established, and participation in the survey did not influence group membership.

Another threat to internal validity was the nature of the survey to rely on self-reported answers. These were instrumentation threats that had been prior addressed by Petrides (2009b) as desirable due to the EI construct in recognizing the inherent subjectivity of emotions. The instrument was administered in an online survey only, which provided excellent consistency in how the instrument was delivered, minimizing possible threats due to varying modes of data collection.

Although the posttest-only approach was limited in capturing confounding variables, it did minimize testing threats, such as history, maturation, or regression effects of pre-test-post-test approaches (Pam, 2015). The neutral control group without internship participation helped to create a comparison but could not verify strict equivalence between the groups with and without internships because observed or calculated environmental influences within the internship group could not be captured (see Nguyen et al., 2019). It was also possible that there may have been threats to construct or statistical conclusion validity, such as EI-construct-related or other interaction effects between dependent variables and covariates (see Warner, 2013). However, statistical corrections, such as the Holm correction (Coppock, 2015) to MANCOVA results, helped minimizing threats to the statistical conclusions in the multivariate approach. In addition, employing an appropriate sample size based on the intended statistical tests did reduce the chances of making a Type I or Type II error (Frankfort-Nachmias & Leon-Guerrero, 2018).

In summary, the trustworthiness of this study was based on a good balance between internal and external validity (see Burkholder et al., 2016). The level of control over study procedures and randomization was moderate in this posttest-only-with-control-group design but provided an effective solution because pretests were not available due to time and location constraints. The sufficient trade-off was benefitting external validity by collecting information based on experiences in real-world professional internship settings and across a diverse population sample, which made findings applicable to a wide range of situations.

Ethical Procedures

For the execution of this study, I followed ethical procedures by submitting an application to the Institutional Review Board (IRB) at Walden University. My application was approved on April 13, 2022, under the IRB approval # 04-13-22-0649259. The first ethical procedures I had in place was related to the treatment of human participants. Participation in this study was voluntary and anonymous, and participants could stop participation at any time point during the study. Participants' only responsibility was to fill out an online survey, which took less than 10 minutes with minimal burden to participants' time. The survey was only delivered in an online format. There were no other interactions between the participant and me besides the study invitation flyer. Names, IP addresses, or other identifying information about study participants were not collected or inquired about, and the participants were not identifiable through their collected data. Collected demographic information were limited to age and gender besides questions about study inclusion criteria. Ethical participant recruitment was conducted in the following manner:

1. Permission: I asked organizers of engineering professional society of student chapters and gatekeepers for student organizations before posting study announcements in their online spaces. I also obtained permission from administrators of engineering groups on social media, such as Facebook or LinkedIn groups.
2. Contact: I emailed an infographic or study invitation flyer (see Appendix F) to members in shared engineering societies. I kept a detailed log of recruitment progress and whom I had contacted. I also posted infographics in interest groups of engineering fields on social media, platforms of social networking, and annual society meetings advertisement forums.
3. Recruitment: The infographic or study invitation contained an embedded link guiding interested participants to more study information and to the letter of informed consent if they self-identify as undergraduate engineering students in a postsecondary degree program.
4. Consent: The informed letter of consent was housed in the online survey and clearly incorporated study purpose and responsibilities, a description of the procedure, time commitment, the number of participants I am seeking, study inclusion criteria, benefits and potential minor risks to the participants, my contact information, and the note to keep a copy of the consent letter for their records. At the end of the consent form, the participants could decide to take the survey or just exit the form. The consent form instructed voluntary participants to click on the link to the questionnaire embedded at the end of

the consent form with clear wording indicating their implied consent by continuing to click on the link.

5. Data Collection: Participants completed the survey online with 5 demographic and 30 EI-instrument questions or just exited the survey at any time. There were no follow-up procedures or gifts accompanied to completing the short survey besides ending on a survey page that simply stated:” Thank you for completing the survey.”

Other ethical procedures were related to the treatment of data. Data collection and the collection of the consent forms were recorded by SurveyMonkey (SurveyMonkey, n.d.) on a password protected account to which only I have access. Each volunteering participant’s entry was timestamped by SurveyMonkey. The timestamps were the only identification of survey responses and were automatically numbered by SurveyMonkey in chronological order when received. At any timepoint during data collection, I could view the number of started or completed surveys to evaluate study sample sizes. Collected data were and will not be shared with anyone outside of this study nor will they be used for any other purposes.

Once the data collection was completed and the targeted sample size was achieved, raw data were downloaded from SurveyMonkey and stored securely, password protected on an external hard drive. I was the only person with access to the data, and I was the only person analyzing them in SPSS programs. Data will stay securely stored on the hard drive for five years before all data will be deleted. There were no paper versions of the surveys or data. Other ethical concerns related to data were not foreseen in this study because data were entirely anonymous.

Summary

Chapter 3 included the methodological description of this study and the rationale for the study design choice. The rationale behind the best fitted study design was to achieve a balance between minimal participant burden and a study design with appropriate internal and external validity to answer the research questions. The quantitative, posttest-only-with-control-group design was identified as best choice to measure global and four domain EI scores as dependent variables at a single time point after the completion of the internships with a control group of students who had not performed such internship in engineering industries due to differing availability, offerings, or timing of student internships in engineering industries. Group membership in the student groups with or without internship participation was the independent variable and gender and age were controlled for as covariates.

The targeted population group were undergraduate engineering students enrolled in a 4-year engineering college program across the United States and were recruited through gatekeepers in engineering societies, engineering student groups, participants at annual engineering meetings, and professional groups, such as LinkedIn. Data collection was limited to a single anonymous online survey consisting of 35 questions, five demographic question and 30 questions based on the established and validated TEIQue-SF questionnaire for EI measures (Petrides, 2009b). Collected survey result data were scored according to the EI scoring key provided by Petrides (2009a) and computed in

SPSS 28.0. Global and domain EI scores were analyzed with ANCOVA (for global EI scores) and MANCOVA (for domain EI scores) statistics to determine a possible existence of a statistically significant difference in EI scores between the two student groups with and without internship participation. Participants were asked for consent and data were collected anonymously and stored password-secured on my hard drives to protect participants' information. Although there was a limitation in addressing preexisting confounding variables in this posttest-only-with-control-group research design, a good balance between internal and external validity was achieved by utilizing experiences in professional, real-world internship settings and across a diverse population sample from multiple engineering colleges in the United States. Besides, the preexisting groups provided a moderate randomization approach that minimized validity threats to the study and aided to answer the research question with its five hypotheses.

In Chapter 4 I will present the results of this study, starting with a description of the data collection process. I will further provide descriptive characteristics of my populations sample and a discussion of the fulfillment of statistical test requirements for ANCOVA family statistics in my data. Lastly, I will provide the results of my statistical analyses comparing Petrides's (2010) EI global and four domain scores of undergraduate engineering students with and without internships when controlled for age and gender.

Chapter 4: Results

The purpose of this basic quantitative study using a posttest-only-with-control-group design was to determine whether global and domain EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries when controlled for age and gender. To accomplish this purpose, I collected and compared global and domain EI scores from 206 undergraduate engineering students with and without internships, using the TEIQue-SF questionnaire developed by Petrides (2010). I developed five hypotheses based on the five measures available from Petrides's (2010) EI assessment instrument to answer the single research question that sought to determine whether there were differences in undergraduate engineering students' EI based on their participation or lack thereof in an engineering industry internship. Each EI score in this model derived from answers to the TEI-Que short form questionnaire and was separated into global EI scores (H1) and four domain EI scores for emotionality (H2), sociability (H3), wellbeing (H4), and self-control (H5).

Chapter 4 provides the results of this quantitative study, including a description of the data collection process, descriptive characteristics of the sample, a discussion of the fulfillment of statistical test requirements, and the results of the statistical analyses from ANCOVA and MANCOVA tests comparing Petrides's (2010) EI global and four domain scores from undergraduate engineering students with and without internships.

Data Collection

There was no need for a pilot study because I employed a survey instrument that had published evidence of validity and reliability. Participant recruitment started on April

14th, 2022, the day after I received IRB approval (approval # 04-13-22-0649259) and went through May 10th, 2022, when I reached a sufficient participant number ($N = 226$). As preplanned, I had informed gatekeepers in my personal learning network across the United States and from professional engineering societies about my study being launched. Immediately after IRB approval, I sent them my study invitation flyer with the embedded link to my anonymous online survey intended for student participants. I asked my gatekeepers to further distribute the study invitation in their personal learning networks.

During the first week of recruitment, I only received 14 responses to my survey, which I tracked on SurveyMonkey. However, after one week, the response rate increased substantially as the flyer distribution seemed to have reached the targeted student population through various channels from my gatekeepers. I also conducted follow-up communication using multiple professional platforms that targeted professional societies including the American Society of Engineering Education (ASEE, n.d.) among others. I was offered to post my study invitation in the monthly newsletter of ASEE, which was distributed to many engineering professors and students across the United States. At the end of the second recruitment week, I had 165 responses anonymously recorded in SurveyMonkey.

The recruitment time near the end of the academic year and about a month before the start of the summer break or graduation in most engineering colleges attested itself as an excellent timing to raise interest in my study. Engineering junior students may start to think about summer internships at this time or senior students have already completed an internship during their final year. Therefore, my study invitation seemed to have reached targeted engineering students at a good time to recruit a relatively large number of students in a short time frame. In the third and fourth weeks of my recruitment, additional responses were recorded in SurveyMonkey, frequently after follow-up announcements in student chapter groups of professional societies. On May 10th, 2022, I had 226 participants in my study as recorded in SurveyMonkey. There were no discrepancies in the data collection from the plan presented in Chapter 3.

Next, I discuss thoughts on demographic characteristics of my sample. As my survey was anonymous and my flyer was distributed among colleges and engineering societies across the United States, I assumed that there was a wide range of demographic characteristics represented in my sample, which supported the generalizability of study results (see Burkholder et al., 2016). However, I did not have any information on study participants besides age and self-identified gender and therefore am not able to make any statements on the demographic distribution of my study population besides the inclusion criteria. My study's inclusion criteria determined that participants were currently enrolled in an undergraduate engineering degree program and had not completed any other postsecondary degrees. I used a stratified sampling method because all population members fell into one or the other group without exception, and samples were drawn for each group across the U.S. and inclusive of all engineering disciplines. Undergraduate engineering students were recruited through several channels involving numerous gatekeepers from my personal learning network, from engineering societies, social media, engineering interest groups, or other affiliations and communication platforms, such as Discord or Slack. With the wide and inclusive recruitment strategies across locations and engineering disciplines (e.g., engineering societies, social media, engineering interest groups), my study sample was assumed to be representative of the targeted heterogenous undergraduate engineering student population.

After I reached a participant number of $N = 226$, which was larger than the needed minimum number determined in Chapter 3, I examined the responses by downloading the files from SurveyMonkey and stored them on a password-protected folder on my personal computer. I noticed that three study participants had started the survey but had been automatically exited out of the survey at the inclusion criteria questions because they had not fulfilled the inclusion criteria. I had purposefully programmed SurveyMonkey's flow logic to automatically exit and thank participants that answered one of the inclusion criteria questions in a way that would not qualify them for study participation (see Figure 2). I did not collect data on these three students as they were automatically exited before they reached the page with the TEIQue-SF questionnaire. Another 17 qualified participants had started the page with the TEIQue-SF questions in the survey but had not completed all 30 questions; thus, no responses were recorded for them either. Because SurveyMonkey only recorded the answers to the TEIQue-SF questionnaire after the page was completed and submitted by a click on a green submit button at the end of the 30 questions, I did not have any partial survey answers for the EI assessment. In total, I collected valid and complete datasets from 206 undergraduate engineering students from across the United States. To confirm my statistical power, I computed the power of statistics for this number of participants in G*Power (UC

Regents, 2021) for ANCOVA family statistics with F tests. I verified a power of statistics for global EI scores of 0.95 and domain EI scores of 0.82 for a medium effect size (see Appendix I), which was sufficient for my statistical tests and associated analyses and confirmed the power analysis estimates provided in Chapter 3.

After I downloaded and organized the scores of the 30 answered questions from 206 study participants in an Excel file, I used Petrides's (2010) EI scoring key to generate global and domain EI scores for all participants in my study. Petrides's EI model was a weighted construct of using 30 questions from which a selected number of questions contribute independently to each EI domain score and included additional questions for global EI scores (see Figure 1). Therefore, the scoring key was essential to produce valid EI scores for this EI construct. Petrides offers a scoring tool on the website for their EI lab (Psychometric Lab, 2021a) that is available for research studies, and that I used. The scoring tool quantifies raw data of the answers to the 30 questions in the TEIQue-SF questionnaire into Petrides's five EI measures. I submitted my Excel file to the online scoring tool and retrieved the EI composite scores for my dataset. The returned file included Cronbach's alpha values to confirm internal consistency and reliability of the scores in my data. Based on my study population sample of 206 undergraduate engineering students, the Cronbach's alpha values were comparable to those published in Petrides's EI Manual (Petrides, 2009b), which was based on a standardized sample population of 1,721 individuals (see Appendix H). Thus, the EI scores from my data provided adequate internal consistency and reliability (see Table 5).

Table 5

Cronbach's Alpha Values for EI Global and Domain Scores (N=206)

EI Scores	Cronbach's Alpha	*N*
Emotionality	0.70	206
Sociability	0.70	206
Well-being	0.84	206
Self-Control	0.65	206
Global EI	0.89	206

Examining the data in more detail, I first inspected the group distributions. Of the 206 survey responders, approximately one-third of the students had completed an internship at the time of survey participation, and two-thirds of surveyed students had not. This result aligned roughly with Wolfgram et al.'s (2021) report that 40-50% of students had completed an internship by the time they graduated. One explanation for this slightly lower internship completion rate in my study as compared to literature data is because I collected data from students while they were in their junior and senior years of their education and still active in the program, whereas literature data were based on time of graduation. Therefore, it is plausible that I had captured a slightly lower internship completion rate with approximately 33% or 67 students with an internship versus 139 students without than I would have at the time of graduation. With these numbers, the group distribution in my data was slightly unbalanced. Ideally, evenly balanced group sizes would be best suited for ANCOVA family statistics (Warner, 2013); however, the statistic was reported as robust with moderately different group sample sizes as long as error variances were homogenous across the groups (Statistics Solution, 2020).

Homogeneity of error variances was one of the test requirements for ANCOVA statistics and is further examined in my data analysis section in a later section of Chapter 4.

Lastly, I uploaded global and domain EI scores to SPSS 28.0 for data analyses. I started with tests to justify my choices of covariates. Petrides (2010) reported gender and age-related differences in scores of their EI construct, so I started by computing univariate analyses of gender and age versus EI measures in my dataset to determine potential correlations between EI scores and age or gender. This step was intended to justify the inclusion of these two covariates in my data analyses. Results of basic univariate analyses showed that neither gender nor age was statistically significantly correlated with global EI scores or with the domain EI scores of self-control or wellbeing (see Appendix J). However, age showed a statistically significant correlation with domain EI scores for sociability with $F(9, 188) = 2.84$, $p_{\text{age}} < .01$, and gender showed a statistically significant correlation with domain EI scores for emotionality with $F(1, 188) = 5.35$, $p_{\text{gender}} = .02$ (see Appendix J). These findings aligned with reports in the literature that age and gender may influence EI scores either depending on the EI construct (Aloiseghe, 2018), on specified EI domains (Meshkat & Nejati, 2017), or on specific circumstances in which the EI scores were collected (Esnaola et al., 2017). In my study, the age range of the study participants was narrow as only undergraduate students were included in the study. Thus, expectations of finding significant differences in EI scores due to the age of the participants were minimal. Yet, controlling for age as a measure to account for possible influences due to accumulated additional life experiences was justified because I found some significant influences of age in my data for some specified domain EI scores. This finding supported the literature suggesting that EI domain scores are more sensitive to variations in age and gender than global EI measures (Aloiseghe, 2018; Costa et al., 2021). Although age and gender did not show statistically significant correlations in all EI domains, controlling for age and gender as covariates minimized confounding influences. Hence, the use of these covariates in my analyses was justified.

In summary, my data collection processes were successful and sufficient to produce a valid dataset with adequate statistical power to answer the research questions in my study. The internal and external validity and consistency in my collected data confirmed a strong trustworthiness of the results of my study. Also, my choice of covariates was confirmed to minimize confounding influences on my dependent variables of specified EI scores and to determine optimized findings from my statistical analyses using the ANCOVA family tests as was proposed in Chapter 3. In the following section, I will present the results of the statistical analyses using SPSS 28.0.

Results

Descriptive statistics that characterized the sample included global EI and EI domain scores for emotionality, sociability, wellbeing, and self-control for a control group without internships and for the group of students who had completed an internship (see Table 6). The range of all EI scores was between 2 and 7, with the maximum possible EI score measure of 7. Means and standard deviations for each EI score are shown in Table 6.

Table 6

Descriptive Statistics for Global and Domain EI scores (N = 206)

	Internship	Mean	*SD*	*n*
Wellbeing	yes	5.46	.888	67
	no	5.20	1.062	139
	Total	5.28	1.014	206
Self-Control	yes	4.63	.842	67
	no	4.54	.910	139
	Total	4.57	.887	206
Emotionality	yes	5.07	.834	67
	no	5.09	.884	139
	Total	5.08	.849	206
Sociability	yes	4.79	.854	67
	no	4.58	.886	139
	Total	4.65	.879	206
Global EI	yes	5.01	.676	67
	no	4.86	.696	139
	Total	4.91	.691	206

Overall, means for global EI scores were slightly higher in the participant group with an internship versus no internship. Measures for domain EI scores for wellbeing, self-control, and sociability were also higher in the participant group with an internship; however, the standard deviations for the domain scores were also higher compared to the standard deviation for global EI scores indicating larger variances. The measures for emotionality EI domain scores showed no changes between the groups with a minimal tendency of going down in the group with an internship in descriptive statistics. However, the differences in the means were generally small between the groups.

In the following steps, the covariate distribution and internship participation rates were examined. The age range of the participating undergraduate engineering students was between 18 and 27 years old, distributed between 57% of self-identified males and 43% of females. Completed internship participation was reported by 33% of participating students, and the remaining 67% of students did not complete an internship while enrolled in their engineering degree program. Details on frequency distributions can be viewed in Appendix K.

To interpret statistical analyses for ANCOVA family tests, several test assumptions must be met to produce meaningful outcomes (Warner, 2013). According to Laerd Statistics (2018), the following test assumptions apply to ANCOVA and MANCOVA family tests: (a) multivariate normality, (b) homogeneity of variances, (c) homoscedasticity, (d) absence of multicollinearity, (e) homogeneity of covariate regression coefficients with linear relationship of regression slopes, and (f) absence of significant unusual points. In the following paragraphs, I evaluated each test assumption for ANCOVA and MANCOVA statistics, described the tests used for each assumption, and reported on whether the assumption was met or violated in my dataset.

Multivariate Normality

According to the central limit theorem, a population size larger than 50 can be assumed to have normal distribution (Frankfort-Nachmias, & Leon-Guerrero, 2018). All my groups had more than 50 participants. Nevertheless, I tested for multivariate normality in my dataset with the Shapiro-Wilk test and visual inspections of histograms for frequency distributions for all five EI measures in my dataset (see Appendix L). Results confirmed multivariate normality of all EI measures. The test assumption of multivariate normality was met in my dataset.

Homogeneity of Variances

As proposed in Chapter 3, homogeneity of variances was tested with Levene's test to verify equal variances of residuals across the groups. This test was particularly important in my dataset because I had a moderate departure from equal sample sizes in each group. The ANCOVA and MANCOVA tests are robust against unbalanced sample sizes as long as equal variances of residuals are present (Laerd Statistics, 2018). Table 7 shows the results of the Levene's tests for all five EI measures in my dataset.

Table 7

Levene's Test of Equality of Error Variances[a]

EI Scores	*F*	*df1*	*df2*	Sig.
Wellbeing	3.800	1	204	.053
Self-Control	.002	1	204	.969
Emotionality	.019	1	204	.889
Sociability	.014	1	204	.907
Global EI	.174	1	204	.677

Note. Tests the null hypothesis that the error variance of the dependent variable is equal across groups[a]
a. Design: Intercept + Age + Gender + Internship

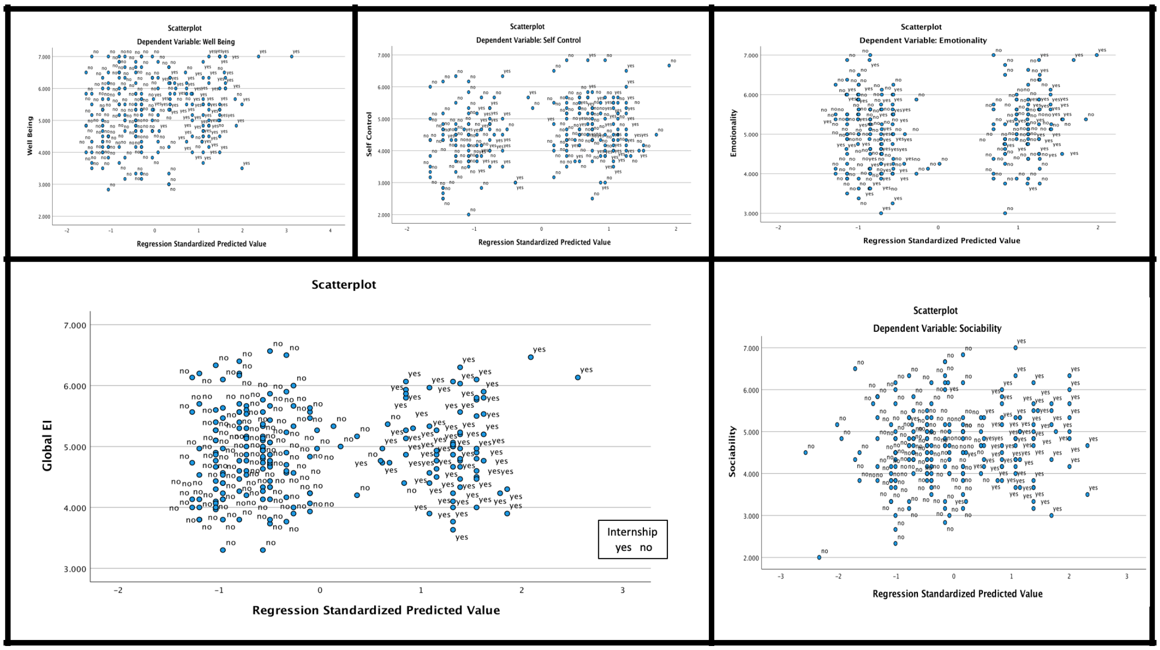
The results from the Levene's test for univariate (global EI scores) and multivariate (domain EI scores) procedures showed non-statistically significant results for all EI scores above the conventional level (p > .05). Because the Levene's tests were not statistically significant, the null hypothesis was failed to be rejected, and equal variances between groups were confirmed (see Field, 2013). The test assumptions for the homogeneity of variances were met for all five EI measures in my dataset.

Homoscedasticity

Homoscedasticity was addressed by visual inspection of residual scatter plots. When residual scatter plots show random distribution without the visual image of a funnel or other structured shapes across the data points, equal or similar variances can be assumed when different groups are compared. Figure 3 displayed the residual scatter plots from global and all four EI domain scores. Each scatter plot showed the groups with and without internship as labeled data points with “yes or no” for each of the five EI measures. In some cases, the “yes” and “no” groups were intermingled with a random distribution of the residuals across the graph, whereas in other cases, the groups in the graph showed uniform clusters of the “yes” and “no” group (see Figure 3). However, the residual distribution in each group in itself showed no funnel or shape in the distribution of the data points and appeared rather random within each group in all five graphs. With the random distribution of data points in the residual scatter plots, homoscedasticity can be assumed. Therefore, this test assumption was met for all five EI measures in my dataset.

Figure 3

Scatterplots for Standardized Residuals of Global and Domain EI Scores



Absence of Multicollinearity

Multicollinearity is present when predictor or independent variables, including covariates, are highly correlated with each other (Field, 2016). A simple method to detect multicollinearity in a dataset was the use of the variance inflation factor (*VIF*) for each predicting variable (Hair et al., 2013). When multicollinearity exists, standard errors might be inflated, leading to false hypothesis rejection in *F*-tests with an increased Type II error (Hair et al., 2013). The *VIF* measures how much the variance of the estimated regression coefficient is inflated above the expected level when no multicollinearity would be present (Hair et al., 2013). A *VIF* between 1 and 2 confirms no or minimal correlation, a *VIF* between 2 and 5 is moderately correlated, and a *VIF* greater than 10 needs to be corrected in the given model. Table 8 displayed the *VIF* factors for global and the four EI domain scores assessing multicollinearity between age, gender, and internship participation in my dataset. All *VIF*s were close to 1 (see Table 8), which indicated that no correlation existed between assessed variables and confirmed the absence of multicollinearity for the covariates and the independent variable of internship group membership in my dataset.

Table 8

Collinearity Statistics for Predictors in Global and Domain EI Scores (N = 206)

		Coefficients					Collinearity Stat.	
Model		*B*	*Std. Error*	*Beta*	*t*	Sig.	Tolerance	*VIF*
Well-Being	(Constant)	4.770	.971		4.911	<.001		
	Internship	-.285	.155	-.128	-1.835	.068	.991	1.010
	Age	.048	.044	.076	1.091	.276	.989	1.011
	Gender	-.041	.146	-.020	-.282	.778	.997	1.003
Self-Control	(Constant)	4.334	.829		5.227	<.001		
	Internship	-.092	.132	-.047	-.692	.490	.991	1.010
	Age	.027	.037	.049	.725	.469	.989	1.011
	Gender	-.421	.124	-.230	-3.381	<.001	.997	1.003
Emo-tionality	(Constant)	4.592	.792		5.800	<.001		
	Internship	-.027	.127	-.015	-.212	.832	.991	1.010
	Age	.020	.038	.040	.575	.566	.989	1.011
	Gender	.239	.119	.140	2.014	.045	.997	1.003
Socia-bility	(Constant)	6.040	.835		7.235	<.001		
	Internship	-.247	.133	-.128	-1.850	.066	.991	1.010
	Age	-.046	.038	-.084	-1.212	.227	.989	1.011
	Gender	-.108	.125	-.060	-.860	.391	.997	1.003
Global EI	(Constant)	4.971	.659		7.542	<.001		
	Internship	-.169	.105	-.112	-1.604	.110	.991	1.010
	Age	.011	.030	.026	.369	.713	.989	1.011
	Gender	-.029	.099	-.021	-.296	.768	.997	1.003

Equality of Covariances and Linearity of Covariate Regression Slopes

As proposed in Chapter 3, equality of covariances between groups was tested with Box’s M test of equality of covariance matrices (see Field, 2016). Test results showed a non-statistically significant result for the multivariate test (Table 9), which indicated equal covariances because the test was highly sensitive (Statistics Solutions, 2020).

Table 9

Box's Test of Equality of Covariance Matrices[a]

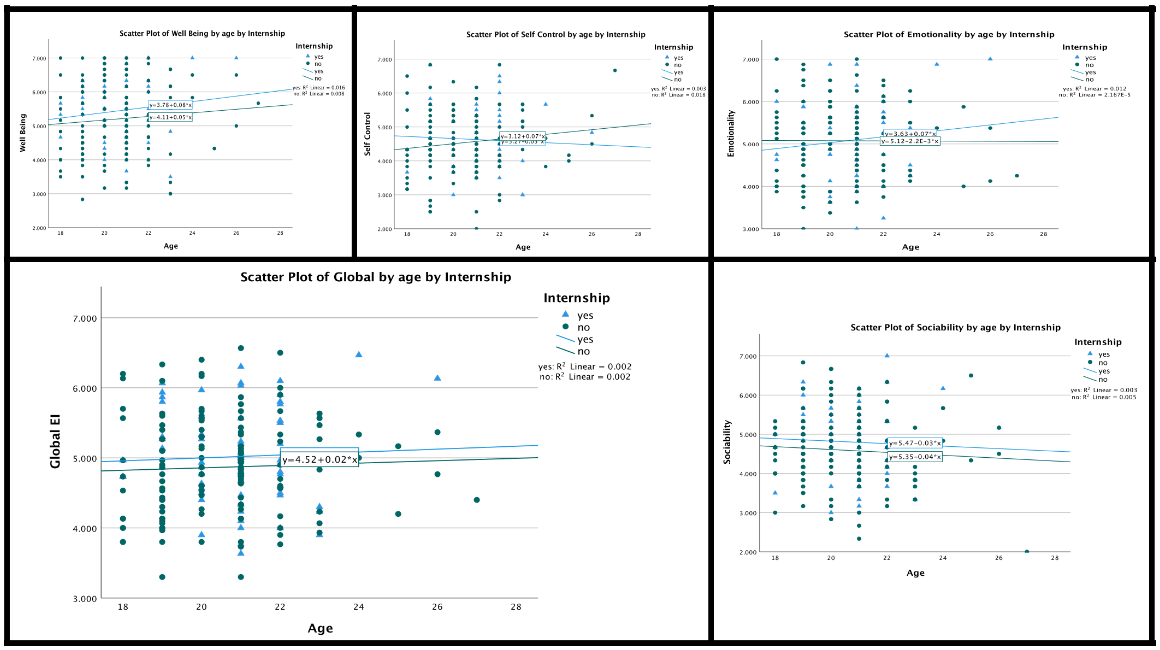
Box's M	14.230
F	1.387
df1	10
df2	82606.834
Sig.	.179

Note. Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups[a]
a. Design: Intercept + Internship * Age + Internship * Gender

Furthermore, the linearity of covariate regression slopes was addressed by scatter plots with plotted regression lines for each group of participants with and without internship (labeled as “yes” and “no” in the graphs). Results of the scatter plots for each EI measure were displayed in Figure 4. The homogeneity of regression slopes was a strict assumption of ANCOVA family tests, because the interpretation of an overall relationship between the dependent variable and the outcome variable was based on a regression line for the entire dataset ignoring group membership, therefore the slopes of the individual group regression lines must be similar to each other to be comparable in the main effect tests (Grace-Martin, 2019).

Figure 4

Scatterplots and Covariate Regression Slopes for EI Scores With and Without Internships



Visual inspection of the plotted regression lines for each group (with and without internship) showed similar regression lines with little distortion from being parallel for global EI, sociability, emotionality, wellbeing, and self-control scores. Consequently, the test assumption for the linearity of covariate regression slopes was met in my dataset for all five EI measures.

Absence of Significant Unusual Points

The final assumption for ANCOVA family tests was the absence of significantly unusual points in each group (Statistics Solutions, 2020). By visual inspection of the scatterplots for standardized residuals of global and domain EI scores (see Figure 3), no extremely unusual points in any group were detected. Nevertheless, I computed box plots for each group and confirmed the absence of extreme outliers (see Appendix M). The only EI measure with mild outliers, as defined as < 3*IQR from the upper or lower quartile or within the outer fence (see Engineering Statistics Handbook, 2012), was the “no” internship group for the EI domain for sociability (see Appendix M). The few mild outliers were almost evenly split between high and low and were not considered extreme because they were located within the outer fence of the boxplot. Thus, the requirement of the absence of extremely unusual points was met in my dataset.

After all test assumptions were evaluated with no violations detected in my dataset, I ran the main tests in SPSS 28.0. For global EI, I used ANCOVA, and for domain EI scores, I used the MANCOVA statistic as described in Chapter 3. For the ANCOVA family analyses, interaction effects with covariates must be statistically non-significant to interpret main between-subject effects correctly (Frankfort-Nachmias & Leon-Guerrero, 2018). Findings for interaction as well as main effects between subject groups were further discussed for each hypothesis in the next sections.

Hypothesis 1: Global EI Differences

A univariate ANCOVA test was computed to determine main differences between global EI scores of undergraduate engineering students with and without internship participation when controlled for age and gender. First, I tested for interaction effects with covariates in a custom-build model in SPSS 28.0, and did not find any statistically significant interactions between internship and age with $F(2, 201) = .152$, $p = .859$ or between internship and gender with $F(2, 201) = .639$, $p = .529$ for global EI scores (Table 10). Thus, main effects of between-subject differences for internship participation can be interpreted after adjustment for age and gender in a full factorial model (Laerd Statistics, 2018).

Table 10

Tests of Interaction Effects for Global EI (N=206)

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	1.835[a]	4	.459	.957	.432	.019
Intercept	27.066	1	27.066	56.476	<.001	.219
Internship * Age	.146	2	.073	.152	.859	.002
Internship * Gender	.612	2	.306	.639	.529	.006
Error	96.329	201	.479			
Total	5076.617	206				
Corrected Total	98.164	205				

Note. a. R Squared = .019 (Adjusted R Squared = -.001)
b. Computed using alpha = .05

After adjustment for age and gender, main between-subject effects for internships in a full factorial ANCOVA test showed no statistically significant differences in global EI scores. Thus, the test failed to reject the null hypothesis, $F(1, 202) = 1.98$, $p = .161$, partial $\eta^2 = .010$. Table 11 showed the results of the ANCOVA test for global EI. Therefore, there was no statistically significant difference in the means of global EI scores in undergraduate engineering students with and without internships when controlling for age and gender.

Table 11

ANCOVA Test for Global EI Scores, Between-Subjects Effects (N=206)

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	1.223[a]	3	.408	.850	.468	.012
Intercept	26.659	1	26.659	55.550	<.001	.216
Age	.182	1	.182	.379	.539	.002
Gender	.001	1	.001	.003	.956	.000
Internship	.948	1	.948	1.976	.161	.010
Error	96.941	202	.480			
Total	5076.617	206				
Corrected Total	98.164	205				

Note. a. R Squared = .012 (Adjusted R Squared = -.002)
b. Computed using alpha = .05

Hypothesis 2: EI Domain Differences for Emotionality

Grounded in Petrides (2010) EI model, four domain EI scores were computed and subjected to the multivariate MANCOVA test to determine main differences between domain EI scores of undergraduate engineering students with and without internship participation when controlled for age and gender. Emotionality was one of the four domain EI scores. Again, I tested for interaction effects with covariates in a custom-build model in SPSS 28.0 for all four EI domain scores in my dataset. Results of the interaction tests, computed in SPSS as internship times age and internship times gender, were displayed in Table 12.

Table 12

Tests of Interaction Effects for Domain EI Scores (N=206)

Source	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	Well-Being	5.207[a]	4	1.302	1.272	.282	.025
	Self-Control	8.993[b]	4	2.248	2.962	.021	.056
	Emotionality	5.970[c]	4	1.492	2.115	.080	.040
	Sociability	3.386[d]	4	.847	1.096	.360	.021
Internship * Age	Well-Being	3.607	2	1.803	1.762	.174	.017
	Self-Control	.800	2	.400	.527	.591	.005
	Emotionality	.909	2	.454	.644	.526	.006
	Sociability	1.362	2	.681	.882	.416	.009
Internship * Gender	Well-Being	.023	2	.012	.011	.989	.000
	Self-Control	7.539	2	3.770	4.966	.008*	.047
	Emotionality	5.821	2	2.911	4.125	.018*	.039
	Sociability	.750	2	.375	.485	.616	.005
Error	Well-Being	205.771	201	1.024			
	Self-Control	152.581	201	.759			
	Emotionality	141.829	201	.706			
	Sociability	155.261	201	.772			
Corrected Total	Well-Being	210.979	205				
	Self-Control	161.574	205				
	Emotionality	147.799	205				
	Sociability	158.647	205				

Note. a. *R* Squared = .025 (Adjusted *R* Squared = .005)
b. *R* Squared = .056 (Adjusted *R* Squared = .037
c. *R* Squared = .040 (Adjusted *R* Squared = .021)
d. *R* Squared = .021 (Adjusted *R* Squared = .002)
e. Computed using alpha = .05*

Interaction effects for internships and age did not show statistical significance for emotionality (see Table 12). However, interaction effects for internships and gender were found to be statistically significant in my dataset for emotionality with $F(2, 201) = 4.13$, $p = .018$ (Table 12). Therefore, main effects of internships on emotionality were significantly intercorrelated with gender and main between-subject statistical results for emotionality could not be interpreted accurately (Laerd Statistics, 2018). Nevertheless, the scores for emotionality were computed as part of the full factorial MANCOVA tests and results showed that there was no statistically significant difference in means of emotionality scores between undergraduate engineering students with and without internships with $F(1, 202) = .02$, $p = .890$. MANCOVA test results were displayed in Table 13.

Table 13

MANCOVA Test for Domain EI Scores, Between-Subjects Effects (N=206)

Source	Dependent Variable	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	Well-Being	5.154[a]	3	1.718	1.686	.171	.024
	Self-Control	8.935[b]	3	2.978	3.942	.009	.055
	Emotionality	3.407[c]	3	1.136	1.589	.193	.023
	Sociability	2.847[d]	3	.949	1.231	.300	.018
Age	Well-Being	2.004	1	2.004	1.966	.162	.010
	Self-Control	.884	1	.884	1.170	.281	.006
	Emotionality	.194	1	.194	.272	.603	.001
	Sociability	.756	1	.756	.980	.323	.005
Gender	Well-Being	.021	1	.021	.021	.885	.000
	Self-Control	7.417	1	7.417	9.815	.002	.046
	Emotionality	3.271	1	3.271	4.575	.034	.022
	Sociability	.210	1	.210	.272	.602	.001
Internship	Well-Being	2.649	1	2.649	2.600	.108	.013
	Self-Control	.192	1	.192	.255	.614	.001
	Emotionality	.014	1	.014	.019	.890	.000
	Sociability	2.119	1	2.119	2.747	.099	.013
Error	Well-Being	205.825	202	1.019			
	Self-Control	152.639	202	.756			
	Emotionality	144.392	202	.715			
	Sociability	155.800	202	.771			

Note. a. R Squared = .024 (Adjusted R Squared = .010)
b. R Squared = .055 (Adjusted R Squared = .041)
c. R Squared = .023 (Adjusted R Squared = .009)
d. R Squared = .018 (Adjusted R Squared = .003)
e. Computed using alpha = .05

Hypothesis 3: EI Domain Differences for Sociability

Sociability was the second of the four domain EI scores and was also computed using the MANCOVA test for domain EI scores. Before a full factorial MANCOVA test, interaction tests were executed for covariates and showed no statistical significance for age or gender in sociability scores (see Table 12). Therefore, main effects of between-subject differences for internship participation were analyzed for sociability after adjustment for age and gender. Results showed that there was no statistically significant difference in the mean of EI domain scores for sociability in undergraduate engineering students with and without internships when controlled for age and gender with $F(1, 202) = 2.75$, $p = .099$, partial $\eta^2 = .013$ (see Table 13).

To confirm test findings, I performed a second MANCOVA test for sociability scores to determine if the removal of the five mild outliers (see Appendix M) would provide a different test result. The mild outliers were removed from the "no" internship group for sociability scores, and MANCOVA between-subject test results were computed again for sociability with 201 subjects. Results showed a slightly lower *p*-value for sociability, but remained not statistically significant different in means for sociability scores with and without internships, computed as $F(1, 197) = 3.07$, $p = .082$, partial $\eta^2 = .015$ (Table 14).

Table 14

MANCOVA Test for Sociability EI Scores, Between-Subjects Effects (N=201)

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	2.138[a]	3	.713	1.070	.363	.016
Intercept	24.454	1	24.454	36.710	<.001	.157
Age	.022	1	.022	.033	.855	.000
Gender	6.719E-5	1	6.719E-5	.000	.992	.000
Internship	2.042	1	2.042	3.065	.082	.015
Error	131.228	197	.666			
Total	4481.194	201				
Corrected Total	133.367	200				

Note. a. *R* Squared = .016 (Adjusted *R* Squared = .001)
b. Computed using alpha = .05

With and without mild outliers, scores for the EI domain of sociability failed to meet significance so the null hypothesis could not be rejected ($p > .05$). Therefore, there was no statistically significant difference in the mean EI scores for sociability between undergraduate engineering students with and without internships in my dataset when controlled for age and gender.

Hypothesis 4: EI Domain Differences for Wellbeing

Wellbeing was another of the four domain EI scores and was also computed using the MANCOVA test for domain EI scores. Before a full factorial MANCOVA test was executed, interaction tests were performed for covariates and showed no statistical significance for age or gender in wellbeing scores (see Table 12). Therefore, main effects of between-subject differences for internship participation were analyzed for wellbeing after adjustment for age and gender. Results showed that there was no statistically significant difference in the means of EI domain scores for wellbeing in undergraduate engineering students with and without internships when controlling for age and gender, $F(1, 202) = 2.60$, $p = .108$, partial $\eta^2 = .013$ (see Table 13).

Hypothesis 5: EI Domain Differences for Self-Control

The fourth EI domain in Petrides (2010) EI model was self-control and the analysis of self-control scores were also computed using the MANCOVA test for domain EI scores. Again, before a full factorial MANCOVA test was performed, interaction tests were conducted for covariates and showed no statistical significance for age and internships among the self-control scores. However, interaction effects for internships and gender were found to be statistically significant in my dataset for self-control, $F(2, 201) = 3.77$, $p = .008$ (see Table 12). Therefore, main effects of internships on self-control scores were significantly intercorrelated with gender. Consequently, main between-subject statistical results for self-control could not be interpreted accurately (Laerd Statistics, 2018). Nevertheless, scores for self-control were computed as part of the full factorial MANCOVA tests and results showed that there was no statistically significant difference in means of self-control scores between undergraduate engineering students with and without internships with $F(1, 202) = .255$, $p = .614$ (see Table 13).

In summary, the research question in my study sought to determine whether there were differences in global and domain EI scores in undergraduate engineering students with and without internships when controlled for gender and age. In my data analyses, I compared two groups of undergraduate engineering students with and without internships using the ANCOVA test for global EI scores, and the MANCOVA test for the four domain EI scores of emotionality, sociability, wellbeing, and self-control. I included age and gender as covariates in the statistical tests to explain additional nuances of differences in scores that may be due to these factors. When controlling for age and gender, I achieved a slightly higher power of statistics for differences in scores based on internship group membership, thus explaining a higher percentage of differences not accounted for otherwise. Based on my statistical analyses, however, there were no statistically significant differences in all five assessed scores for EI in undergraduate engineering students based on internship participation when controlling for age and gender. However, gender appeared to be statistically significantly intercorrelated with internships for differences in emotionality and self-control.

Summary

Chapter 4 included a description of the recruitment of 226 study participants and of my data collection steps, descriptive statistics of my 206 valid datasets, and statistical test procedures, including the results from ANCOVA and MANCOVA tests in my dataset. After ANCOVA and MANCOVA test requirements had been examined, I found that my dataset fulfilled the test requirements for multivariate normal distribution, homogeneity of variances across all groups, homoscedasticity, absence of multicollinearity, absences of extremely unusual points, and homogeneity of regression slopes for covariates and dependent variable through associated statistical post hoc tests, scatterplots, and residual analyses. Thus, all test assumptions were met in my dataset to provide a trustworthy interpretation of ANCOVA and MANCOVA tests on my data.

The key findings of this study were that, in observations from descriptive statistics, a small difference between undergraduate engineering students with and without internships in global EI and domain EI scores for wellbeing, self-control, and sociability were indicated with slightly higher scores in the internship group. However, the differences were on the level of a small effect size, only indicating a tendency. Scores for emotionality did not project a difference between the groups in descriptive statistics. Following these observations with results from full factorial ANCOVA and MANCOVA tests, main results from the ANCOVA test for global EI showed that there were no statistically significant differences between undergraduate engineering students with and without internships when controlled for age and gender ($p > .05$), tested for a medium effect size. In the MANCOVA test for EI domain scores, emotionality and self-control scores exhibited a statistically significant interaction between gender and internships for the differences between the groups. Therefore, the main effect test results must be considered with caution for emotionality and self-control, as the internship group membership could not be separated from gender influences for differences in those two EI domain scores. For the other EI domain scores, the MANCOVA test postulated that the main results for wellbeing and sociability did not show a statistically significant difference between undergraduate engineering students with and without internships when controlled for age and gender ($p > .05$), tested for a medium effect size. Consequently, the metric failed to reject all five null hypotheses of my research question. Overall, there were no statistically significant differences between undergraduate engineering students with and without internships when controlled for age and gender for global EI and domain EI scores for wellbeing, self-control, emotionality, or sociability in my dataset.

In Chapter 5, I will restate my purpose of the study, the study's nature, and the connection of how the study's findings fit into the current literature in my field of study for engineering education. Furthermore, I will address my study's limitations and recommendations for future studies to continue the quest for the understanding of the effects of work-based educational models, such as internships in engineering industries, on holistic competencies of engineering students. Chapter 5 will conclude with a discussion on social change through the initiation of my research and potential contributions this and future work may provide to close the gap between the performance expectations of employers in engineering industries and the academic preparation of competent and successful engineering graduates (see Bae et al., 2022; Hirudayaraj et al., 2021).

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this basic quantitative study was to determine whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries when controlled for age and gender. Using a posttest-only-with-control-group design, I collected data from undergraduate engineering students across the United States through an online survey, utilizing Petrides's (2010) established EI assessment instrument. Multivariate analyses of covariance with gender and age as covariates was used to test for significant differences between group means of global EI and EI domain scores for emotionality, sociability, wellbeing, and self-control in undergraduate engineering students with and without internships. The student group without internship participation served as control group in this research design. Guided by transformative EI theory and based on Petrides's EI model, the determination of whether EI scores of engineering students with and without the participation in an internship differed may foster further research on the effects of internships on students' holistic competencies and EI development in postsecondary engineering education.

The key findings of this study showed that global EI and EI domain scores for emotionality, sociability, wellbeing, and self-control were not statistically significant different between undergraduate engineering students with and without internships when controlled for age and gender. Furthermore, results for EI domain scores for emotionality and self-control exhibited a statistically significant interaction between gender and internships when analyzing for differences between students with and without internships. Thus, the research question of whether there were statistically significant differences between the EI scores of undergraduate engineering students with and without internships when controlled for age and gender was answered with “no" based on the applied test statistics and for the assessed student population sample in this study. Nevertheless, observations from descriptive statistics, despite being small, may indicate directional differences toward higher scores in global EI and domain EI for sociability in the student group with an internship, whereas domain EI for emotionality did not show this directional difference. Though the effect size for group mean differences in these observations was too small to be significant in the statistical tests of this study and may only indicate a directional tendency, this may lay the ground for further research.

Interpretation of the Findings

The question of whether there were differences in EI in undergraduate engineering students with and without internships was viewed through the lens of transformative EI theory (Gardner, 1983; Goleman, 1995; Nelson et al., 2017) and guided by Petrides’s (2010) trait EI model. Internships in engineering education may be viewed as life experiences that possibly shape students’ EI competencies when preparing them for their transition into the workforce (Luk & Chan, 2021). Therefore, differences in EI scores between students who participated in an internship or not may provide a first indication for the need for more research on this possibly additional benefit of internships in postsecondary engineering education. However, in this study, statistically significant differences in EI scores of undergraduate engineering students with and without internship experiences were not found.

One reason for this result may be that the student population sample was too generalized when including all disciplines of engineering programs, such as bioengineers, computer engineers, or electrical engineers. Skipper et al. (2017) found differences in EI of engineering students from different disciplines. Therefore, including all engineering students in my study may have disguised any potentially existing differences between disciplines. However, my choice of sampling this population helped reach as many undergraduate engineering students across the United States as possible as I wanted to recruit a statistically representative sample of undergraduate engineering students for this initial basic quantitative study.

Despite having multiple engineering disciplines in my student sample, the findings of this study extend the existing literature because EI measures have not been recorded in conjunction with internship participation in engineering education. Regardless of the lack of statistical significance, this study may initiate a new line of research on the effects of internships as educational models in postsecondary engineering education utilizing EI measures. From my study results, descriptive statistics and observed tendencies regarding each hypothesis can be formulated, which I will interpret and discuss in the following sections organized by hypothesis.

Differences in Global EI

As reviewed in the literature, global EI as a summative score has been identified to serve protective functions in developing desirable behaviors leading to better physical and mental health (Brackett & Cipriano, 2020) and to moderate anxiety and stress (Naseem, 2018). Shortly before the transition from college to the engineering workforce, a higher global EI score seemed desirable to lessen anticipated stress in undergraduate engineering students facing this transition. Although it has been shown that internships in engineering programs, viewed as an influential and preparatory activity before entering the workforce, have many positive effects on engineering students close to graduation (Bender, 2020; Hora et al., 2017; Kolmos & Holgaard, 2018; Luk & Chan, 2021; Nachammai et al., 2020; Pardo-Garcia & Barac, 2020; Powers et al., 2018; Wilson, 2019), my study was the first one to quantitatively employ EI measures in conjunction with internship experiences.

In my results, I did not detect a statistically significant difference in global EI scores between students with and without internships in global EI scores. However, Esnaola et al. (2017) pointed out that individual domain EI scores may fluctuate following certain unplanned or planned influential activities, sometimes in opposing direction to other EI domains. Therefore, affected EI domain scores may be averaged out in global EI measures. Furthermore, the incremental development of specified EI domains may be small and may take time to be fully embodied (Romosiou et al., 2019). Consequently, potential changes may not lead to an overall significant increase in global EI scores, particularly shortly after an interventive activity. Hence, the study's findings confirmed the current notion in the literature that global EI may be less sensitive to detect changes due to specified life events or activities because of asynchronous incremental changes in fluctuating domain EI development (Snowden et al., 2018). Snowden et al. (2018) concluded that domain EI scores might provide more useful information on EI development than the global EI measure by itself. Nevertheless, general developmental tendencies may be discovered from global EI measures.

In descriptive statistics of my study, global EI showed, on average, higher EI scores in the internship group of students than in the group that had not performed an internship. This observation could indicate a tendency of positive direction in the differences of global EI, although too small to be statistically significant. As I could not find any reports in the literature on quantitative EI measures combined with internship experiences in engineering education, I did not have a direct comparison of the magnitude of findings in my study. Overall, the findings on global EI scores in this study may mean that future studies with EI measures in engineering education may place less emphasis on global EI measures and focus more on differentiating activities that are aligned with the specific EI domain that the interventive activity is supposed to target.

Differences in Domain EI for Emotionality

Emotionality is one of the four domains of Petrides's (2010) EI model, which describes the perception and expression of emotions in oneself and in others. Although findings on gender-related strengths and weaknesses in intra- and interpersonal EI domain competencies related to emotionality were not consistent in the literature, in my data, a statistically significant interaction between gender and internship participation regarding differences in emotionality was found. This result confirmed other findings in the literature in which Petrides's domain EI measure for emotionality was sensitive to gender association (see Petrides, 2009b). Alas, with the intercorrelation of gender and emotionality, main differences in emotionality between student groups with and without internships could not be singled out and interpreted accurately (see Laerd Statistics, 2018). Despite the intercorrelation of gender and emotionality, I found no statistically significant differences in EI domain scores for emotionality of students with and without internships in my study.

However, observations from descriptive statistics for emotionality differed from observations from other EI domain measures. As the EI domains for sociability, wellbeing, and self-control, as well as global EI scores, exhibited, on average, higher scores in the internship student group, the domain EI score for emotionality did not. The EI scores for emotionality stayed the same or were slightly lower in the group of students who participated in an internship, as noticed in the estimated marginal means graph for emotionality (see Appendix N) and in descriptive statistics in Table 6. Although the observation of little or no change in emotionality scores cannot be distinguished from *p*-values of statistical tests for group mean differences, the observed flat or possibly negative directional tendency may become of interest in future investigations as the scores exhibited different behavior than seen for all other EI measures in this study. This simple observation may initiate new research questions, for example, on how emotional sensitivity may impact work performance in engineering disciplines. Engineering is still considered a profession that is dominated by masculine stereotypical behavior (Antoniadou et al., 2020; Loweth et al., 2021), and emotionality has been viewed as a weakness in engineering industries (Ngwenya et al., 2019). In this context, the observation of a negative directional difference in emotionality scores for students with internships, even if small, in comparison to students without internships, may raise new questions on the practices in engineering industries and the experiences for undergraduate engineering students in engineering internships. The index of emotionality may hold new meaning in future research on the reality of engineering practice and whether engineering industry may discourage emotionality. Hence, this observation may initiate a new array of research questions and the EI domain measure for emotionality may gain importance in future research studies on engineering internships and engineering practice.

Further, the opposing directional behavior of emotionality compared to other EI domains in this study affiliated with reports in the literature that some EI domain measures were desired to be low instead of high. For example, high EI domain scores expressing overly emotional sensitivity (Wall et al., 2018), assertiveness (Abdullah et al., 2019), or aggressiveness (Nelson et al., 2017) were viewed as negative sides of EI, and desired scores were placed in the lower range. Negative implications of emotional sensitivity in adults have also become a recent topic discussed in the literature (Scott & Gans, 2022). My observation on the tendencies of the EI domain for emotionality may contribute more clues to this discussion. Furthermore, the potential advantages of lower emotionality levels have not been a focus in the context of Petrides's (2010) EI model, and this thought may initiate a new direction in the understanding of the EI domain of emotionality in Petrides's (2010) EI construct. Thus, my findings may lead to an extension of the existing literature through new discussions of low and high scores of emotionality. The observation of similar or slightly lower emotionality scores in the internship group may also mean that the question of whether internships play a role in adjusting emotional sensitivity in work situations for engineering graduates might become a topic that needs further investigation.

Differences in Domain EI for Sociability

Sociability was another domain of Petrides's (2010) EI construct and related to interpersonal skills in a social context. Social awareness, positive behavior in social relationships, and an ability to build social networks are part of Petrides's (2009b) EI domain for sociability. Contrary to the historical view that higher sociability was associated with females (Aloiseghe, 2018; Faulkner, 2000; Tonso, 2006), my study did not find a statistically significant correlation between gender and internships for differences in sociability. Because I had nearly a balanced number of male and female undergraduate engineering students who participated in my study and I did not find interaction between gender and emotionality in the two student groups, the widely spread perspective that engineering is a male profession and engineers are not social (see Loweth et al., 2021) was not supported by my findings. The common view is that engineers are less social than individuals from other disciplines because they devaluate interpersonal competencies while prioritizing technical knowledge as the core to engineering work, which reinforces the centrality of maleness in engineering (Loweth et al., 2021). However, I did not find a correlation between gender and sociability in my study; therefore, the topic of sociability in engineering will have to be further investigated in future studies. Besides no gender association, my analysis did not find statistically significant differences in sociability between students with and without internships.

Nonetheless, descriptive statistics for sociability showed higher scores, on average, in students with internships compared to those without (see Table 6). Again, the effect size was too small to be statistically significant in my tests, but the residual scatterplot distribution showed a distinct separation for each group, with a cluster for the "yes" internship group in the positive range and a cluster for "no" in the negative range (see Figure 3). These observations indicated a distinct group tendency of higher EI scores for sociability in the student group with an internship. As the plots and observations triggered my interest in further examining potential differences for sociability between the two student groups, I computed the statistics again with removed mild outliers from the sociability dataset. Extreme outliers may influence the results of MANCOVA tests (Statistics Solutions, 2020), and the non-internship student group for sociability was the only group in my dataset that exhibited a few mild outliers (see Appendix M). Although the outliers in my dataset for sociability scores were not considered extreme, through the removal of the mild outliers, the *p*-value of the statistical test went down compared to the results of the tests that included the mild outliers. Though *p*-values alone do not show the richness of data interpretations (Nahm, 2017), *p*-values closer to $p < .05$ may show a need for re-testing, for example, in my study, with a possibly better-defined sample population. Nevertheless, the results for differences in sociability scores between the student groups in my study remained not statistically significantly different ($p > .05$) with or without the mild outliers in my dataset.

Still, differences in sociability scores were observed in descriptive statistics and scatter plots of my results, although their effect size was too small to be statistically significant in the test statistics. A larger sample size may provide more insights into the observation that there was a small but clear difference in averaged sociability scores between the two student groups. Sociability scores for each group cluster also had a more distinct and noticeable separation than compared to any other domain scores (see Figure 3). Therefore, findings in my study suggested that the EI domain scores for sociability have a strong potential for further examination in the context of internships in engineering education. More studies are needed, probably best executed with a differentiated approach to target social situations in internships. As this was the first study in the literature that used EI measures for sociability in internships with undergraduate engineering students, the results and observations may lay the groundwork to select and target promising EI domains, such as sociability, and to extend the literature in understanding the learning outcomes of internships in engineering education.

Differences in Domain EI for Wellbeing

The third domain of Petrides's (2010) EI model was wellbeing, reflected as a generalized sense of the intrapersonal psychological state captured at a momentarily snapshot in one's life. According to Petrides (2010), wellbeing included the level of self-esteem based on past achievements and future expectations, as well as the ability to recognize and pursue new opportunities. Wellbeing has been associated in the literature with stress-management (Sanchez-Ruiz et al., 2021) and coping with fear of change (Warrier et al., 2021). Both attributes apply to undergraduate engineering students close to the transition into the workforce. Although descriptive statistics showed a small difference in means of wellbeing scores between the two student groups, the standard deviation was also higher than compared to the other domain scores in my analyses (see Table 6). The higher standard deviation of wellbeing scores in comparison to the magnitude of score differences between the student groups indicated that the differences between the two groups have a higher probability of being by chance. In addition, the main between-subject-effects test for wellbeing did not show a statistically significant difference for wellbeing between students with and without internships.

Overall, the non-significant findings on wellbeing in my study were contradictory to expectations based on literature that proposed learning experiences may strengthen the readiness for change (see Koç, 2019) and that internships may be viewed as activities that may lessen the fear of transition into the workforce (Myint et al., 2021). In my study, there was no difference in wellbeing scores between the group of students with and without internships when controlled for age and gender. A possible explanation could be that other factors of the internship did outweigh the benefits that internships may potentially have on wellbeing regarding pursuing new opportunities or preparing for the transition into the workforce. After all, the internship in engineering industries was a new situation for students as well, which came with its own stresses and fear of change effects. In conclusion, wellbeing was a measure with too many unknown factors and may not be a suitable measure to establish learning outcomes of internships in engineering education. The realization of the wellbeing measure being not a good fit for answering questions regarding the benefits of internships was fundamental for streamlining further research in engineering education using EI measures.

Differences in Domain EI for Self-Control

The last of the four domains in Petrides's (2010) EI model was self-control, reflecting the level of intrapersonal emotion regulation skill, including low impulsiveness and management of external pressures without being overly cautious. High levels of self-control also included the development of strategies to deal with external tension (see O'Connor et al., 2019). Just like for emotionality, I found a statistically significant interaction between gender and internships regarding group differences in self-control. This aligned with reports in the literature that females have been recorded to have higher competencies in self-management when adjusting to change in college (Qutishat, 2020). Furthermore, males in postsecondary technical programs have been found to score higher on an aggression scale with less intrapersonal control of impulsiveness (Bibi et al., 2020). With the significant intercorrelation of gender and internships for differences in self-control in my data, main differences in self-control between student groups with and without internships could not be interpreted accurately (see Laerd Statistics, 2018). In my study, I found no statistically significant differences in EI domain scores for self-control of students with and without internships, even with the intercorrelation of gender and internships for self-control scores.

Similar to scores of wellbeing and sociability, self-control measures exhibited, on average, higher scores in the internship student group in descriptive statistics (see Table 6). However, the difference was smaller than for sociability, and datapoints for self-control in the residual scatter plot were spread out evenly across the groups for "yes" and "no" internships lacking a visual separation by group (see Figure 3). Therefore, self-control scores were less likely to be useful as future measures for internship evaluation in engineering education, particularly as they have been confirmed by this and other studies in the literature to be correlated with gender association.

In summary, the key findings of this study were based on descriptive and observational data interpretation, with no statistically significant findings on differences in global and EI domain scores from undergraduate engineering students with and without internships when controlled for age and gender. As noted in the literature, global EI scores were confirmed to be not sensitive enough to detect fluctuating domain changes in EI development. Supporting this notion of competing directional development of EI domain competencies, domain scores for emotionality did not follow the same upward directional tendency as other domain EI scores in students with internships. The observation of the different behavior of emotionality scores may trigger new discussions on the benefits of low EI domain scores for emotionality in engineering practice and education and, also, for applications of Petrides's (2010) EI model in general. Future discussions on high or low emotionality may lead to new understanding of current and future perceptions of a holistic engineer with a substantial extension of new research topics in the existing literature on EI development, engineering education, and the benefits of internships. The EI domain scores for sociability, nevertheless, showed promising results as a measure to continue research on the benefits of internships in engineering education, particularly if assessment strategies can be designed that focus on social activities in internships. On the contrary, EI domain scores for wellbeing or self-control were found not to be suitable measures for assessment of outcomes and for research on the benefits of internship in future studies because wellbeing scores seemed to have too many confounding influences, and self-control scores could not be separated from gender influences. Thus, my findings can lead to an extension of the existing knowledge through the initiation of new discussions and new directions in research involving the benefits of internships in engineering education.

Limitations of the Study

The research design of my study had several limitations. As my study was a posttest-only-with-control-group design, it was limited in rigid group membership randomization compared to truly experimental studies (Trochim, 2005). At the time of data collection, engineering students already had completed an internship or had not participated in an internship in engineering industries. The student group without an internship served as a control group. Therefore, group membership was already established at the time of survey participation. The benefit of this research design was that participation in an internship was not influenced by study participation. However, pre-existing biases for group membership selection may have existed, for example, due to higher motivation in students who have completed an internship compared to those who have not. Also, my research design could not control for pre-existing differences in EI scores. A pre-test-post-test approach could have provided these adjustments but would have carried other limitations, such as history or maturation effects (see Pam, 2015). In my study, pre-test data were not available, and the posttest-only-with-control-group design provided an effective solution to balance internal and external validity (see Burkholder et al., 2016).

For the external validity of my study, high generalizability and transferability were accomplished by the inclusion of undergraduate students from all engineering disciplines and all engineering colleges across the U.S. Therewith, a relatively high diversity of population characteristics was assumed within my sample, which in turn minimized variations in the baseline of participants' characteristics (see Stronks et al., 2013). However, the limitation of this approach was that I did not collect any demographic data on the study participants and did not have any information on other characteristics of my sample population other than self-reported age and gender. The inclusion of multiple engineering disciplines also may have affected the study results by possibly disguising group differences that may exist in more specified engineering student cohorts separated by discipline. Nevertheless, this study was intended as an initial approach to generate an understanding of whether engineering students with and without internships exhibited different global or domain EI scores and to determine the directions for promising further research in this context.

Another limitation of this study was the way how results can be interpreted from the statistical analysis comparing group means between students with and without internships. A group means comparison does not provide evidence of a causal conclusion from the intervention (Warner, 2013). Therefore, my findings lacked the possibility of causal conclusions on the effects of internships, and non-statistically significant *p*-values for differences between students with and without internships did not necessarily mean that, generally, internships have no effect on EI development (see Nahm, 2017). Just my study with my population sample did not reveal results of statistically significant differences, which may result from many factors (Nahm, 2017). Conclusively, a closer look at the differentiation of the student sample, the EI scores, and the internship activities must occur in future studies.

Yet, the findings of my study provided observations that may lead the direction of asking further questions in a deeper and more specified quest to understand how internships work in engineering education. The tendencies and directions on how EI scores differed between the groups for specified domains, such as sociability or emotionality, may help to ask focused questions for future research studies, including an emphasis on social activities or situations that trigger emotional responses in interning students. In general, the lack of knowledge of specific circumstances for each internship was limiting in drawing conclusions on the effects of specific incidents or activities in the internship. However, internships in engineering education were highly regulated and had common learning objectives related to their targeted engineering industry (U.S. Department of Labor, n.d.), which allowed to make engineering internships universally comparable in this basic comparative research study without further qualitative exploration of each internship situation. In future studies, this limitation can be addressed by adding qualitative research components exploring the similarities and specifics in the internship environment.

Lastly, limitations of EI-construct and instrumentation may have existed in my study, as recorded EI scores were based on self-reported measures. Petrides (2009b) addressed the instrumentation limitation as desirable due to the EI construct being based on the inherent subjectivity of emotions that should be part of the assessment strategy to produce valid and applicable data. Furthermore, I confirmed the internal consistency and reliability of the EI measures in my data with Cronbach Alpha values (see Table 5) that were similar to published data using a standardized sample population (see Appendix H).

In summary, the trustworthiness of this study showed a good balance between internal and external validity, as suggested as a desired trade-off by Burkholder et al. (2016). The level of control over group randomization was moderate in this posttest-only-with-control-group design; however, the inclusion of a wide range of real-world professional settings in internships in engineering industries and across a diverse engineering student population sample benefitted the generalizability of my study. Furthermore, the results of this study were limited to interpretation of group mean differences and directional tendencies in descriptive statistical observations without taking into account environmental nuances of internship experiences that could indicate a possible causal conclusion. However, this study was not intended to provide comparative causal conclusions for internships but instead focused on the initial assessment of whether EI scores differed in undergraduate engineering students based on internship participation.

Recommendations

Recommendations for further research were based on study results and limitations of the study. In findings of my study, EI domain measures for sociability and emotionality appeared to be factors of most interest for further research on internships in engineering education. Therefore, my first recommendation is to focus additional research questions specifically on social learning opportunities in internships.

Additionally, and to further extract confounding variables in internships from various environmental influences in internships, I recommend qualitative research studies to understand how internships in engineering education may affect EI development, particularly in the domain of sociability and, also, in the domain of emotionality.

Emotionality appeared to be a particularly interesting new discussion topic in the world of engineering as more women have engaged in this profession in recent decades; yet, they seem to struggle to be retained in the engineering professions (Jones, 2022). Findings from this study confirmed the correlation between emotionality and gender by showing a statistically significant interaction effect between these variables. Furthermore, the definition of an appropriate level of emotionality in engineering professions has yet to be discussed in the literature, as emotionality is still perceived as weakness in engineering practice (Ngwenya et al., 2019) and the stigma associated with engineering professions is still primarily masculine, in which only the toughest can succeed (see Antoniadou et al., 2020). Besides, the need for emotionality has been skewed in the historical perception of an engineer, as emotions were considered counterproductive to cognitive thought processes and logical thinking (Kumar et al., 2019). Therefore, the topic of emotionality in engineering may, altogether, trigger a new research field in engineering education with many discussions. The findings of this study indicated that the same or lower emotionality scores may be exhibited in students after they were exposed to a real-world engineering work environment, for example, in internships, when compared to students who did not. Therefore, more research questions illuminating this topic are needed to understand the perspectives on emotionality in the engineering world and how to address emotionality expectations in engineering education.

Another recommendation is related to the sample population. In this study, small effect size differences in EI scores were observed in descriptive statistics, although not statistically significant in the chosen student sample population. Therefore, I recommend conducting more studies with either a larger student sample size or with a differentiated student population by engineering disciplines. Skipper et al. (2017) showed differences in EI scores between students of different engineering disciplines. Thus, this study could be replicated with only bioengineers or computer engineers, for example, to determine if statistically significant differences may be found based on internship participation in a specified engineering field. Results may also contribute to further knowledge about baseline EI scores in students of various engineering disciplines and, in comparison to nontechnical disciplines.

Moreover, the limitations of only working with post-test data may be addressed by creating longitudinal research studies with undergraduate engineering students that compare pre-internship and post-internship scores for EI. This methodology could also address some questions on causal conclusions on the effect of internships on EI development in engineering education. Complemented by qualitative research components, such as student interviews, a mixed-method research approach may be the most comprehensive continuation in this research area to understand how internships affect undergraduate engineering students' competencies. In addition, such an approach may provide some insights on specific learning activities within the internship that had the most impact on engineering students' EI development.

Lastly, other EI measures can be employed to capture EI development in undergraduate engineering students. Some EI instruments conceptualize EI as transformative through a set of skills and social-emotional abilities that should be taught and learned in education. For example, EI assessment instruments developed by Nelson et al. (2017) have been used with college students to develop EI skill acumen in person-centered ways. One such instrument is the Emotional Skills Assessment Process (ESAP; Nelson & Low, 1998). With a transformative EI instrument, EI domains that need improvement or need more control can be identified in undergraduate engineering students with and without internships. Comparative results may provide more understanding of how specified domains are affected by activities, such as internships, particularly, when a pre-and post-test research design can be utilized. Follow-up studies with a transformative EI instrument may not only provide further knowledge on EI development in engineering students, but also may positively affect participating students in the process. Finally, concurrently using multiple EI instruments that conceptualize the EI differently in a correlation study that also compares the EI scores of students with and without internships could help clarify the validity of the construct in terms of its value for assisting in the meaningful development of undergraduate engineering students.

Generally, this study provided the first approach to understand whether EI differs in undergraduate engineering students when participating in a voluntary internship. Results are promising to initiate a new line of EI-related research in conjunction with internships in engineering education. The findings of this study also determined the focus of recommended follow-up research studies.

Implications

This study may contribute to positive social change in several ways. As little is understood about how internships in engineering education assist the successful transitions of undergraduate engineering students into the workforce through EI development, this was one of the first studies in the literature that used an EI measurement in conjunction with internships and engineering students. Following the recommendations of Gillespie et al. (2020), who indicated a positive relationship between internship participation and a number of psychosocial factors, including EI, based on an integrative literature review, the findings of this study provide guidance for future research in this area with this initial basic quantitative approach. Results from this introductory study indicated a need for further research on how internships may affect sociability and emotionality in engineering students.

Besides research, this study may also advance knowledge in the field of higher education, leadership, and policy, because there is a potential for change at the organizational level of universities in curriculum development as more is understood of the effects of internships as an educational model in engineering education. First, observations from this initial basic study and related recommended follow-up studies will help to expand on what is understood about the benefits of internships for students in engineering industries. Second, this study indicated the usefulness of internships as practical strategies for engineering students to potentially boost EI domain competencies in sociability in engineering disciplines. On the contrary, observational findings in this study possibly indicated that practical experiences in engineering internships may have a tendency to produce lower scores related to emotionality, which raises more questions about whether this potential effect may be related to lingering maleness issues in the engineering field (see Loweth et al., 2021) or may be interpreted as a development to help engineering students adjust to the reality in the engineering workforce. Both EI domains, sociability and emotionality, have been highlighted in this study as competencies that stakeholders and policymakers in postsecondary engineering education need to be aware of. As engineering education is still primarily focused on technical content (Antoniadou et al., 2020), the awareness of the need to include social and emotional components in engineering education, as well as the possibility that internships may help to serve this need, carries the potential to lead to long-term social change in undergraduate engineering education. In addition, this new research direction may pose challenging questions regarding societal views of the modern engineer (see Loweth et al., 2021).

Lastly, this study may initiate discussions on how EI, particularly in the domain of emotionality, is viewed in engineering professions and how it may differ between the perceptions of undergraduate engineering students and the performance expectations of engineering employers. Findings may contribute to positive social change by better understanding how best to educate tomorrow's holistic engineers, thereby decreasing the performance expectation gap between engineering graduates and employers (see Hirudayaraj et al., 2021). Furthermore, this study contributed to the understanding of the impact of internships in engineering education as educational models that have the potential to address the skill gap between the academic preparation in engineering education and changes in workforce expectations posed on the 21st-century engineer (see Gilar-Corbi et al., 2018). Observations from this study may lay the ground to initiate questions on the level of acceptance of social-emotional competencies in postsecondary engineering education and in engineering professions in general.

Conclusion

This basic quantitative research study investigated whether EI scores of undergraduate engineering students differed based on the voluntary participation in an internship in engineering industries when controlled for age and gender. It was the first approach to use EI measures on undergraduate engineering students in conjunction with internships as educational models in postsecondary engineering education. Although the results of this study did not reveal statistically significant differences in EI scores between engineering students with and without internships, observations on the existence and direction of small differences in EI scores in engineering students with and without internships provided fundamental insights into new areas of research in engineering and engineering education. One example was the observation that averaged EI domain scores for emotionality may not develop like other EI domains when students were exposed to a real-world engineering work environment and may even be lower in students who have participated in an internship in engineering industries. Although not confirmed with my statistical analyses, this observation initiates the need for further investigation and raises questions about the understanding and acceptance of emotionality in engineering practice. Besides, other EI domains, for example, targeting sociability, showed a possibility of being useful as a new measure of internship outcomes in engineering education. Ultimately, this study added knowledge to the understanding of the impact of internships in engineering education and how to measure them, therewith, providing another puzzle piece in the changing needs to educate holistic engineers of the future and to close the performance expectation gap of engineering graduates and engineering employers. In addition, and most importantly, the findings of this study may initiate the investigation of the understanding, the acceptance, the need, and the challenges of developing social-emotional competencies in engineering education and in engineering practice.

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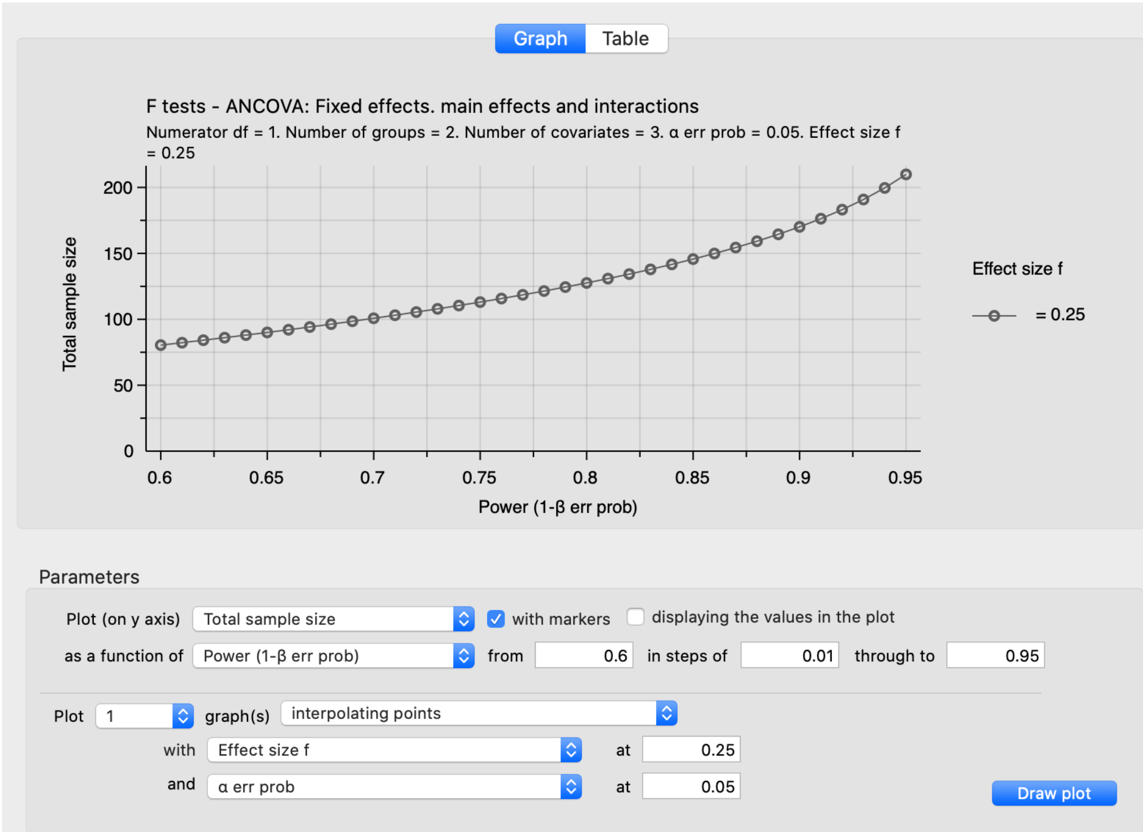
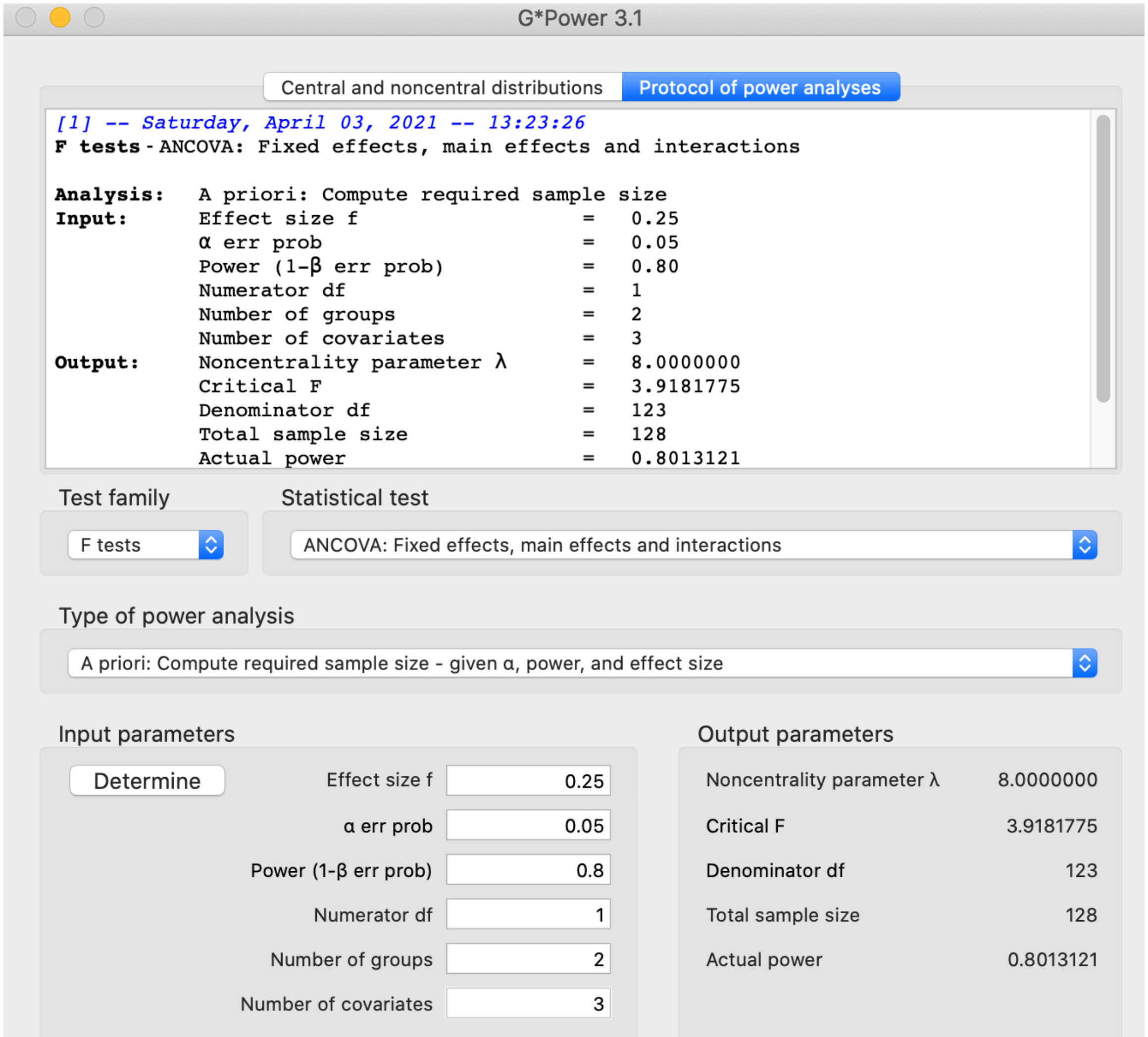
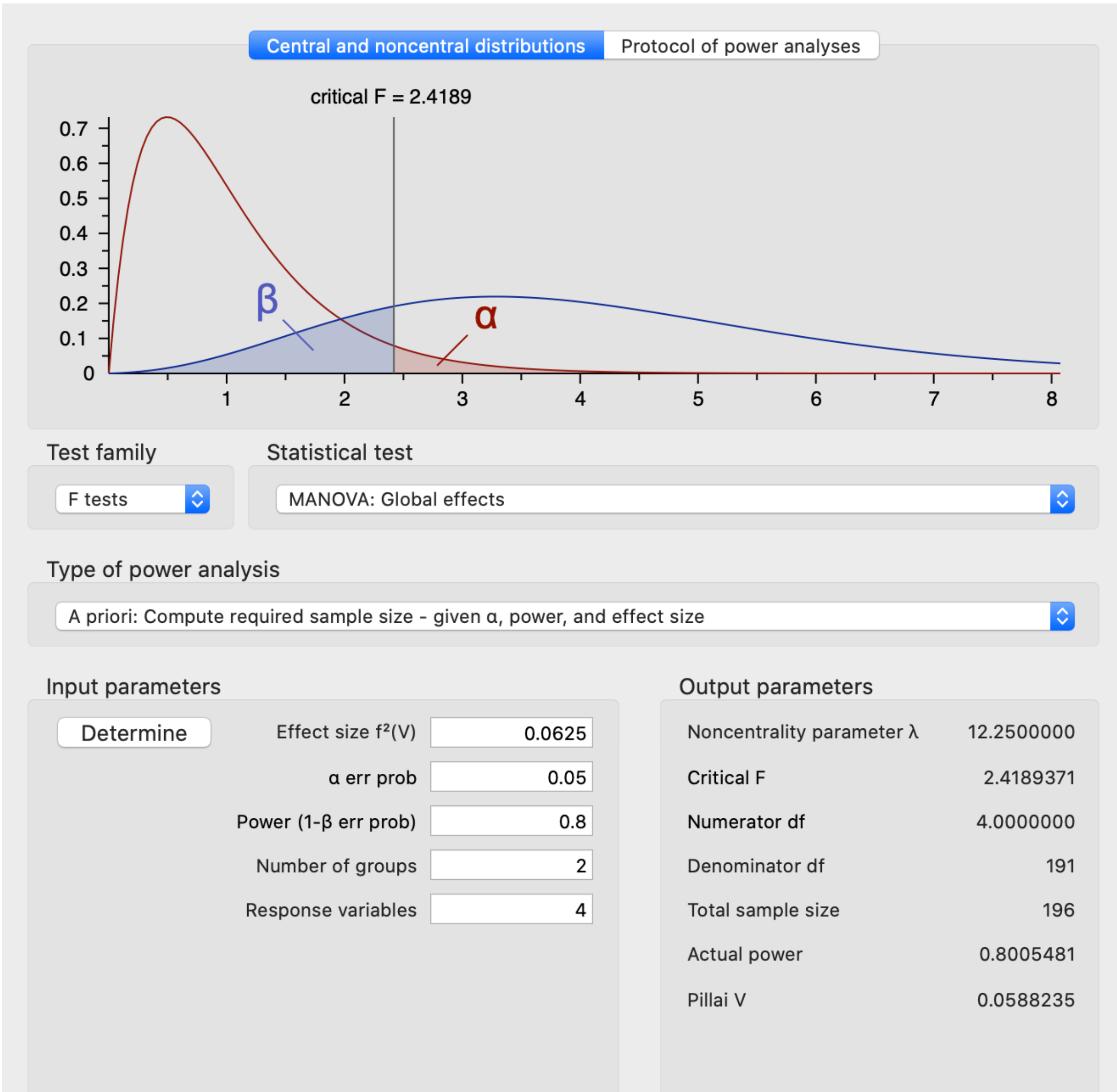
Appendix A: G*Power Graph for Medium Effect Size Ranges for ANCOVA



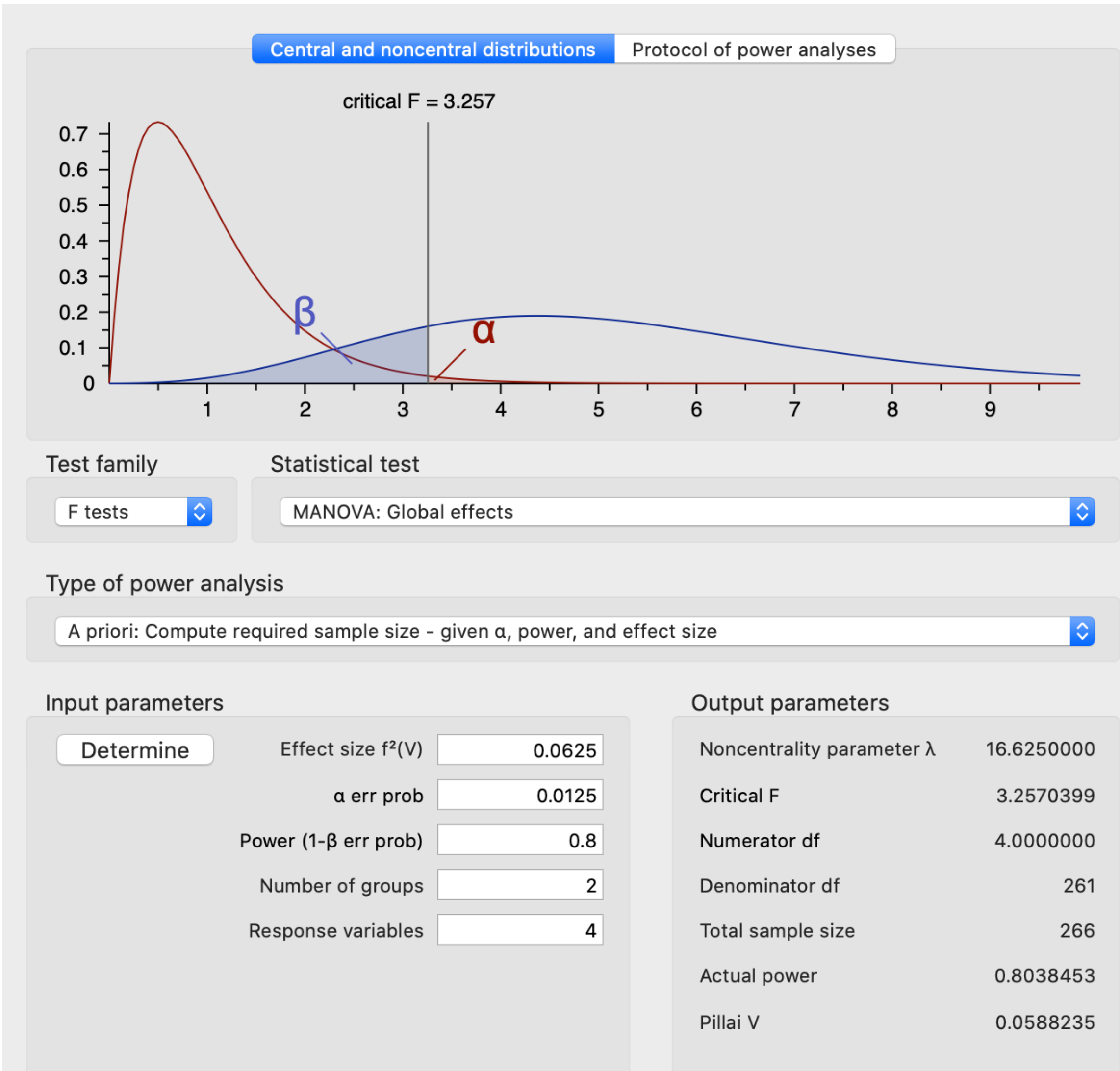
Appendix B: G*Power Output for Minimum Sample Size at Power .08 for ANCOVA



Appendix C: G*Power Graph for Minimum Sample Size for MANOVA



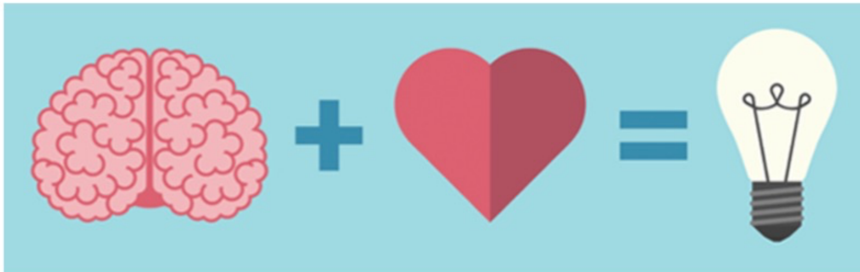
Appendix D: G*Power Graph for Minimum Sample Size for MANOVA with Bonferroni Correction



Appendix E: List of Student Chapters of Targeted Engineering Societies

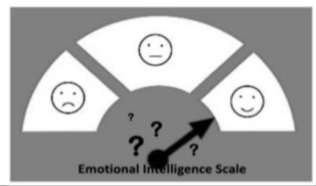
- BMES: Biomedical Engineering Society, https://www.bmes.org/students
- ISPE: International Society for Pharmaceutical Engineering, https://ispe.org/about
- ACM: Association of Computing Machinery, https://www.acm.org
- PIB: Project in a Box, https://www.pibucsd.org
- UBIC: Undergraduate Bioinformatics Club, https://ubicucsd.github.io
- IEEE: Institute of Electrical and Electronics Engineers, https://www.ieee.org
- Student Honor Society of IEEE: Eta-Kappa-Nu (Kappa-Psi Chapter), https://hkn.ieee.org
- SHPE: Society of Hispanic Professional Engineers, https://www.shpe.org/students/student-chapters
- NSBE: National Society of Black Engineers, https://www.nsbe.org/home.aspx
- SWE: Society of Women Engineers, https://swe.org
- SEDS: Students for the Exploration and Development of Space, https://seds.org
- Tau-Beta-Pi: Premier Engineering Honor Society, https://www.tbp.org/recruit/recruitHome.cfm
- ASEE: American Society for Engineering Education, https://www.asee.org

Appendix F: Study Announcement Image and Infographic Scheme



A Study with Engineering Students.

Looking for
Undergraduate Engineering Students
to volunteer 10 minutes of their time to complete an anonymous emotional intelligence online survey.

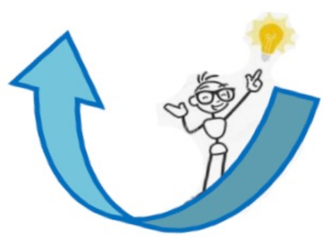


This survey is part of the doctoral study for Isgard Hueck, a Ph.D. student at Walden University
[redacted]

To participate in this study, you must be **18 years or older** and currently **enrolled in a 4-year undergraduate engineering degree program.**

CLICK HERE to LEARN MORE

https://www.surveymonkey.com/r/LEARN_MORE



Appendix G: Permission to Use Petrides's EI Instrument and Scoring Key

Dear Isgard

Thank you for your email. I have just sent you the Paypal invitation. You do not need permission to use the Trait Emotional Intelligence Questionnaire (TEIQue) for academic research, provided it is strictly for non-commercial purposes and no individualized feedback is given to respondents. Please also see our FAQ at http://psychometriclab.com/faq/

You can download the various TEIQue forms from the same website (see menu on the left), which also incorporates an automated on-line scoring system for the TEIQue and TEIQue-SF. The scoring key for the TEIQue-SF and TEIQue-ASF is exactly the same and both forms can be scored via the online scoring engine that is available on the website (www.psychometriclab.com). You can also download the scoring key from http://psychometriclab.com/scoring-the-teique/

Please note that we cannot provide any additional support beyond what is already on the website, although you can join us on our social media below.

I hope this helps and may I take this opportunity to wish a very Merry Christmas and Happy New Year!
Konstantinos Petrides

K V Petrides BBA DipPsych MSc PhD CPsychol AFBPsS

UCL | *Professor of Psychology and Psychometrics* University College London | *Founding Director* London Psychometric Laboratory

Subject: RE: TEIQue Technical Manual and Permission to reprint one of your figures for my dissertation.
From: "Petrides, Konstantinos" [redacted]
Date: Sat, Jul 02, 2022 3:51 am
[redacted]

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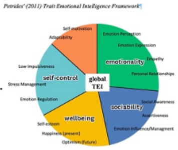
Figure 1

Petrides' (2011) Trait Emotional Intelligence Framework



Note. The 15 facets of TEI are positioned with reference to their corresponding EI domains. Two facets do not relate to any domain and are referenced under the global EI only. Figure 1 is modified after graphics by Petrides (2009b), *Technical manual for the Trait Emotional Intelligence Questionnaires (TEIQue)* (1st ed.). London Psychometric Laboratory.

Dear Ms Hueck

Thank you for your email and request, which is hereby granted. Kindly include in your work the following copyright notice:

"Figure reprinted with permission from London Psychometric Laboratory – www.psychometriclab.com by K. V. Petrides. © Copyright K. V. Petrides 1998 – . All rights reserved. "

I wish you the best of luck going forward
Konstantin

K V Petrides BBA DipPsych MSc PhD CPsychol AFBPsS

UCL | *Professor of Psychology and Psychometrics* University College London | *Founding Director* London Psychometric Laboratory

Dear Dr. Petrides,
Thank you for sending me your technical manual for the TEIQue. I used the short version to collect data for my dissertation. I modified your figure on the faucet and domains from your EI model and created a figure that I would like to use in my dissertation. I attach the modified figure to this email for your review. As I am now very close to finalizing my dissertation, I need to show proof of permission to use this modified figure in my document.
Can you please give me permission to reprint your figure in the modified version in my dissertation.
An email response will be sufficient on this matter.

Sincerely and with many thanks,
Isgard

Isgard Hueck
Ph.D. candidate (ABD), Walden University, USA

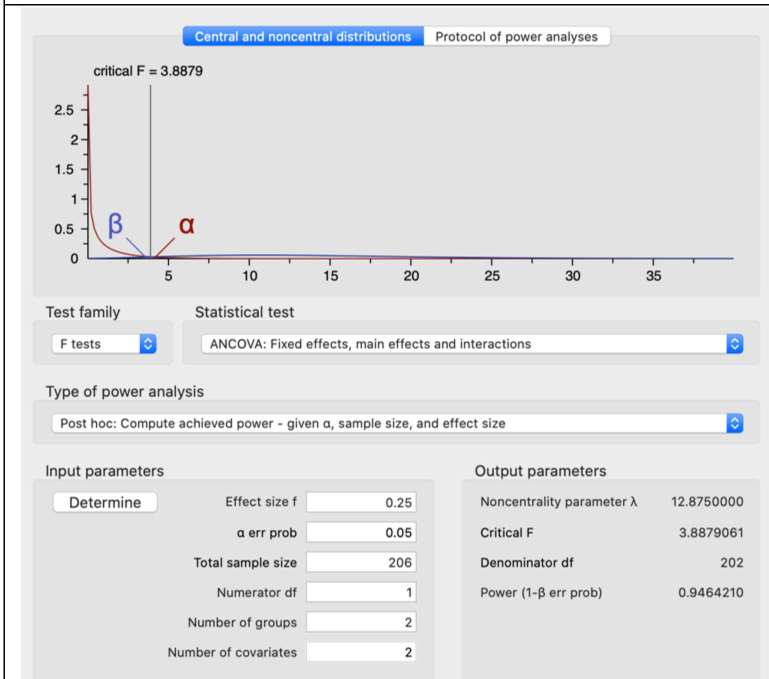
Appendix H: Cronbach Alpha Values for Standardized Sample Population

	Mean	SD	Cronbach's a	No. of items
Well-Being	5.43	1.01	.80	6
Self-Control	4.62	0.94	.65	6
Emotionality	5.25	0.90	.73	8
Sociability	4.97	0.88	.69	6
Global trait EI	5.11	0.89	.88	30

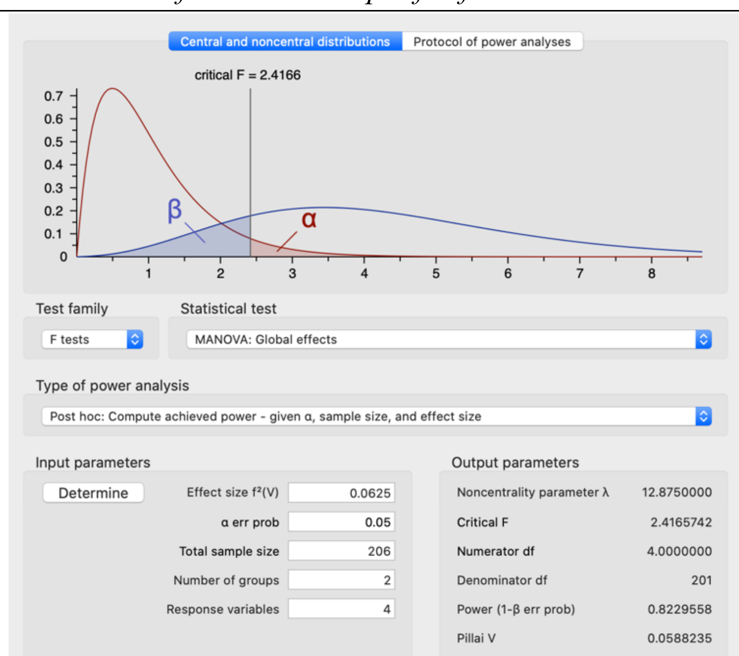
Note. According to Petrides (2009b), measures on EI values for global and domain EI scores showed sufficient internal consistency and reliability based on a standardized sample population of 1721 individuals. Image taken from Petrides and Furnham (2006).

Appendix I: G*Power Post Hoc Tests for Given Sample Size of 206 Participants

Power of Statistics Output for Global EI



Power of Statistics Output for four Domain EIs



Appendix J: Univariate Tests for the Justification of Covariates

Tests of Between-Subjects Effects (N = 206)	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Global EI						
Corrected Model	8.246[a]	17	.485	1.014	.445	.084
Age	4.436	9	.493	1.030	.417	.047
Gender	.181	1	.181	.378	.539	.002
Age * Gender	2.992	7	.427	.894	.513	.032
Error	89.917	188	.478			
Corrected Total	98.164	205				
Sociability						
Corrected Model	21.611[b]	17	1.271	1.744	.038	.136
Age	18.630	9	2.070	2.840	.004*	.120
Gender	.217	1	.217	.297	.586	.002
Age * Gender	.717	7	.102	.141	.995	.005
Error	137.037	188	.729			
Corrected Total	158.647	205				
Emotionality						
Corrected Model	12.156[c]	17	.715	.991	.470	.082
Age	1.830	9	.203	.282	.979	.013
Gender	3.857	1	3.857	5.346	.022*	.028
Age * Gender	6.530	7	.933	1.293	.256	.046
Error	135.643	188	.722			
Corrected Total	147.799	205				
Self-Control						
Corrected Model	19.807[d]	17	1.165	1.545	.083	.123
Age	5.826	9	.647	.858	.563	.039
Gender	.239	1	.239	.316	.574	.002
Age * Gender	6.080	7	.869	1.152	.333	.041
Error	141.767	188	.754			
Corrected Total	161.574	205				
Wellbeing						
Corrected Model	24.501[e]	17	1.441	1.453	.116	.116
Age	15.264	9	1.696	1.710	.089	.076
Gender	.513	1	.513	.517	.473	.003
Age * Gender	6.737	7	.962	.970	.454	.035
Error	186.478	188	.992			
Corrected Total	210.979	205				

a. R Squared = .084 (Adjusted R Squared = .001)
b. R Squared = .136 (Adjusted R Squared = .058)
c. R Squared = .082 (Adjusted R Squared = -.001)
d. R Squared = .123 (Adjusted R Squared = .043)
e. R Squared = .116 (Adjusted R Squared = .036)
f. Computed using alpha = .05*

Appendix K: Frequency Distribution of Covariates and Internship Participation

Table K1

Descriptive Statistics of Age, Gender, and Internship Group Distribution (N = 206)

		Internship (yes=1, no=2)	Age	Gender (M=0, F=1)
N	Valid	206	206	206
	Missing	0	0	0
Mean			20.67	
Median		2.00	21.00	0
Mode		2	21	0
Std. Deviation			1.663	
Variance			2.767	
Range		1	9	1
Minimum		1	18	0
Maximum		2	27	1

Figure K1

Bar Charts for Age, Gender, and Internship Group Distribution (N = 206)

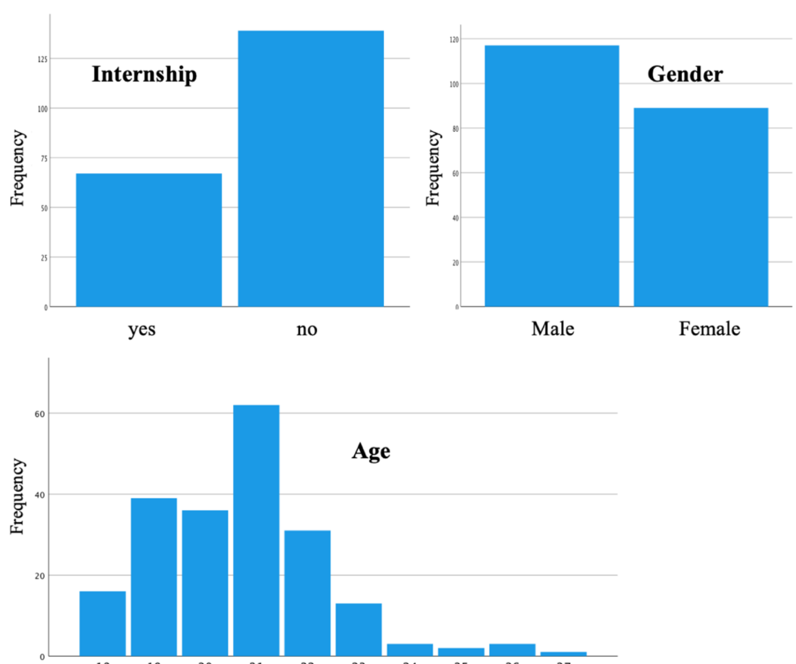


Table K2

Frequency Distribution for Age, Gender, and Internship Group Distribution (N = 206)

		Frequency	Percent	Valid Percent	Cumulative Percent
Internship	yes	67	32.5	32.5	32.5
	no	139	67.5	67.5	100.0
	Total	206	100.0	100.0	
Gender	Male	117	56.8	56.8	56.8
	Female	89	43.2	43.2	100.0
	Total	206	100.0	100.0	
Age (in years)	18	16	7.8	7.8	7.8
	19	39	18.9	18.9	26.7
	20	36	17.5	17.5	44.2
	21	62	30.1	30.1	74.3
	22	31	15.0	15.0	89.3
	23	13	6.3	6.3	95.6
	24	3	1.5	1.5	97.1
	25	2	1.0	1.0	98.1
	26	3	1.5	1.5	99.5
	27	1	.5	.5	100.0
	Total	206	100.0	100.0	

Appendix L: Multivariate Normality Tests

Figure L1

Histogram for Global EI Score Distribution (N = 206)

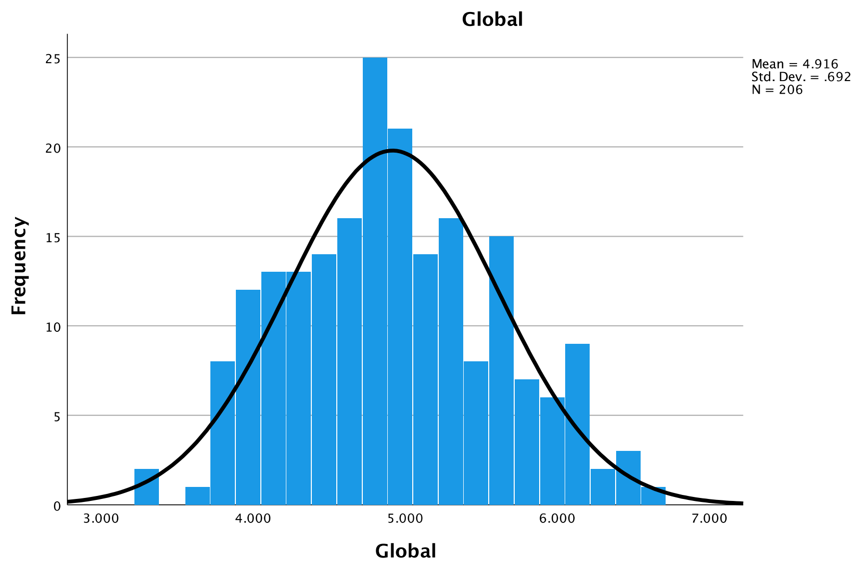


Figure L2

Histogram for Emotionality EI Score Distribution (N = 206)

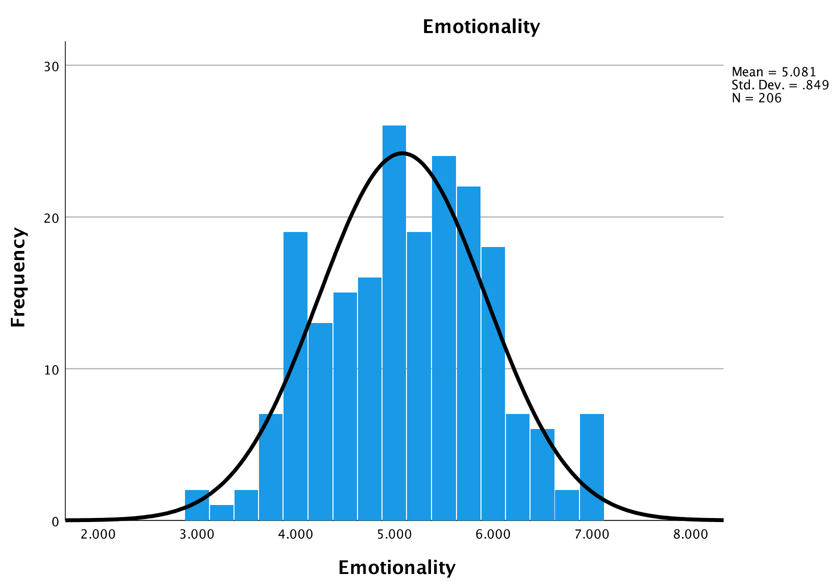


Figure L3

Histogram for Sociability EI Score Distribution (N = 206)

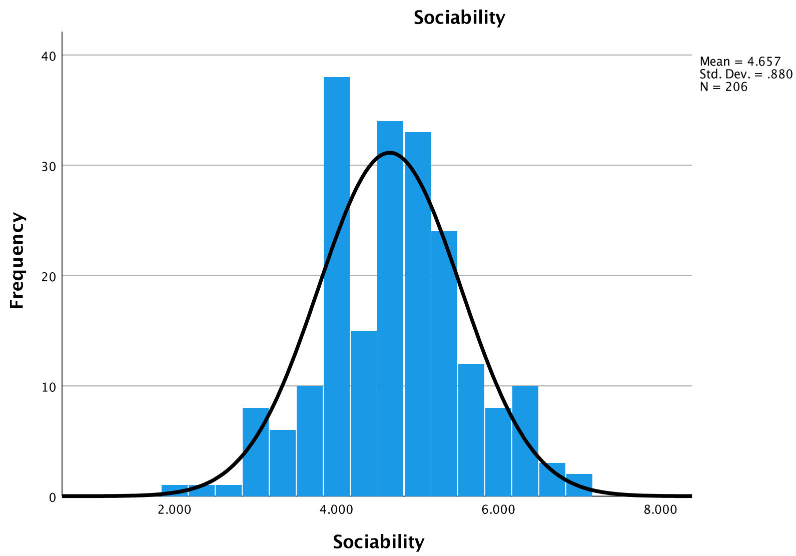


Figure L4

Histogram for Self Control EI Score Distribution (N = 206)

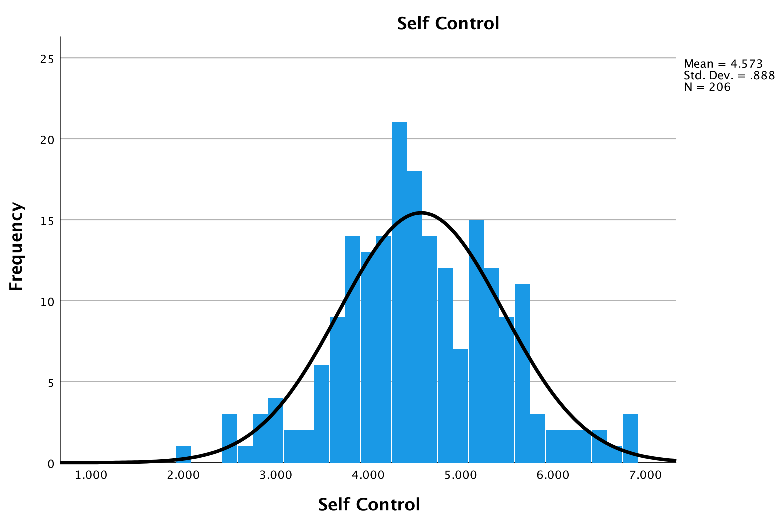
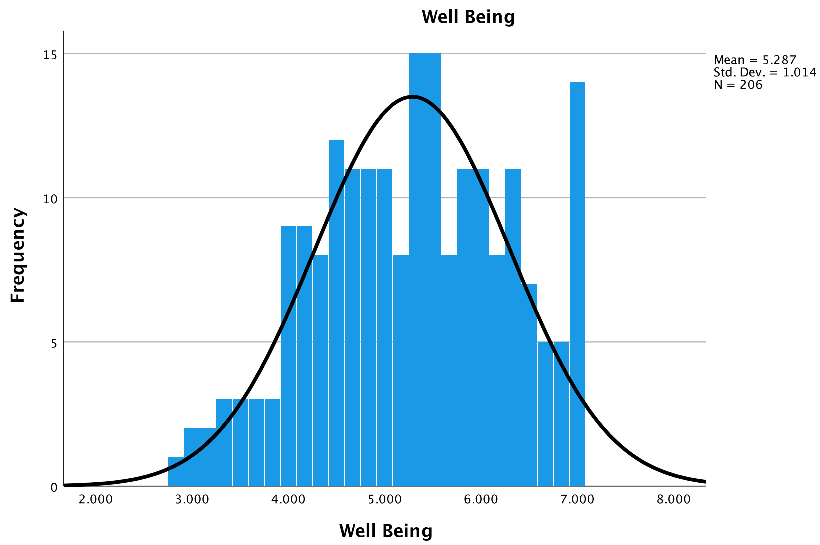


Figure L5

Histogram for Well-Being EI Score Distribution (N = 206)



Note. Well-being scores show a small diversion from normality in the "without internship" group, as noticed in the statistically significant result of the Shapiro-Wilk test (see Table L1) and a higher frequency at the upper end of the histogram.

Table L1

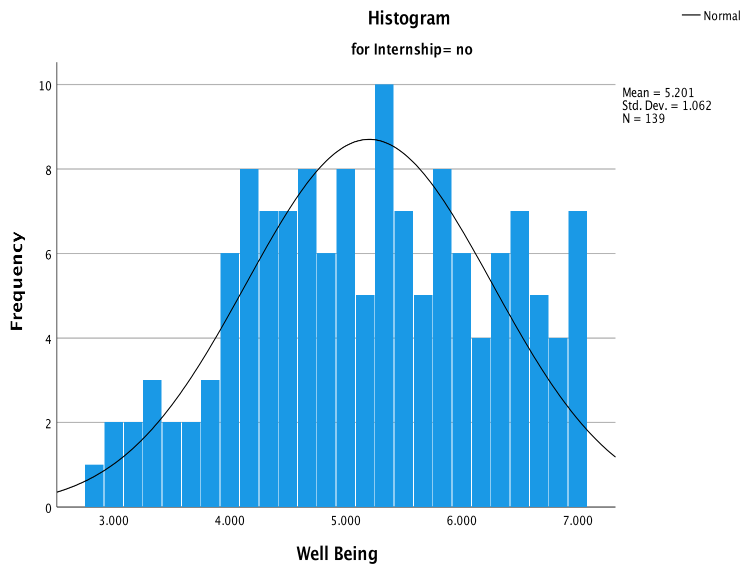
Shapiro-Wilk Test of Normality

	Internships	Statistic	*Df*	Sig.
Well-Being	Yes	.973	67	.156
	No	.975	139	.011*
Emotionality	Yes	.985	67	.597
	No	.988	139	.263
Sociability	Yes	.990	67	.885
	No	.987	139	.220
Self-Control	yes	.982	67	.451
	no	.989	139	.307
Global EI	yes	.977	67	.239
	no	.987	139	.213

Note. *This is a lower bound of the true significance.
a. Lilliefors Significance Correction

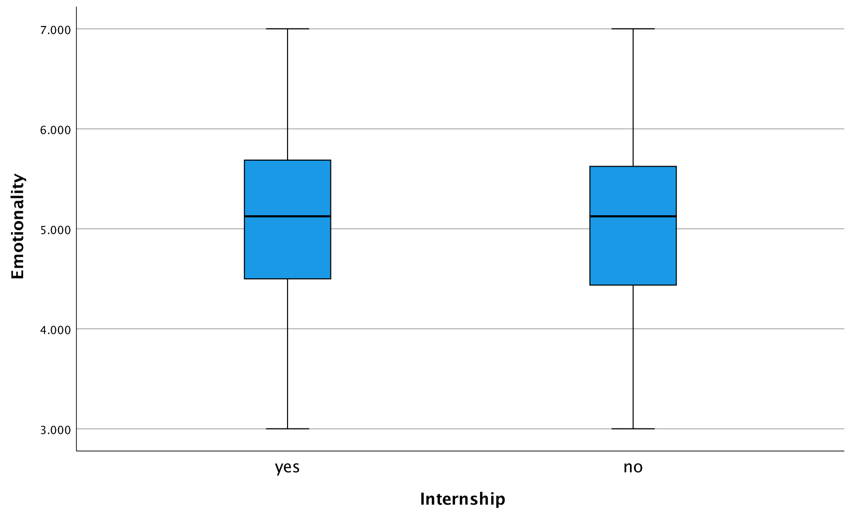
Figure L6

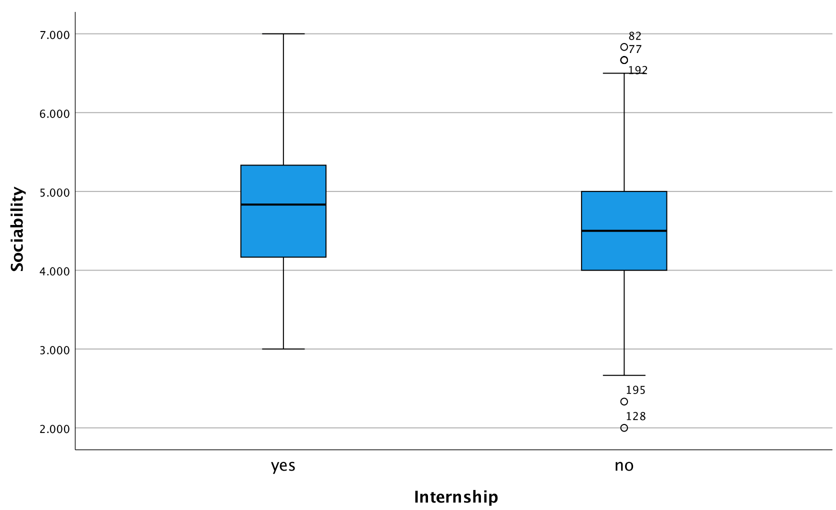
Histogram for Well-Being Domain Scores for the "No" Internship Group Only (N = 139)

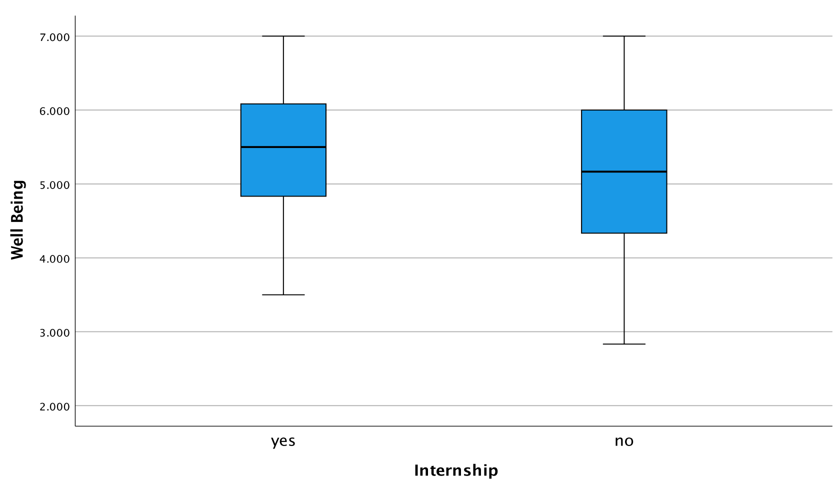


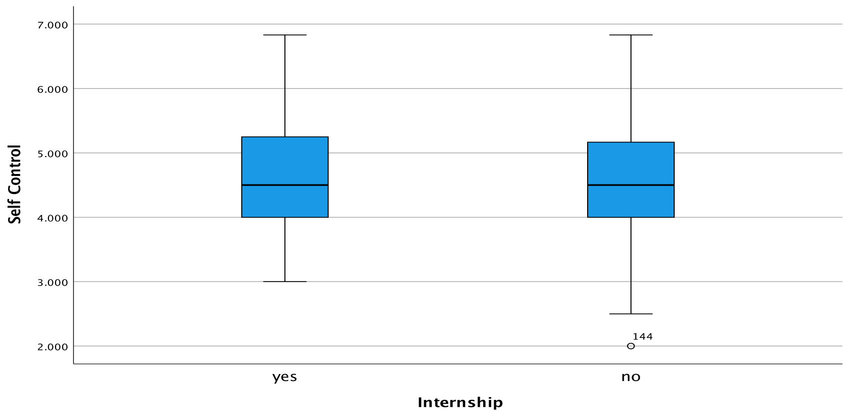
Note. A follow-up histogram of the "without internship" group distribution showed overall normal distribution by visual inspection

Appendix M: Boxplots for EI Measures

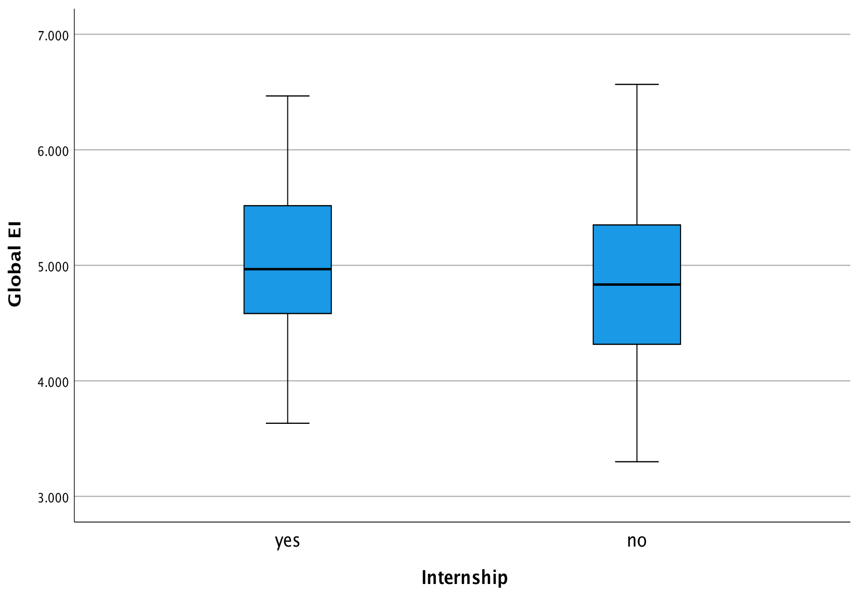








7.000
6.000
5.000
4.000
3.000
2.000
Self Control
144
yes
no
Internship



7.000
6.000
5.000
4.000
3.000
Global EI
yes
no
Internship

Appendix N: Trend Data for Differences in Emotionality and Sociability