The Impact of Entrepreneurship Education on the Development of Entrepreneurial Intention Among Engineering Students: The Mediating Role of Entrepreneurial Mindset and Self-Efficacy.

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Abstract

This thesis explores how entrepreneurship education (EE) influences the development of entrepreneurial intention (EI) among engineering students, specifically examining the mediating roles of entrepreneurial mindset (EM) and entrepreneurial self-efficacy (ESE). Considering the growing global importance of innovation and entrepreneurial skills, the study investigates the degree to which EE enhances EI by fostering EM and strengthening ESE. Using a quantitative survey of 431 engineering students at York University's Lassonde School of Engineering, the study applied structural equation modeling to examine the direct and indirect effects of EE on EI through EM and ESE. Our findings show that EE significantly enhances EI, with both EM and ESE positively mediating this relationship. In this research, we investigated the impact of entrepreneurship education on entrepreneurial mindset and on entrepreneurial intention. In reality this relationship is more complex, and causality might be in the opposite direction. Future research should investigate the interplay between these entrepreneurial components and the iterative nature of their evolving relationships. This highlights the value of integrating EE into engineering curricula to develop the EM needed in today's technology-driven world. The research contributes to existing literature by quantifying EE's impact on EI and offers practical implications for educational policy and curriculum development, advocating for the continued inclusion of EE to effectively prepare engineering students for entrepreneurial careers and foster economic innovation and growth.

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1.Introduction

Despite increasing interest in promoting entrepreneurship within engineering, there is a lack of research on the specific ways this can be achieved. Therefore, this study examines the interconnected relationship between three key aspects of entrepreneurship: entrepreneurial education (EE), entrepreneurial mindset (EM), and entrepreneurial intention (EI). This research critically examines the impact of EE on fostering an EI among engineering students, centering particularly on the mediating role of EM and entrepreneurial self-efficacy (ESE). In an era where innovation and entrepreneurial skills are increasingly valued across the global economic landscape, EE emerges as a pivotal educational strategy. EE is described as a university-level course that imparts both theoretical and practical aspects of entrepreneurship (Ginanjar, 2016).

EI reflects a personal commitment to becoming an entrepreneur, beyond traditional career paths or professional identities, as described by (Ullah et al., 2021). EI is also described as a mental orientation, including desire, wish, and hope, that can influence an individual's decision to pursue entrepreneurship (Peng et al., 2013). Higher education institutions must play an essential role in engaging students for entrepreneurial careers and enhancing their skills for entrepreneurship activities. EE programs have seen a swift and widespread increase across higher education institutions worldwide (Karlidag-Dennis et al., 2020; Zaring et al., 2021). For students who are relatively new to entrepreneurship, engaging in EE typically yields positive outcomes. Participation in these programs generally enhances students' EI, self-efficacy (SE), and attitudes (Fayolle & Gailly, 2015). Cultivating an EM among engineering students is essential for thriving in today's dynamic, technology-driven market, as it not only fuels innovation and sustainable economic development but also equips students with creativity and self-confidence, making them highly valuable in the global marketplace—regardless of whether they pursue startups or other career paths (João & Silva, 2018; Nowiński et al., 2019; Wegner et al., 2020).

Despite the recognized importance of EE in enhancing entrepreneurial skills and intentions broadly, the literature reveals a notable gap in understanding the direct effects of EE on EM and EI among engineering students, as well as the impact of EM and EI on who chooses to pursue EE. The backbone of the global economy is entrepreneurship, and engineers play an essential role by finding solutions for big problems and creating innovative and novel solutions. Today's job market

increasingly demands multidisciplinary engineers with entrepreneurial skills, particularly in light of high unemployment rates. Hence, educating engineers faces a lot of new challenges, such as equipping engineers with entrepreneurship (Barba-Sánchez and Atienza-Sahuquillo, 2018). Unfortunately, training entrepreneurship in the engineering faculty is rare. Therefore, equipping engineering instructors with strategies and tools that allow them to educate the EM is essential (Bosman et al., 2018). Engineers have to develop their EM because entrepreneurship is an essential part of the economy (Bosman and Fernhaber, 2019). Our society needs individuals with entrepreneurial merits because they keep society and the economy vibrant with their new ideas. EE can support the process of developing these entrepreneurship competencies (Lindner, 2018). While some define entrepreneurship narrowly as business creation, the concept encompasses a broader set of skills and mindsets applicable across disciplines. EM and skills are practical in all majors. If engineers learn to enhance their EM, they can approach their jobs differently. Among the tools that foster an EM, design thinking has emerged as a powerful method. Engineers can solve their problems by using the design thinking method, which is one of the most important components of the EM. Design thinking, a creative and innovative approach to problem-solving, helps engineers divide their problems into several small sections and solve each of them progressively (Commarmond, 2017). Furthermore, the design thinking method is recognized as a practical strategy not only for fostering an EM but also for innovative thinking and developing creativity in young people (Zupan et al., 2018).

Additionally, there is a lack of insight into how SE specifically mediates these outcomes. This oversight is significant as SE is essential for students to apply their learned entrepreneurial skills effectively (Bandura & Wessels, 1997). It also underestimates the potential of EE to enhance the application of these skills, particularly in a field that emphasizes problem-solving and innovation. Although the learning processes for students and entrepreneurs differ due to the students' limited initial entrepreneurial experience, the importance of experimentation in EE remains significant (S. Mueller, 2012).

This thesis aims to fill this gap by empirically investigating one aspect of this complex relationship how EE can influence engineering students' EIs, strengthen SE, and help develop a robust EM, thereby contributing effectively to both economic growth and innovation. As a result, recent emphasis has been placed on integrating EE within engineering programs as a strategic approach

to strengthen the connection between the field and innovation (Byers et al., 2013). EE not only imparts knowledge through traditional curricular methods but also a variety of extracurricular activities, effectively boosting students' SE. Additionally, skills in communication and persuasion are developed through engaging students in speech competitions, roadshows, and similar events. An EM is a "way of thinking" that leverages the positive aspects of uncertainty to create a competitive advantage (Ireland et al., 2003). It refers to the capacity to recognize and capitalize on opportunities independently of the resources one currently possesses (McMullen & Kier, 2016). It is a combination of motivations, skills, and thinking patterns that set entrepreneurs apart from non-entrepreneurs (M. H. Davis et al., 2016). Furthermore, through hands-on field studies, EE aims to inspire students and help them envision success and entrepreneurial achievement in their future careers (M. Kim & Park, 2018; Nabi et al., 2018).

Economic and workforce changes have led engineering schools to consider adding EE to their offerings. While EE is considered a valuable addition to engineering studies, the level of its integration into modern students' programs is poorly documented (Duval-Couetil et al., 2012). It is now more critical than ever to foster an EM and intention in engineering students through effective EE. Given the paramount importance of innovation and entrepreneurial skills in the rapidly changing global economy, EE serves as a key educational approach, empowering students with technical skills, an EM, and the SE to translate ideas into real-world solutions. Significant research supports the notion that EE extends beyond the mere act of starting a business; it is fundamentally about fostering a deep-seated EM characterized by the energy and passion required to develop and implement innovative ideas and solutions (Kuratko, 2005). This mindset is essential not only for business creation but also for enhancing the creative and self-confidence aspects of students, making them invaluable in various marketplaces (Fayolle et al., 2006). Moreover, the relationship between EE and EI is well documented. According to (Hoang et al., 2020) EE significantly influences EI by enhancing SE. By highlighting the mediating influence of SE in converting educational experiences into entrepreneurial action, this study seeks to demonstrate the transformative potential of EE in shaping the next generation of innovative engineers.

2. Literature Review

2.1 The Impact of Entrepreneurship Education on Economic Growth and Job Creation

Given the societal and individual value of entrepreneurial engineers, it is important to examine how EE supports their development, which prepares them for business creation and economic innovation. EE is increasingly recognized as a critical driver for economic development, contributing significantly to economic welfare and innovation globally (Mathisen & Arnulf, 2013; Ratten & Usmanij, 2021; Wardana et al., 2020). It plays a pivotal role in economic growth and job creation. It is not solely about launching viable enterprises; it encompasses a comprehensive grasp of market dynamics to innovate products and services. It also involves devising a sustainable business plan, which equips entrepreneurs with insights into the probable success of their venture (Zemlyak et al., 2022). Entrepreneurship, traditionally viewed as the capacity to initiate, manage, and succeed in a business venture, encompasses a wide array of activities including the discovery, evaluation, and exploitation of opportunities to introduce new goods and services (Shane & Venkataraman, 2000; Venkataraman, 2019).

EE not only imparts knowledge through traditional curricular methods but also a variety of extracurricular activities, effectively boosting students' SE. Participation in student-led organizations such as student councils, clubs, and entrepreneurship associations plays a crucial role in cultivating leadership qualities and an independent spirit among students (Zhang & Huang, 2021). In this way, EE plays a pivotal role in shaping the career decisions of students by aligning their employment choices with their developed skills (Meoli et al., 2020). As a significant driver of economic prosperity, innovation, and entrepreneurship are essential; hence, policymakers must implement robust EE frameworks across universities and colleges in various disciplines (Cui & Gu, 2024). EE fosters a readiness for change, a willingness to adapt to new situations, and an ability to operate effectively in uncertain environments (Van Auken, 2013).

Technology entrepreneurship is a key driver of prosperity for individuals, companies, regions, and nations. It is widely recognized as indispensable for growth, differentiation, and gaining a competitive edge at the firm, regional, and national levels (Bailetti, 2012). It is crucial not only as a subject of academic study but also as a dynamic driver of scalable economic growth. It revitalizes equilibrium-based theories with its emphasis on innovation and disruption, leading to significant

enhancements in social welfare, ecological sustainability, and wealth creation. This makes it an essential area for both research and practical engagement in the economic landscape (Beckman et al., 2012).

As many countries are currently experiencing significant unemployment issues, entrepreneurial knowledge and skills could assist these nations in mitigating their unemployment challenges (Iqbal et al., 2012). Indeed, entrepreneurship significantly contributes to economic growth and development, with EE crucially supporting this dynamic by fostering job creation and wealth generation (Gómez-Gras et al., 2010; Nabi et al., 2010a; Oosterbeek et al., 2010), enhancing Innovation and Productivity (Awogbenle & Iwuamadi, 2010), Addressing Unemployment (Iqbal et al., 2012), boosting Economic Competitiveness (Vodă & Florea, 2019), and Poverty Alleviation (Ali & Yousuf, 2019). Moreover, the Global Entrepreneurship Monitor (GEM) study highlights entrepreneurship as a fundamental tool for job creation and wealth generation, demonstrating that economic growth and development are intricately linked to entrepreneurial activities (Acs et al., 2004; Gómez-Gras et al., 2010; Nabi et al., 2010a; Oosterbeek et al., 2010).

2.2 Entrepreneurship Education in Engineering

Engineering students are particularly well-positioned to pursue entrepreneurial endeavors, as their training equips them with both the technical skills and the problem-solving mindset needed to excel in such ventures (Duval-Couetil et al., 2012). Since entrepreneurship is a fundamental component of economic activity, engineers need to cultivate an EM through genuine educational experiences (Bosman & Fernhaber, 2018a). Many engineering schools are increasingly considering and offering EE to their students, believing it to be complementary to their technical training. The goal is to develop engineers who possess not only scientific and technological expertise but also the ability to recognize opportunities, comprehend markets, commercialize products, and demonstrate strong leadership and communication skills (Duval-Couetil et al., 2012).

This approach is intended to provide engineering students with vital skills that go beyond traditional technical expertise, thereby improving their potential for innovation, productivity, and

adaptability in their careers. Within the changing framework of engineering education, entrepreneurship has become a crucial element, essential for fostering innovation and promoting economic growth. In recent years, educational institutions specializing in engineering have shown a growing interest in fostering an entrepreneurial culture among students(Gilmartin et al., 2016). Beyond traditional academic boundaries, EE provides unique opportunities to innovate in teaching and curriculum design. This includes integrating guest lectures and practical assignments that not only enrich the entrepreneurship courses themselves but also positively influence other business-related courses, ultimately enhancing the overall student experience (Grecu & Denes, 2017). Accreditation for engineering programs requires that universities ensure their courses, particularly capstone design courses, effectively foster entrepreneurial skills and mindsets (Gilmartin et al., 2016). Today, engineering education must produce "entrepreneurial engineers"—individuals who possess an EM and innovative spirit. These engineers can either become intrapreneurs, leading innovation within established companies, or entrepreneurs, launching their businesses (Kriewall & Mekemson, 2010; Leibenstein, 1976). (Wei, 2005) Argues that the number of attractive research and development jobs in manufacturing for top engineering graduates has been declining.

(Wijayati et al., 2021) Highlight that engineering students, due to their specialized knowledge, may need distinct educational programs compared to business students. (Souitaris et al., 2007) Examined the impact of EE programs on the entrepreneurial attitudes and intentions of science and engineering students. Their study revealed that such programs enhance overall EIs.

The curriculum for EE typically incorporates a range of experiential learning methodologies that enable students to engage in practical, real-world business experiences. This hands-on approach is instrumental in developing students' capabilities for entrepreneurial actions and cultivating a robust EM (Cui et al., 2021a; Ndou et al., 2019). Moreover, EE is seen as a driver for personal development, enhancing students' sense of independence, self-confidence, and their ability to identify opportunities (Hahn et al., 2020). (Handayati et al., 2020) This suggests that the primary aim of EE is to enhance skills, knowledge, and experience geared towards entrepreneurial activities. As such, students might channel their entrepreneurial skills toward improving their engineering practices or creating new business ventures (M. Kim & Park, 2018). The integration of entrepreneurship into engineering curricula not only addresses the technical and analytical skills necessary for engineering students but also emphasizes the importance of creativity, business

acumen, and effective communication (Awogbenle & Iwuamadi, 2010). These transversal skills are increasingly recognized as essential for enhancing employability and facilitating economic activity.

2.3 Entrepreneurship Education

Entrepreneurship education is a crucial component of economic development globally, enhancing innovation, technology adoption, job creation, and alleviating poverty by cultivating intentions to start sustainable businesses (Lampridi et al., 2019; Nawawi et al., 2022). EE equips individuals with the necessary knowledge and skills to identify and seize entrepreneurial opportunities (Nadelson et al., 2018). EE facilitates the sharing of knowledge and information, thereby enabling individuals to engage effectively with peers and establish a network that supports entrepreneurial activities (Nowiński et al., 2019).

The rapid expansion of EE in higher education over the past two decades underscores its importance in today's global economy (Fayolle, 2018; Neck & Greene, 2011). This expansion is driven by the need to equip individuals with the necessary skills and mindset to thrive in dynamic and rapidly changing environments (Grecu & Denes, 2017). EE has thus become widely integrated into both undergraduate and graduate programs worldwide (Kuratko, 2005; Nabi et al., 2017a), drawing on disciplines such as economics, management, education, and technical studies (Davidsson, 2008).

Importantly, EE extends beyond merely encouraging learners to start their businesses; it helps them acquire skills necessary for identifying and pursuing new opportunities (Van Auken, 2013). Furthermore, EE emphasizes practical learning through business practices, company visits, and interactions with successful entrepreneurs, which are critical in developing entrepreneurial skills and intentions (Farny et al., 2019; Potishuk & Kratzer, 2017). In addition, entrepreneurial education enriches individuals by broadening their knowledge, skills, attitudes, and personal traits related to entrepreneurship, fostering a holistic approach to their personal and professional growth in the entrepreneurial sector (Hussain & Norashidah, 2015). This educational approach not only improves mindfulness towards entrepreneurship as a viable career path but also encourages the

reflection on and enhancement of personal attributes necessary for entrepreneurial success (Kalyoncuoğlu et al., 2017; Kirkwood et al., 2014).

Specifically, the primary objectives of EE include: enhancing knowledge and skills (Lüthje & Franke, 2002), fostering an EM (Fayolle & Gailly, 2015; Yuan et al., 2021), promoting EI (Hoang et al., 2020; Jiatong et al., 2021), developing transferable competencies (Awogbenle & Iwuamadi, 2010), encouraging innovation and creativity (M. Kim & Park, 2018), and Enhancing ESE (Bandura, 2012; Cui & Gu, 2024; Wardana et al., 2020). Consequently, EE not only prepares students for entrepreneurial ventures but also equips them with valuable skills for the job market. EE harnesses the power of social networks and the insights from successful entrepreneurs to foster EI (Vodă & Florea, 2019).

2.4 Entrepreneurship Education in Action

Educational programs and activities in entrepreneurship have been shown to positively affect the EIs of higher education students (Bae et al., 2014; Haddoud et al., 2022; Nowiński et al., 2019; Rauch & Hulsink, 2015). Experiential learning, central to a social constructivist learning paradigm (S. Mueller et al., 2015), meets the need to develop skills, attributes, and competency. EE, also known as enterprise education or entrepreneurial education, utilizes experiential learning to enhance noncognitive skills and prepare students for professional careers by engaging them in entrepreneurial studies (Lackéus, 2015; Plasman et al., 2017). Specifically, it plays a crucial role in EE, a field that increasingly embraces constructivist approaches to enhance student engagement and efficacy in entrepreneurial activities. Entrepreneurial learning experiences can shape students through curricular, co-curricular, and extracurricular activities, treating entrepreneurship more as a collection of practices than a process (Neck et al., 2021). Moreover, the literature advocates for a dynamic shift in EE towards experiential learning methodologies, which facilitate the practical application of knowledge and skills and significantly enhance the learners' ability to engage actively and reflectively in their entrepreneurial development process, thereby fostering an effective EM and competencies. Indeed, experiential learning is enhanced when the learner actively engages, directs, and reflects

on their actions, deepening both personal and professional growth through practical application (Boström & Lassen, 2006).

Furthermore, entrepreneurial learning is both an individual construct and dependent on specific developmental stages and is a collaborative effort that evolves through social interactions among peers and lectures, closely mirroring the real-world practices of entrepreneurship beyond educational settings (S. Mueller, 2012). While extracurricular activities provide a different learning environment than traditional courses and have demonstrated a direct effect on students' entrepreneurial inspiration and cognitive mindsets (Cui et al., 2021b), their impact on EE has not been sufficiently researched (Arranz et al., 2017). According to (Neck & Greene, 2011), a methodological approach to teaching entrepreneurship should emphasize acquiring entrepreneurial skills through practical pedagogies such as simulation games and reflective practice. These methods enhance constructivist and experiential learning by fostering confidence and competence through practical challenges. They also argue that entrepreneurship should be taught as a method focused on specific ways of thinking and acting, rather than a rigid, linear sequence. Practice-based pedagogies such as simulations, design-based learning, and reflective practices, allow students to develop entrepreneurial skills through real-world experiences. This constructivist approach fosters active learning, with educators guiding students to construct knowledge through hands-on activities. By engaging in real-world entrepreneurial tasks, learners develop confidence and competence in applying theoretical knowledge to practical challenges. Additionally, Entrepreneurial Education Activity (EEA) is recognized as a crucial element of EE (Gielnik et al., 2015).

Complementing these views (Bell & Liu, 2019) also suggest that the benefits of experiential learning might be limited by insufficient resources, training, and practical challenges. They note that educators' perception of it as time-consuming can also discourage them from adopting the necessary versatile roles, leading to a preference for traditional teaching methods. (B. Jones & Iredale, 2010; C. Jones & English, 2004) Emphasize the importance of creative problem-solving and learning-by-doing in EE. These experiential learning methods deeply engage students, immersing them in the entrepreneurial process and moving away from passive, traditional teaching methods. The research (Fuchs et al., 2008; Honig, 2004) underscores the effectiveness of experiential learning in entrepreneurship, highlighting its ability to foster both engagement and

competency development. While there is some ambiguity around the precise definition of experiential learning, it is widely associated with active, practice-oriented methodologies both inside and outside the classroom(Fayolle, 2018; Hägg & Kurczewska, 2016; Roberts, 2012).

Despite these developments, (Pittaway & Cope, 2007) argue that EE still lacks robust intellectual foundations, particularly in its theoretical and methodological aspects. This points to a need for more refined frameworks that support a constructivist perspective, which encourages learners to actively construct knowledge through real-world experiences (Hägg & Gabrielsson, 2020). Thus, educators like (Fenwick, 2003; Mathews, 2007) to highlight the importance of creating learning environments that foster active participation and independent thinking.

In addition to this, the need for multidisciplinary skills in technology fields is increasingly critical. Therefore, technology professionals must adapt quickly to innovations (João & Silva, 2018). Additionally, current economic challenges, including high unemployment rates, demand that engineers not only possess diverse technical skills but also entrepreneurial abilities (Barba-Sánchez & Atienza-Sahuquillo, 2018). To prepare graduates for the dynamic technological landscape, engineering curricula are evolving to integrate entrepreneurial education, thereby equipping them with multidisciplinary skills (Creed et al., 2002; Duval-Couetil et al., 2012). This shift towards experiential learning is supported by organizations like the National Academy of Engineering and the American Society for Engineering Education (Rover, 2005), which recognize the value of this educational approach in developing necessary entrepreneurial competencies (Bell & Bell, 2020; Fuchs et al., 2008; Honig, 2004).

Further, experiential learning should not only focus on the acquisition of knowledge but also on engaging students in entrepreneurial practices to develop competencies and experiential knowledge (Fayolle & Gailly, 2008; Lackéus & Williams Middleton, 2015). Constructivist theories align with experiential learning practices in EE, illustrating how these methodologies foster a deeper understanding of entrepreneurial actions (Kirschner et al., 2010; S. Mueller & Anderson, 2014). Therefore, constructivist approaches are widely recognized as highly effective in EE, promoting active, experience-based learning that fosters entrepreneurial thinking and problem-solving skills (Balan & Metcalfe, 2012; Kyrö, 2018). This method serves as a critical foundation for developing an EM (Bell, 2022). Therefore, Experiential Entrepreneurial

Education (EEE) should move beyond traditional business creation to focus on cultivating entrepreneurial attitudes and mindsets (Cherwitz, 2005), prioritizing hands-on, experiential learning as an essential strategy for effectively preparing students for entrepreneurial careers (Kozlinska, 2016; Pepin, 2012; Ramsgaard, 2018).

2.5 Exploring the Entrepreneurial Mindset Foundations, Development, and Role in Entrepreneurial Intention

The concept of EM has gained significant attention in recent years, particularly within the fields of entrepreneurship, education, and engineering (Bosman & Fernhaber, 2018b; Byers et al., 2013; Huang-Saad et al., 2018; Ridley et al., 2017). This has resulted in numerous studies exploring its definition, development, and impact, especially regarding EIs (Cui, 2021; Handayati et al., 2020; Wardana et al., 2020). Researchers have shifted away from the idea that entrepreneurs are born with specific traits and instead have focused on EM, which is understood as a way of thinking that distinguishes entrepreneurs from non-entrepreneurs (Gartner, 1988; Palich & Bagby, 1995; Shaver & Scott, 1992). In the study (Asenge et al., 2018), the EM is considered a holistic perception that involves generating novel ideas, evaluating opportunities and risks, or starting and running a business. It emphasizes an internal assessment by individuals of their perceptions based on holistic rather than functional attributes. This mindset is not static but rather evolves (Aima et al., 2020) from past and current experiences and through interactions with the environment and is influenced by education and learning (Gupta & Govindarajan, 2002; Mathisen & Arnulf, 2013). Several definitions of EM have been proposed, reflecting different perspectives. Research such as that (Baek et al., 2017) has demonstrated a significant impact of entrepreneurship on aspects like career decision-making SE and career maturity, further emphasizing the broad applicative reach of an EM in personal and professional development. (Shepherd et al., 2010) Further refined this definition by suggesting that EM involves the ability to rapidly sense opportunities, act decisively, and mobilize resources effectively in response to uncertainty.

The EM is regarded as an approach to dynamic thinking and decision-making in uncertain, complex, and volatile environments. It involves the ability to swiftly identify opportunities, take

action, and mobilize efforts, even under conditions of high uncertainty. EM is also described as an inclination or capacity to offer critical and creative thinking skills(Nabi et al., 2017b). It is associated with an individual's ability to think strategically, focusing on opportunities rather than obstacles, and presenting solutions instead of complaints (M. H. Davis et al., 2016; Naumann, 2017). EM is typically viewed as a mindset that guides human behavior towards engaging in entrepreneurial activities and achieving entrepreneurial outcomes. It also involves an individual's commitment toward entrepreneurial activities (Bosman & Fernhaber, 2018b; Jena, 2020; Naumann, 2017). with an inclination that combines risk-taking, need for achievement, and passion to start new ventures (Bosman & Fernhaber, 2018a). Additionally, an EM includes the capability to organize and oversee projects to meet specific goals (Bosman & Fernhaber, 2018b).

The literature also highlights the cognitive aspect of the EM, defining it as a deep-seated cognitive phenomenon that embodies a distinctive dedication to entrepreneurial activities(Jena, 2020; Kuratko & Hodgetts, 2020). This cognitive perspective indicates that entrepreneurs utilize mental models for thinking, which includes the capability to adjust their thought processes in response to varying contexts and the demands of different tasks (Haynie & Shepherd, 2007). In addition to the cognitive aspect, the emotional and behavioral aspects of EM are also important (Kuratko et al., 2021).

According to (Jung & Lee, 2020), key components of EM include innovativeness, risk-taking, need for achievement, autonomy, and proactiveness. Innovativeness refers to the inclination to pursue novel opportunities and solutions. It alludes to the ability to create meaningful novelty and plays a critical role in driving EIs and innovative efforts (Stauffer, 2015). Innovativeness reflects an individual’s willingness to adopt new technologies, systems, and processes, often leading to the development of creative products and solutions (Law & Breznik, 2017). Research highlights its role in enhancing human capital, improving skills, and broadening knowledge through openness to novel learning approaches (Aboobaker & KA, 2023). Innovativeness is also associated with higher self-esteem and resilience, which are critical attributes for navigating entrepreneurial challenges (Syed et al., 2020). Those with high levels of personal innovativeness tend to embrace technological advancements and unconventional ideas, demonstrating a strong inclination to experiment and innovate (A. Khan et al., 2019).

Risk-taking involves a willingness to engage in uncertain and potentially risky endeavors to achieve entrepreneurial goals (Dhliwayo & Van Vuuren, 2007). Entrepreneurs exhibit a higher tolerance for uncertainty and a proactive approach to navigating challenges, which enables them to uncover opportunities and achieve groundbreaking outcomes (Zemlyak et al., 2022). This capacity to take calculated risks is fundamental to the entrepreneurial process, as it drives bold actions and fosters innovation in dynamic markets (Yoopetch, 2021).

The need for achievement reflects the drive and determination to accomplish tasks efficiently and effectively (Isaga, 2018). This trait is closely linked to ESE and intention, highlighting its importance in predicting entrepreneurial success (Soomro & Shah, 2022). Furthermore, NFA can be nurtured through effort and dedication, making it a skill that can be developed through education and experience (Gwadabe & Amirah, 2017; Palmer et al., 2019).

Autonomy refers to the ability to act independently and take ownership of decisions (Holt, 1997). Entrepreneurs often exhibit a strong preference for individualism and a desire to retain authority in decision-making (Wegner et al., 2020). Autonomy allows entrepreneurs to leverage unexpected opportunities and adapt to unforeseen challenges with flexibility and initiative (Busch & Barkema, 2022). These qualities enable entrepreneurs to navigate complex environments and maintain control over their ventures, reinforcing the significance of autonomy in fostering entrepreneurial success.

Proactiveness embodies a future-oriented approach to decision-making and action. Entrepreneurs with a proactive mindset anticipate challenges, take initiative, and address potential needs ahead of time (Sarasvathy, 2001). Proactiveness equips individuals to identify opportunities early, optimize resources, and respond effectively to changing external conditions (E. A. Khan et al., 2021; Palmer et al., 2019).

EE plays a crucial role in developing an EM. Recent attention has been given to entrepreneurial-minded learning as a pedagogical approach within higher education, emphasizing its effectiveness in enhancing students' entrepreneurial capabilities (S. Y. Kim et al., 2017; Morton et al., 2016). Accreditation for engineering programs requires proof that curricula, notably capstone design courses, nurture students' entrepreneurial skills and mindsets. These courses typically move from

problem identification to prototyping, focusing on technological feasibility and entrepreneurial approaches (Gilmartin et al., 2016). EE provides students with opportunities in entrepreneurship tasks and can stimulate their cognitive factors that lead toward entrepreneurial action (Cui et al., 2021a; Shepherd et al., 2010; Yuan & Wu, 2020). Studies have shown that EE, especially extracurricular activities, can positively affect students' EM (Cui et al., 2021a). The literature has found that engagement in co-curricular and research activities not only enhances students' problem-solving and critical-thinking abilities but also encourages the development of an EM (Bonesso et al., 2018; K. A. Davis & Amelink, 2016; Sheppard et al., 2010; Yasuhara et al., 2012). Furthermore, experiences outside of university settings can also positively influence students' EM development (S.-C. Chen et al., 2017; Yasuhara et al., 2012).

It has also been shown that EM is a crucial antecedent of EI, the desire to start a new business (Jiatong et al., 2021; Wach & Wojciechowski, 2016). The EM is positively related to EI (Cui & Bell, 2022; Wegner et al., 2020). Research has also shown that EM can mediate the relationship between EE and EI (Handayati et al., 2020; Hussain & Norashidah, 2015; Walter & Block, 2016). A higher level of EM is associated with increased knowledge, skills, and experience in initiating and running new businesses (Benchrifa et al., 2017; Burnette et al., 2020). Therefore, fostering the EM is an important goal of education as it can lead to positive outcomes for individuals and the economy as a whole.

In summary, the EM is a dynamic and multifaceted concept that is crucial for success in entrepreneurship and other areas. Research, including studies (Moore et al., 2021), has acknowledged the entrepreneurial mindset's significant role in both the successes and failures of entrepreneurs within the field of entrepreneurship research. It can be developed through education, experience, and interaction with the environment, and its development can lead to an increase in EIs. This mindset encapsulates several key components like innovativeness, risk-taking, need for achievement, autonomy, and proactiveness, which are all vital for recognizing and pursuing opportunities. The concept of an EM is not static and is influenced by the environment as well as the individual's interactions with the environment.

2.6 The Mediating Role of Entrepreneurial Self-Efficacy in Engineering Education

Entrepreneurial self-efficacy (ESE), derived from social cognitive theory, is a key determinant of EI and behavior, reflecting an individual's belief in their capability to perform entrepreneurial tasks successfully. Research demonstrates that ESE positively influences EIs, motivation, effort, and perseverance, enabling individuals to navigate challenges and seize opportunities. ESE is shaped by education, experience, and social learning, with EE playing a pivotal role in enhancing SE by equipping individuals with the skills to identify opportunities, evaluate viability, and execute business plans. Additionally, ESE mediates the relationship between EE and EI, fostering creativity and an EM, and empowering individuals to effectively initiate and manage ventures.

ESE is a crucial concept in understanding EI and behavior (Akhtar et al., 2020; Asimakopoulos et al., 2019; Memon et al., 2019). ESE is considered a major factor influencing EI (Asimakopoulos et al., 2019; Memon et al., 2019; Schmutzler et al., 2019). SE significantly and positively affects EI (Puni et al., 2018; Rachmawan et al., 2015). However, some studies have found no significant relationship between SE and EI (Ferreira et al., 2017; Ogunleye & Osagu, 2014). This presents a contradiction in the literature, which this research will investigate further to clarify these discrepancies.

Higher levels of SE correlate with stronger EIs (Jin & Huang, 2019). Furthermore, ESE greatly influences the choices people make, the amount of effort they dedicate to actions, and their perseverance when facing obstacles (Pihie & Bagheri, 2013; Shane & Delmar, 2004). It refers to an individual’s belief in their capability to perform the various roles and tasks of entrepreneurship successfully (Bandura, 1986; C. C. Chen et al., 1998). Specifically, ESE is an individual's belief that they have the necessary skills and competence to succeed in entrepreneurial activities (Memon et al., 2019). The concept of SE, from which ESE is derived, originated from social cognitive theory (Bandura, 1977, 2012). The theory outlines that EE enhances an individual’s SE, equipping them to recognize opportunities, evaluate business viability, and execute business plans. Social cognitive theory suggests that individuals are more likely to strive for their goals when they believe their skills and abilities are sufficient to achieve the outcomes they desire (Lim et al., 2020; Y. J. Wu et al., 2020). In addition, ESE helps explain

the connection between formal education, entrepreneurial experience, and the EM, as individuals develop stronger entrepreneurial beliefs through education and experience (Burnette et al., 2020).

It is a learning theory that emphasizes the role of observational learning, modeling, and SE in individual development (Beauchamp et al., 2019). This theory, introduced by (Bandura, 1985), suggests that individual behavior is shaped through a variety of activities, including social interactions, personal participation, and environmental influences. SE is a fundamental component of social learning theory (Saraih et al., 2018). SE refers to an individual's belief in their ability to achieve tasks that are oriented towards specific goals (Barbaranelli et al., 2019). It is an image of a person’s capacity to perform specific behaviors. This significantly influences EI, either directly or indirectly through perceived feasibility (Krueger Jr et al., 2000; Krueger, 1993). An individual's motivation and willingness to exert effort on a task depends more on their beliefs than on an objective analysis of the outcome (Khedhaouria et al., 2015). Individuals with high ESE are more likely to take risks (Ali & Yousuf, 2019). They tend to invest more effort into their goals and adhere more to the entrepreneurial process (Jiang et al., 2017).

Several studies have shown that EE has a positive impact on ESE (Kusumojanto et al., 2020; Wardana et al., 2020; Wilson et al., 2007), as well as on EI (L. Wu et al., 2022). Students who receive EE tend to be more proactive and effective in launching and managing their businesses. The positive effect of EE on ESE suggests that students are better equipped to oversee the initial development stages of a business. Individuals with higher ESE are more likely to perceive higher entrepreneurial education and are more creative (Jiatong et al., 2021).

2.7 Entrepreneurial Intentions: The Nexus of Education, Mindset, and Self-efficacy

EI is a critical concept in understanding the decision-making process of individuals aspiring to start a business. Defined as a self-recognized belief and conscious commitment to pursue entrepreneurship, EI represents the foundation of entrepreneurial activity and reflects a mindset oriented toward innovation and enterprise. Rooted in the Theory of Planned Behavior (TPB), EI is influenced by personal attitudes, social norms, and perceived behavioral control, which collectively shape an individual's entrepreneurial aspirations. Research highlights the significant

role of EE in fostering EI by enhancing skills, motivation, and SE, ultimately equipping individuals to identify and exploit opportunities. As the precursor to entrepreneurial behavior, EI not only predicts entrepreneurial actions but also underscores the transformative impact of education, mindset, and personal experiences in shaping future entrepreneurs. College students with prior entrepreneurial experiences, including participation in entrepreneurial competitions, generally exhibit higher EIs compared to their peers without such experiences (L. Wu et al., 2022).

EI is a well-researched concept in the field of entrepreneurship, and many scholars have explored its definition and impact. EI is commonly defined as an individual's self-recognized belief in their intention to start a new business venture (Hsu et al., 2019), coupled with a conscious commitment to pursue this goal in the future (Thompson, 2009). It represents the initial and most crucial step for an entrepreneur (Ashourizadeh et al., 2014). Furthermore, EI is a mindset to start a sustainable business. It encompasses elements of entrepreneurship, innovation, and enterprise. EI is defined (Bird, 1988) as a "state of mind that directs attention, experience, and action toward a business concept, and sets the form and direction of organizations at their inception." It also reflects an individual's willingness to achieve a specific entrepreneurial goal. The stronger the intention toward a particular behavior, the more likely it is that the behavior will be performed (Ajzen, 1991). Entrepreneurial activity stems from EIs, and EE plays a crucial role as it can shape and direct these intentions (Rideout & Gray, 2013). The TPB emphasizes the direct link between formal EE programs and EI (Soomro & Shah, 2022). Studies have also outlined that individuals with a higher level of entrepreneurial education, EM, and creativity are more likely to start their businesses (Handayati et al., 2020; Hu & Ye, 2017). Research indicates substantial differences in EIs between undergraduate and master’s students, with the latter group displaying a higher propensity towards starting their businesses (J. Mueller et al., 2014). As a result, EI can significantly predict entrepreneurial behavior (Krueger Jr et al., 2000). It plays a key role in an individual's decision to establish a new business (Bird, 1988; Nabi et al., 2010b). As such, EI represents a strong belief among individuals who aim to establish and manage a new enterprise in the future (Thompson, 2009). Additionally, the EI of college students can predict the likelihood of them starting a business in the future (Liu et al., 2011). Furthermore, a longitudinal study has confirmed that EI effectively predicts entrepreneurial action (Kautonen et al., 2015). While the TPB explains that intentions are strong predictors of behavior, EI does not always lead to action.

In some cases, individuals exhibit entrepreneurial behavior despite having weak EI, with students becoming entrepreneurs even when their initial intentions were low (Joensuu-Salo et al., 2020).

Much of the previous research on entrepreneurial education has been conducted at the individual level and often employs the Theory of Planned Behavior (TPB) as a framework (Krueger Jr et al., 2000; Souitaris et al., 2007). The theory of planned behavior (TPB) (Ajzen, 1991) is one of the dominant psychological perspectives used to study EI. According to the Theory of Planned Behavior (TPB), EI is an indicator of the effort an individual is willing to exert to engage in entrepreneurial behavior (Liñán & Chen, 2009). The Theory of Planned Behavior (TPB) seeks to explain the development of an individual's EI by examining three antecedents: personal attitude (PA), social norm (SN), and perceived behavioral control (PBC) (Liñán & Fayolle, 2015). These three elements help explain the variations in EIs among different individuals. The attitudinal predictors within the TPB have consistently been validated (Liñán & Fayolle, 2015). Attitude toward start-up (personal attitude, PA) refers to an individual's positive or negative personal evaluation of becoming an entrepreneur(Ajzen, 2001; Autio et al., 2001; Kolvereid, 1996). Subjective norm (SN) assesses the perceived social pressure an individual feels to either engage in or refrain from entrepreneurial activities. Perceived behavioral control (PBC) refers to an individual's perception of the ease or difficulty associated with becoming an entrepreneur.

2.8 Impact of Entrepreneurship Education on Mindset, Self-Efficacy, and Intention

2.8.1 Impact on Entrepreneurial Mindset

There is a large body of research linking entrepreneurship education to mindset, self-efficacy and intention…in this research, given our interest in how we might enhance entrepreneurship education, we focus on finding support for how education impacts mindset, self-efficacy and intention, recognizing that in practice the relationship is complex and causality cold be reversed. For example, individuals with a strong pre-existing entrepreneurial intention may be more likely to seek out entrepreneurship education in the first place. Moreover, the relationship is likely reciprocal and iterative: increased intention can motivate participation in educational programs, which in turn can further reinforce or elevate entrepreneurial intention over time.

Entrepreneurship education plays a crucial role in cultivating an EM, which is a key outcome of educational programs designed to foster entrepreneurship. An EM is defined as a specific state of mind that directs individuals toward entrepreneurial activities, characterized by an orientation toward opportunities, innovation, and the creation of new value (K. A. Davis & Amelink, 2016; Putta, 2014). Moreover, this mindset equips individuals with the abilities to manage risks, learn from failures, and navigate ambiguities (Ali et al., 2012). Furthermore, the EM has the capacity for innovative problem-solving in uncertain environments, alongside the vision to spot and seize new opportunities (Ireland et al., 2003). Research demonstrates that EE has a direct, positive, and significant effect on developing the EM (Pauceanu et al., 2018) , particularly in university settings (Cui et al., 2021a; Hultén & Tumunbayarova, 2020). Educational initiatives aimed at engineers have shown that not only do these programs inspire students to become entrepreneurs, but they also underline the pivotal role engineers play in solving critical issues and innovating within their fields. These capabilities are crucial for entrepreneurial success and are key outcomes of EE, as highlighted by (Cui et al., 2021a; Wardana et al., 2020). In effect, this promotes a better understanding of entrepreneurship, guiding students toward suitable career choices, and enabling them to identify and exploit entrepreneurial opportunities in the market (Jiatong et al., 2021; Yuan et al., 2021). Consequently, educational experiences in entrepreneurship are critical in shaping the EM of college students (Jung & Lee, 2020). Indeed, the EM successfully mediates the relationship between entrepreneurial education and students' EI (Handayati et al., 2020).

In addition to the above points, EE across various educational levels serves two key functions in fostering an EM. First, it helps students to cultivate a deep understanding and appreciation of entrepreneurship culture. Second, it equips students with the experiences necessary to embark on entrepreneurial ventures (Fayolle & Gailly, 2015).

(Jackson et al., 2023) the university ecosystem profoundly influences the development of the EM among engineering students. For example, classroom experiences significantly shape their understanding of engineering and business practices, thereby preparing them for future entrepreneurial endeavors. Also, many engineering departments in colleges and universities have adapted their curricula to promote the development of an EM among students. These educational changes have been successful, enabling engineering students to develop and

sharpen essential technical and business skills (Jensen & Schlegel, 2017; Nezami et al., 2016; Riofrio et al., 2015).

The realization that integrating business acumen with engineering expertise is essential in a dynamic society has fostered stakeholder support for embedding Entrepreneurship Mindset (EM) development within engineering education (Brunhaver et al., 2018; Dabbagh & Menascé, 2006). (Cui et al., 2021b) reported that extracurricular activities had a significant positive direct effect, but curriculum attendance had a significant negative direct effect.

Therefore, EE, through both curriculum attendance and extracurricular activities, significantly boosts the EM of students, which in turn enhances their EI (J. Sun et al., 2023).

2.8.2 Impact on Entrepreneurial Self-Efficacy

Entrepreneurship education significantly influences ESE, according to (Soomro & Shah, 2022). In addition, several studies indicate that ESE partially mediates the relationship between EE and EI (Anwar et al., 2020; Nowiński et al., 2019; Rauch & Hulsink, 2015; Wegner et al., 2020; L. Wu et al., 2022; Zhao et al., 2005). For example, this mediation is supported by the findings of (Mandel & Noyes, 2016), who emphasize that experiential EE effectively bridges the gap between theory and practice, thereby enhancing students' ESE. Moreover, education helps to transfer knowledge and skills, which then increases SE, ultimately predicting the effectiveness of future entrepreneurs (Bandura, 1986). In fact, (Bandura, 2012) theory of social cognitive posits that EE bolsters an individual's SE, further illustrating how theoretical frameworks support the practical applications of EE. Universities are therefore dedicated to enhancing student motivation and capabilities by fostering an environment conducive to those aspiring to be founders (Walter et al., 2013).

Furthermore, such educational settings can markedly elevate students' ESE and outcome expectations by diminishing their perceived barriers and challenges, positively impacting their EM. Also, a study by (Cui & Gu, 2024) confirms that EE significantly impacts ESE, outcome expectations, and EM, thereby highlighting its effectiveness in university and college settings (Cui & Gu, 2024). Although, (Duval-Couetil et al., 2012) report that engineering students show a keen interest in EE, yet exposure remains limited even within institutions with formal entrepreneurship programs. However, those who participate in one or more entrepreneurship courses exhibit significantly higher ESE. They also gain valuable, marketable skills in areas

such as market analysis, technology commercialization, business communication, and internships within startup companies, which are highly sought after by today's employers.

2.8.3 Impact on Entrepreneurial Intention

A vital factor in shaping the EM, enhancing SE, and fostering EIs among students, particularly in engineering disciplines, is EE. (Barba-Sánchez & Atienza-Sahuquillo, 2018) corroborated the positive effects of EE on the EIs of students. EI refers to an individual's conscious desire and commitment to start a new business venture. EE plays a critical role in shaping these intentions. (Maheshwari et al., 2023) Suggests that identifying the factors influencing students' EIs enables researchers and policymakers to develop educational programs that foster entrepreneurship and equip students with the skills needed to start and manage businesses in the future.

Furthermore, research indicates that EE significantly predicts EIs (Bae et al., 2014). The connection between EE and EI is supported by theories such as human capital theory (Saptono et al., 2020), which posits that education enhances knowledge and skills, and the theory of SE, where education boosts the belief in one's entrepreneurial capabilities (Maresch et al., 2016). Additionally, the Theory of Planned Behavior (TPB) emphasizes the importance of attitudes, norms, and perceived control in forming intentions, and these components of the TPB also affect the success of EE (Gorman et al., 1997; Kuratko, 2005; Rauch & Hulsink, 2015).

Studies show that EE is a significant predictor of EI (Jiatong et al., 2021) and fosters a strong relationship with EI by enhancing skills and fundamental abilities (Cui, 2021; Martin et al., 2013; Nabi et al., 2017a). Moreover, EE programs have a positive impact on students' EIs, attitudes, knowledge, and skills (Burrows & Wragg, 2013; Chang et al., 2014). Debate continues to grow regarding the effectiveness of EE, driven by conflicting research outcomes. Some studies suggest EE programs positively influence students' EI (Dou et al., 2019; Küttim et al., 2014; L. Li & Wu, 2019; Martin et al., 2013; H. Sun et al., 2017). For instance, incorporating two or more entrepreneurship-related elective courses into the curriculum positively impacts students' Eis (Lange et al., 2011).

Research examining the relationship between attitudes towards EE and EIs has yielded inconsistent results, with some studies showing positive effects and others finding no significant or mixed outcomes (Von Graevenitz et al., 2010). Other studies report that EE has no impact or even a negative impact (Lorz, 2011; Oosterbeek et al., 2010; Von Graevenitz et al., 2010). Moreover, there are studies that indicate a detrimental effect (Do Paço et al., 2015; Marques et al., 2012). several authors noted that EE may decrease the entrepreneurial aspiration of people (Laukkanen, 2000; Nabi et al., 2018). They argued that EE provides business knowledge but fails to build the confidence and innovation needed for entrepreneurial action. For example, business programs cultivate a heightened awareness of potential problems and risks, they can create a sense of fear among students, making them hesitant to pursue entrepreneurship and more inclined to seek stable, low-risk jobs. Interestingly, research also suggests that the effectiveness of EE can differ among students, with one study noting variations in impact between business and science/engineering students, though both groups generally benefit (Maresch et al., 2016). This highlights the context of this research, which focuses on engineering students, and the special case of Lassonde School of Engineering, embedding entrepreneurial education into all engineering programs (curricular and co-curricular).

The EM and ESE act as mediating factors in the relationship between EE and EI. EE positively drives vocational students' EIs through the EM (Handayati et al., 2020). Also, EE influences EI primarily through SE (Nowiński et al., 2019; Wegner et al., 2020; L. Wu et al., 2022). EE programs can effectively prepare students for future entrepreneurial endeavors by combining theoretical knowledge with practical experiences. In addition, EE aids in actualizing these intentions by providing students access to the experiences and networks of accomplished entrepreneurs (Vodă & Florea, 2019). Consequently, the evidence from various studies consistently shows that well-designed EE programs significantly contribute to the development of a generation of capable and motivated entrepreneurs.

2.9 Proposed Conceptual Model

Based on a comprehensive literature review on EE and its influence on EIs, mediated by EM and ESE, this thesis proposes a conceptual model. This model, visually represented in Figure 2.1, illustrates the hypothesized relationships among the key constructs of this research.

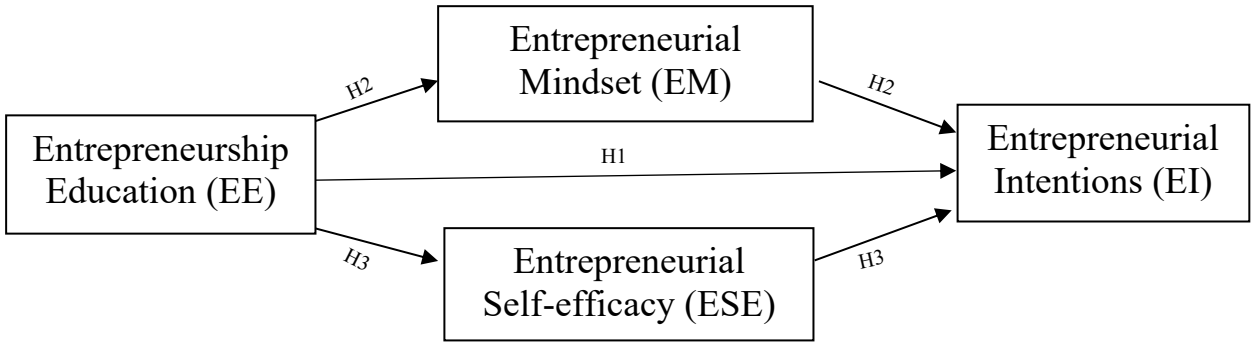

Figure 2.1: Conceptual Model Linking Entrepreneurship Education to Entrepreneurial Intentions

2.10 Hypotheses Development

Earlier studies establish the framework for exploring the link between engineering students' EI and EE. Research by (Jiatong et al., 2021) demonstrates a direct and significant influence of EE on EI. This effect is echoed by (Barba-Sánchez & Atienza-Sahuquillo, 2018), who confirm the positive impact of EE on students' EI. EE is critically effective in enhancing EIs as noted by (Hoang et al., 2020). Further evidence is provided by studies that have found EE programs and activities in higher education settings significantly shape students' EIs, highlighting the crucial role of such education in motivating students to engage more deeply in entrepreneurial activities (Bae et al., 2014; Haddoud et al., 2022; Nowiński et al., 2019; Rauch & Hulsink, 2015). Studies have shown that EE can enhance students' EIs (Hou et al., 2019; Mei et al., 2020; Zhang & Huang, 2021). (Hasan et al., 2017; Westhead & Solesvik, 2016) further enrich this narrative by illustrating how EE enhances EIs through the development of skills, motivation, social networks, and practical experience. (Hasan et al., 2017; Westhead & Solesvik, 2016) demonstrated that EE can influence students' intentions to become entrepreneurs by enhancing motivation, skills, social networks, and

experience. Many researchers have identified a positive mediating effect of ESE on E (Burnette et al., 2020; Fernando & Nishantha, 2019). Based on this theoretical groundwork, I propose the following hypotheses:

H1: Entrepreneurship education positively impacts the development of entrepreneurial intention among engineering students.

(Kuratko, 2005) emphasizes that EE transcends the basic act of starting new ventures, instilling a deep-seated mindset driven by the energy and passion necessary for developing and implementing innovative solutions. This enhancement is further supported through practical engagement, as participation in student-led organizations such as student councils and clubs significantly cultivates leadership qualities and an independent spirit, integral to nurturing an EM (Zhang & Huang, 2021). This view is supported by (Jiatong et al., 2021), who report a direct and significant positive effect of EE on developing an EM in students. Moreover, EE equips students to meet the dynamic demands of entrepreneurship by fostering adaptability and effectiveness in uncertain environments, skills that are indispensable in today's economic landscape (Van Auken, 2013). Further, (Béchard & Grégoire, 2005; Gibb, 2002) argue that this mindset is cultivated through various educational activities, influencing subsequent entrepreneurial behavior.

Research (Cui et al., 2021a; Handayati et al., 2020; Nowiński et al., 2019; Saptono et al., 2020) highlights that EE is vital for providing essential entrepreneurial knowledge and abilities, which are necessary for both launching businesses and cultivating an effective EM. (Iqbal et al., 2012; Mok & Choi, 2010) add that EE equips students to navigate evolving circumstances and tackle larger economic issues like unemployment. Thus, EE plays a pivotal role in developing both the psychological and practical competencies required for successful entrepreneurial endeavors. Critically, the cultivation of an EM is highlighted as a cornerstone of effective EE. Students with a well-developed EM possess essential knowledge, skills, and experience crucial for starting and managing new businesses (Benchrifa et al., 2017; Burnette et al., 2020). This mindset also enhances students' ability to acquire valuable business resources, demonstrating the practical advantages of fostering EM within educational settings (Cui et al., 2021a; Naumann, 2017).

(Hussain & Norashidah, 2015; Walter & Block, 2016) note that EM mediates the influence of EE on students' EIs, suggesting that the cultivation of EM could significantly amplify the impact of educational efforts. Furthermore, (Wach & Wojciechowski, 2016) emphasize that EM significantly influences EI, indicating a direct link between students' entrepreneurial attitudes and their intentions to engage in entrepreneurial activities. These considerations lead to the following hypothesis:

H2: An entrepreneurial mindset positively mediates the relationship between entrepreneurship education and entrepreneurial intention among engineering students.

Grounded in Bandura's social cognitive theory, the foundational belief is that EE significantly boosts an individual's SE (Bandura, 2012). Experiential entrepreneurship programs exemplify this by effectively bridging students to future entrepreneurial endeavors, thus increasing their ESE (Mandel & Noyes, 2016). Research specifically targeting engineering students in electrical and mechanical disciplines further supports this, showing that those engaged in EE courses exhibit markedly higher ESE than their peers (Duval-Couetil et al., 2012). Similarly, students who actively participate in EE activities demonstrate higher ESE (Souitaris et al., 2007).

ESE is identified as a key mediator that enhances students' confidence and capabilities to embark on entrepreneurial ventures (Bandura, 2012; Zhao et al., 2005). Students with experience in entrepreneurship have increased SE, which positively correlates with their EIs (Zhao et al., 2005). Additionally, (Segal et al., 2005) highlight that ESE serves as a vital mechanism through which EE influences individuals' intentions to engage in entrepreneurial activities. (Cui & Gu, 2024) further validate the impact of EE on ESE, emphasizing its role in shaping outcome expectations and EM, thereby strengthening the effectiveness of EE.

The broader implications of EE are substantiated by studies like those of (Cui & Gu, 2024), which demonstrate that EE not only enhances ESE but also positively affects outcome expectations and EM, thereby reinforcing the transformative impact of EE in educational settings. ESE has a mediating role in the relationship between EE and EI (Fuller et al., 2018; C. Li et al., 2020; Mei et al., 2020; Newman et al., 2019; Wardana et al., 2020; L. Wu et al., 2022). The role of ESE as a

mediator in the relationship between EE and EIs is particularly underscored by (Zhao et al., 2005), who suggest that developing SE through EE is pivotal for cultivating EIs.

Further studies, such as those by (Newman et al., 2019), recognize ESE as one of the strongest predictors of EI, highlighting its significant motivational role. Furthermore, (Lent et al., 2005) suggests that ESE mediates the relationship between environmental factors like EE and EI, indicating that the impact of EE on an individual's ESE could critically determine their EIs. This mediation is particularly evident in engineering students, who, when exposed to EE, exhibit significantly higher ESE, which in turn fosters their EIs (Duval-Couetil et al., 2012). Collectively, these theoretical and empirical perspectives lead to the formulation of the following hypothesis:

H3: Entrepreneurial self-efficacy positively mediates the relationship between entrepreneurship education and entrepreneurial intention among engineering students.

While the current model assumes a unidirectional relationship, whereby EE influences EM, ESE, and ultimately EI, it is important to acknowledge that these variables may interact in more complex, reciprocal ways. For example, students with higher EI may be more likely to seek out EE opportunities, and an EM could both shape and be shaped by EE experiences. Future research using longitudinal or experimental designs is needed to explore these bidirectional dynamics and better capture the complexity of entrepreneurial development.

3. Methodology

Employing a quantitative approach, this research investigates the impact of EE on engineering students' EIs. Data was collected through surveys distributed to both graduate and undergraduate students at the Lassonde School of Engineering, York University, with a particular focus on the mediating effects of EM and ESE.

This study gathered data from 431 engineering students, representing a refined sample from an initial 485 participants after removing 54 incomplete responses. The sample size was determined using Morgan's table to ensure representativeness. Surveys were administered both in paper and

electronic formats, allowing for greater participation and accommodating diverse student preferences.

SPSS and AMOS software were used to rigorously analyze the data and test the hypothesized relationships. This analysis included descriptive statistics, reliability checks, and structural equation modeling, providing a comprehensive view of the data's structure.

To ensure the methodological rigor and validity of this study, the questionnaire was developed using adapted versions of established measurement scales. This approach facilitates the reliable assessment of the key constructs under investigation. Specifically, the measurement of Entrepreneurial Education (EE) incorporated adapted items from (Cui & Bell, 2022) (5 items) and (Fatoki & Oni, 2014) (3 items). EM was measured using the 12-item scale developed by (Jung & Lee, 2019). ESE was assessed using the 4-item scale from (Zhao et al., 2005). Finally, EI was measured using the 6-item scale developed by(Liñán & Chen, 2009).

The large and diverse student body at the Lassonde School of Engineering (approximately 5,181 students) makes this study particularly significant, enhancing the research's insights and generalizability within the engineering field.

This chapter outlines the detailed methodological framework used to investigate the impact of EE. A substantial and representative sample was employed to ensure the findings are grounded in real educational contexts. The following sections will provide an in-depth look at the specific statistical methods and analyses used to test the research hypotheses.

3.1 Participant Demographics

With 49% of participants aged between 18 and 20, and another 23.9% between 21 and 24, the study largely comprised younger individuals, indicating a notable representation of early adulthood in the sample (Table 3.1). Males constituted 74.5% of the participants, while females accounted for 24.8%, demonstrating a significant gender disparity (Table 3.2). Regarding educational backgrounds, 74.2% of participants were undergraduates, forming the majority of the sample, with the remaining 25.8% being graduate students (Table 3.3). Notably, 35.3% of participants were first-year students, reflecting a high representation from the initial years of

university education (Table 3.4). Moreover, the distribution between domestic and international students was more balanced yet still domestically skewed, with 42% being international and 57.5% domestic, highlighting the varied backgrounds of the research participants (Table 3.5).

Table 3.1: Age Distribution of Survey Respondents

Age	Percent
18-20	49.0
21-24	23.9
25-29	13.5
30-34	10.0
35 or older	3.7
Total	100.0

Table 3.2: Gender Composition of Participants

Gender	Percent
Male	74.5
Female	24.8
Prefer not to say	.7
Total	100.0

Table 3.3: Enrollment Trends by Academic Level

Level Of Study	Percent
Undergraduate	74.2
Graduate	25.8
Total	100.0

Table3.4: Enrollment Figures by Year of Study

Year of study	Percent
1st Year	35.3

2nd Year	26.2
3rd Year	19.7
4th Year	13.9
5th Year or Higher	4.4
Total	99.5

Table3.5: Enrollment of Domestic vs. International Students

Student Status	**Percent**
Domestic Student	57.5
International Student	42.0
Total	99.5

3.2 Exploring Entrepreneurial Aspirations Among Students

The survey data reveals a strong interest in entrepreneurship among students, with over half (57.5%) considering it as a career option (Table 3.6). However, there's a significant gap between this interest and actual venture creation, as only a smaller percentage (27.6%) have started their own businesses (Table 3.7). This disparity suggests a need for targeted educational interventions to support students in bridging the gap between aspiration and business creation.

While nearly half (46.6%) of the students feel prepared to pursue entrepreneurial activities within the next five years, a larger proportion (53.4%) lack this confidence (Table 3.8). This highlights the importance of enhanced educational programs that build entrepreneurial skills and self-assurance.

A significant majority of students (64.3%) have participated in entrepreneurship-related courses and activities, such as hackathons and entrepreneurial events (Table 3.9, Table 3.10). This diverse

engagement enriches their educational experience and prepares them for future entrepreneurial endeavors.

Table 3.6: Student Responses on Considering Becoming an Entrepreneur

consider becoming an entrepreneur	Percent
Yes	57.5
No	42.2
Total	99.8

Table 3.7: Number of Students Who Launched a Startup

initiated a new business	Percent
Yes	27.6
No	72.4
Total	100.0

Table 3.8: Student Confidence in Starting Entrepreneurial Activities Within 5 Years

start business in 5 years	Frequency	Percent	Cumulative Percent
Yes	201	46.6	46.6
No	230	53.4	100.0
Total	431	100.0	

Table 3.9: Participation in Courses and Activities Related to Entrepreneurship

participation in entrepreneurial activity	Percent
Yes	64.3
No	35.7
Total	100.0

Table 3.10: List of Entrepreneurship Courses and Activities Taken by Students

courses or activities	General Cours	Entrepreneurship Courses	Business Courses	Hackathon	Entrepreneurial Activities	Entrepreneurial Events
N	40	160	42	70	202	212

4. Results

4.1 Descriptive Statistics of Entrepreneurship Variables

This section presents the descriptive statistics for key entrepreneurial variables, including EE engagement, EM, ESE, and EI. These statistics provide a foundational understanding of the study population's characteristics, which is crucial for subsequent analyses examining the impact of these factors on engineering students' EIs.

4.1.1 Descriptive Statistics of Entrepreneurship Education (EE)

Analysis of the Entrepreneurship Education Activity (EEA) data revealed a moderate level of participant engagement with entrepreneurship-related activities. The average score was 2.109, indicating a moderate engagement level, with a standard deviation of 2.008, signifying considerable variability in participant responses. The skewness was 0.660, showing a positive asymmetry and a longer tail towards higher scores, suggesting that while the average involvement is moderate, some participants rated their involvement very highly. The kurtosis was -0.788, indicating a flatter distribution, suggesting a broad range of responses and less likelihood of extreme values, which is important for understanding the diverse experiences of students in entrepreneurship activities. For the traditional EE components, scores were higher, with means ranging from 4.28 to 4.64, and standard deviations between 1.405 and 1.517. This indicates generally high average scores with some variation, suggesting a positive overall response with moderate dispersion in the data. These components showed slight negative skewness and minimal kurtosis, suggesting a more symmetrical distribution around higher mean values, indicative of generally positive responses towards the structured EE questionnaire components (Table 4.1).

Table 4.1: Descriptive Statistics of Entrepreneurship Education (EE)

Variable	N	Mean	Std. Deviation	Variance Statistic	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Statistic
EEA	431	2.1090	2.00825	4.033	.660	.118	-.788	.235
Entrepreneurship Education 6	430	4.28	1.405	1.975	-.261	.118	.384	.235
Entrepreneurship Education 7	429	4.64	1.517	2.301	-.430	.118	-.171	.235
Entrepreneurship Education 8	429	4.30	1.467	2.151	-.249	.118	.084	.235

4.1.2 Descriptive Statistics of Entrepreneurial Mindset (EM)

The EM was evaluated across several items, with average scores ranging from 4.25 to 5.77 on a 7-point scale, indicating generally positive attitudes toward entrepreneurial traits. The standard deviations highlight varied responses, particularly in "Entrepreneurial Mindset 10" which showed the highest deviation of 1.711, reflecting diverse perceptions among students. The consistently negative skewness across most items reveals a tendency towards higher agreement with entrepreneurial traits. The negative kurtosis values suggest fewer outliers and a less peaked distribution, facilitating an understanding of the general consensus on the EM among the participants (Table 4.2).

Table 4.2: Descriptive Statistics of Entrepreneurial Mindset (EM)

Variable	N	Mean	Std. Deviation	Variance Statistic	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Statistic
Entrepreneurial Mindset 1	425	5.77	1.134	1.286	-1.156	.118	2.045	.236

Entrepreneurial Mindset 2	424	5.33	1.210	1.465	-.527	.119	-.011	.237
Entrepreneurial Mindset 3	422	5.27	1.216	1.479	-.517	.119	.040	.237
Entrepreneurial Mindset 4	421	5.07	1.395	1.945	-.531	.119	-.133	.237
Entrepreneurial Mindset 5	424	5.03	1.326	1.758	-.171	.119	-.587	.237
Entrepreneurial Mindset 6	424	5.63	1.194	1.425	-.801	.119	.313	.237
Entrepreneurial Mindset 7	424	5.08	1.384	1.916	-.495	.119	-.202	.237
Entrepreneurial Mindset 8	424	5.12	1.292	1.669	-.346	.119	-.442	.237
Entrepreneurial Mindset 9	424	5.06	1.316	1.731	-.401	.119	-.452	.237
Entrepreneurial Mindset 10	424	4.25	1.711	2.929	-.182	.119	-.929	.237
Entrepreneurial Mindset 11	421	4.78	1.610	2.593	-.376	.119	-.674	.237
Entrepreneurial Mindset 12	424	5.15	1.354	1.834	-.455	.119	-.142	.237

4.1.3 Descriptive Statistics of Entrepreneurial Self-Efficacy (ESE)

Descriptive statistics for ESE indicate the confidence levels of engineering students in their ability to perform entrepreneurship-related tasks. The average scores are moderately high, ranging from 4.61 for ESE 4 to 5.43 for ESE 3, suggesting a generally positive self-assessment of entrepreneurial abilities. The standard deviations, which vary from 1.263 to 1.549, indicate moderate variability in responses, reflecting differences in individual confidence levels. The skewness values, predominantly negative, show a confidence spread skewed towards higher scores, suggesting that most students feel capable of performing entrepreneurial tasks (Table 4.3).

Table 4.3: Descriptive Statistics of Entrepreneurial Self-Efficacy (ESE)

Variable	N	Mean	Std. Deviation	Variance Statistic	Skewness		Kurtosis	
					Statistic	Std. Error	Statistic	Statistic
Entrepreneurial Self-Efficacy 1	419	4.70	1.501	2.254	-.441	.119	-.221	.238
Entrepreneurial Self-Efficacy 2	420	4.69	1.446	2.092	-.371	.119	-.288	.238
Entrepreneurial Self-Efficacy 3	420	5.43	1.263	1.596	-.933	.119	1.057	.238
Entrepreneurial Self-Efficacy 4	420	4.61	1.549	2.401	-.150	.119	-.696	.238

4.1.4 Descriptive Statistics Entrepreneurial Intention (EI)

The average scores for students' EIs ranged from 4.16 to 4.47, indicating a generally positive inclination towards entrepreneurship. However, the standard deviations were relatively high, ranging from 1.816 to 2.009, suggesting significant variability in the intensity of EIs among the students. This variability was also reflected in the notably high variance figures, illustrating the broad range of responses. All six components showed negative skewness, ranging from -0.068 to -0.349, suggesting a concentration of responses at the higher end of the scale, albeit with a few lower outliers. Kurtosis values were negative for all components, indicating flatter distributions compared to a normal distribution. This pattern suggests that while a majority of students are inclined towards entrepreneurship, there is a significant subset whose intentions may be less strong, highlighting potential areas for targeted educational interventions to enhance entrepreneurial drive (Table 4.4).

Table 4.4: Descriptive Statistics Entrepreneurial Intention (EI)

Variable	N	Mean		Variance	Skewness	Kurtosis

			Std. Deviation	Statistic	Statistic	Std. Error	Statistic	Statistic
Entrepreneurial Intention 1	418	4.23	1.816	3.298	-.179	.119	-.919	.238
Entrepreneurial Intention 2	418	4.16	1.957	3.831	-.068	.119	-1.181	.238
Entrepreneurial Intention 3	418	4.34	1.945	3.784	-.275	.119	-1.031	.238
Entrepreneurial Intention 4	417	4.47	1.964	3.855	-.349	.120	-.984	.238
Entrepreneurial Intention 5	418	4.36	1.992	3.968	-.280	.119	-1.102	.238
Entrepreneurial Intention 6	418	4.36	2.009	4.035	-.275	.119	-1.102	.238

The descriptive analysis highlights a generally positive entrepreneurial outlook among participants, characterized by moderate to high engagement and confidence. However, the diverse responses, especially concerning EIs, suggest opportunities for educational programs to improve entrepreneurial traits and motivations. This data serves as a foundation for subsequent research on effective interventions in EE.

4.2 Initial Insights from Pre-questionnaire Analysis

A preliminary reliability analysis of the pre-questionnaire identified several items for potential removal to enhance the internal consistency of the measurement scales. Items with low corrected item-total correlations, indicating weak associations within their respective scales, were considered for deletion. Specifically, the removal of item EE2 from the Entrepreneurship Education scale, which had a corrected item-total correlation of 0.159, improved the scale's Cronbach's Alpha from 0.768 to 0.798. Similarly, items EM3 and EM13, with corrected item-total correlations of 0.049 and 0.088 respectively, were removed from the Entrepreneurial Mindset scale, increasing its Cronbach's Alpha from 0.815 to 0.836. These adjustments were crucial for ensuring the scales' accuracy in measuring the intended constructs and enhancing the validity and

reliability of the study's results. Table 4.5, presents the Cronbach's Alpha values after these deletions, confirming the improved reliability of the final questionnaire.

Table 4.5: Cronbach's Alpha Values for Pre-Questionnaire After Item Deletion

Variable	N	Cronbach's Alpha
Entrepreneurship Education	8	0.798
Entrepreneurial Mindset	12	0.836
Entrepreneurial Self-Efficacy	4	0.812
Entrepreneurial Intention	6	0.946

4.3 Assessment of Survey Reliability Using Cronbach's Alpha

The internal consistency of our measurement tools was high, as demonstrated by Cronbach's alpha. This was particularly true for the EI scale, confirming that our tools were reliable and appropriate for this study (Table 4.6).

Table 4.6: Cronbach's Alpha Values for the Final Questionnaire

Variable	N	Cronbach's Alpha
Entrepreneurship Education	8	0.742
Entrepreneurial Mindset	12	0.839
Entrepreneurial Self-Efficacy	4	0.868
Entrepreneurial Intention	6	0.962

4.4 KMO and Bartlett's Test for Suitability of Factor Analysis

To examine the underlying structure of the constructs, an Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA).

The suitability of the dataset for factor analysis was assessed using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The KMO values ranged from 0.714 to 0.910, indicating moderate to high sampling adequacy. Bartlett's Test of Sphericity was significant ($p < 0.001$) across all constructs, confirming the suitability of factor analysis.

Communalities after extraction ranged from 0.277 to 0.892, suggesting sufficient shared variance for variable retention. These results validate the construct validity of the scales and provide a strong empirical foundation for further analyses.

4.4.1 KMO and Bartlett's Test of Entrepreneurship Education (EE)

To assess the suitability of data for factor analysis in a study on EE, the KMO Measure of Sampling Adequacy and Bartlett's Test of Sphericity were conducted. The KMO value of 0.714 indicated good sampling adequacy, meaning the data was appropriate for detecting underlying structures. Bartlett's Test of Sphericity yielded a chi-square of 584.589 with 6 degrees of freedom and a significance level of less than 0.001. This highly significant result confirmed that the variables were related and not simply random, further supporting the use of factor analysis to identify key aspects of EE (Table 4.7).

Table 4.7: KMO and Bartlett's Test of Entrepreneurship Education (EE)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.714
Bartlett's Test of Sphericity	**Approx. Chi-Square**	584.589
	df	6
	Sig.	.000

4.4.2 KMO and Bartlett's Test of Entrepreneurial Mindset (EM)

The KMO value of 0.863 demonstrated excellent sampling adequacy, indicating a low sum of partial correlations and confirming the data's suitability for structure detection via factor analysis. Furthermore, Bartlett's Test of Sphericity yielded a highly significant result ($\chi^2 = 1788.842$, $df = 66$, $p < .001$), thus rejecting the null hypothesis of an identity matrix and confirming the variables' intercorrelation. These findings substantiate the use of factor analysis to identify the underlying factors influencing EM among engineering students (Table 4.8).

Table 4.8: KMO and Bartlett's Test of Entrepreneurial Mindset (EM)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.863
Bartlett's Test of Sphericity	**Approx. Chi-Square**	1788.842
	df	66
	Sig.	.000

4.4.3 KMO and Bartlett's Test of Entrepreneurial Self-Efficacy (ESE)

KMO measure for ESE was 0.809, categorized as "great," indicating a sufficient proportion of variance attributable to underlying factors for reliable analysis. This suggests an adequate sample size and strong interrelationships among variables, suitable for factor analysis. Bartlett's Test of Sphericity yielded a significant chi-square of 844.788 (df=6, p<.001), rejecting the null hypothesis of an identity matrix. This confirms the correlation matrix's suitability for factor analysis, supporting the exploration of underlying dimensions within ESE (Table 4.9).

Table 4.9: KMO and Bartlett's Test of Entrepreneurial Self-Efficacy (ESE)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.809
Bartlett's Test of Sphericity	**Approx. Chi-Square**	844.788
	df	6
	Sig.	.000

4.4.4 KMO and Bartlett's Test of Entrepreneurial Intention (EI)

A KMO measure of 0.910 was obtained, indicating an outstanding level of sampling adequacy. Bartlett's Test of Sphericity further supported this, yielding a highly significant chi-square value ($\chi^2 = 3030.479$, df = 15, $p < .001$). This result decisively rejected the null hypothesis of an identity matrix, confirming the presence of underlying relationships among the variables and validating the suitability of the correlation matrix for factor analysis (Table 4.10).

Table 4.10: KMO and Bartlett's Test of Entrepreneurial Intention (EI)

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.910

Bartlett's Test of Sphericity	**Approx. Chi-Square**	3030.479
	df	15
	Sig.	.000

4.5 Comparative Analysis Using T-Test

An independent samples t-test was conducted to compare EIs between students with prior involvement in entrepreneurial activities (Involved) and those without (Not Involved). The results showed a statistically significant difference between the two groups ($t(429) = -6.484$, $p < .000$, Cohen's $d = 1.693$). The Involved group ($M = 4.616$, $SD = 1.715$) had significantly higher EI scores than the Not Involved group ($M = 3.371$, $SD = 1.618$). The large effect size (Cohen's $d = 1.693$) highlights the substantial positive impact of prior entrepreneurial involvement on fostering stronger EIs among engineering students.

In essence, these findings indicate that prior involvement in entrepreneurial activities has a significant and positive effect on the EIs of engineering students (Tables 4.11,12,13).

Table 4.11: Table Group Statistics

Variable	**EEE.**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
EI. Total	**Not involved**	102	3.3717	1.61873	.16028
	involved	329	4.6160	1.71564	.09459

Table 4.12: Independent Samples Test

Variable	**Levene's Test for Equality of Variances**	**t-test for Equality of Means**	**95% Confidence Interval of the Difference**

		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
EI. Total	**Equal variances assumed**	.172	.678	-6.484	429	.000	-1.24428	.19190	-1.62146	-.86709
	Equal variances not assumed			-6.686	176.990	.000	-1.24428	.18611	-1.61155	-.87700

Table 4.13: Independent Samples Effect Sizes

Variable		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
EI.Total	**Cohen's d**	1.69333	-.735	-.962	-.507
	Hedges' correction	1.69629	-.734	-.960	-.506
	Glass's delta	1.71564	-.725	-.954	-.496

4.6 Methodological Framework for Evaluating Educational Impact on Entrepreneurial Intentions

In the methodology section of the thesis, the analysis of the EE variable was conducted using the AMOS software, a powerful Structural Equation Modeling (SEM) tool, to evaluate the psychometric properties of the instruments used. This analysis provided insights into the factor loadings, Composite Reliability (CR), and significance of the items in the EE questionnaires.

4.6.1 Structural Evaluation of EE Components Using AMOS

The factor loadings of items demonstrated a strong relationship with the EE construct. Additionally, high Composite Reliability (CR) values confirmed the reliability of the measurement model. The statistical significance of each item further validated their effectiveness in measuring key aspects of EE (see Figure 4.1 and Table 4.14). The findings indicate that the various components of EE demonstrate statistical validity and, taken together, support the conceptualization of EE as a multi-dimensional construct in the model.

Figure 4.1: AMOS Model – Components of Entrepreneurship Education

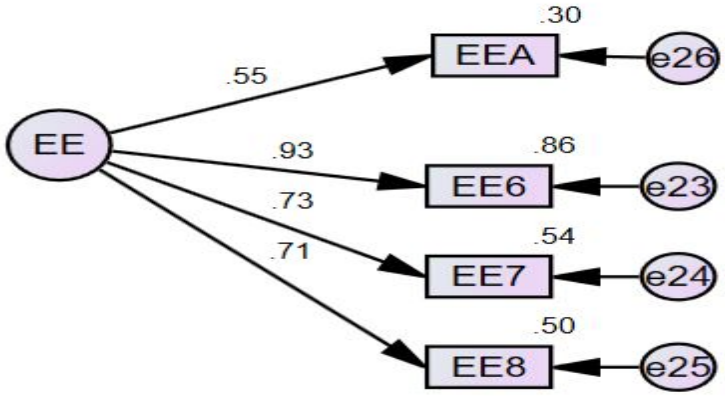

Table 4.14: Statistical Results of AMOS Analysis for Entrepreneurship Education Components

Question	Factor loading	C.R	P.Value
EEA	0.547		Significant
EE6	0.930	7.970	Significant
EE7	0.732	7.242	Significant
EE8	0.709	7.072	Significant

4.6.2 Structural Evaluation of EM Components Using AMOS

The factor loadings were all within an acceptable range, demonstrating strong relationships between the items and their respective constructs, with particularly notable loadings for EM8 (0.769) and EM7 (0.711). The Composite Reliability (CR) values were satisfactory, indicating good reliability for items. All items were statistically significant, confirming their effectiveness in measuring key aspects of EM. The removal of EM11, due to poor factor loading (1.73) and a negative impact on model fit, improved the measurement model's precision. Overall, this analysis demonstrates the questionnaire's ability to effectively capture essential elements of an EM (see Figure 4.2 and Table 4.15). The analysis confirms that EM is a coherent and reliable construct, strengthening the foundation for its proposed mediating role between EE and EI.

Figure 4.2: AMOS Model – Entrepreneurial Mindset Components

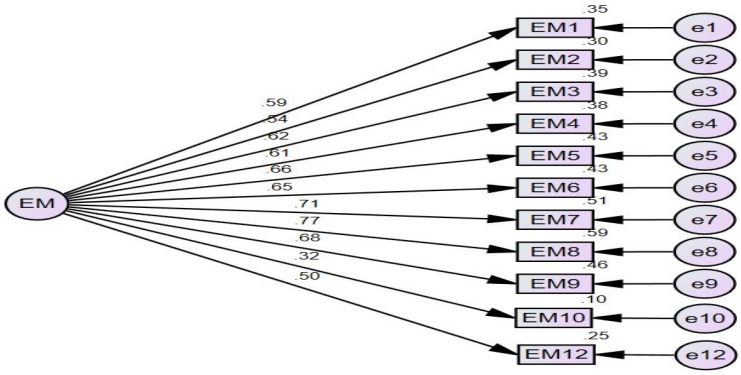

Table 4.15: Statistical Results of AMOS Analysis for Entrepreneurial Mindset Components

Question	Factor loading	C.R	P.Value
EM1	0.589		Significant
EM2	0.545	9.380	Significant
EM3	0.624	10.388	Significant
EM4	0.614	10.304	Significant
EM5	0.659	10.846	Significant
EM6	0.655	10.751	Significant
EM7	0.711	11.380	Significant
EM8	0.769	11.965	Significant
EM9	0.681	11.053	Significant

EM10	0.317	5.604	Significant
EM12	0.500	8.683	Significant

4.6.3 Structural Evaluation of ESE Components Using AMOS

High factor loadings for ESE1 (0.843) and ESE2 (0.902) indicated a strong correlation with the ESE construct. Excellent Composite Reliability (CR) values, such as 21.243 for ESE2, further confirmed reliability. The statistical significance of all items validated their role in measuring key aspects of ESE. This analysis supports the questionnaire's effectiveness in accurately assessing the essential attributes of ESE (see Figure 4.3 and Table 4.16). The results validate ESE as a distinct, measurable factor, supporting its hypothesized mediating role between EE and EI.

Figure 4.3: AMOS Model – Entrepreneurial Self-Efficacy Components

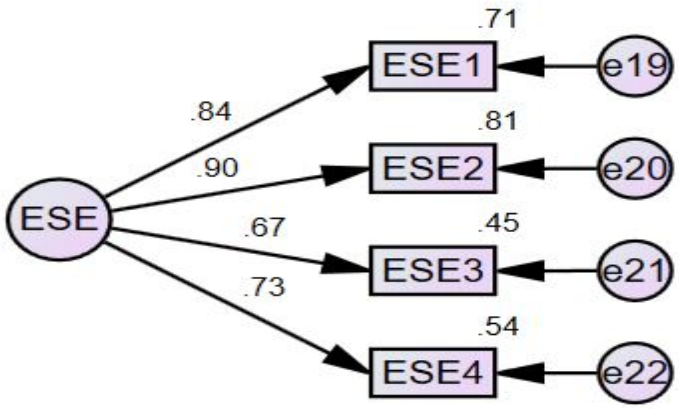

Table 4.16: Statistical Results of AMOS Analysis for Entrepreneurial Self-Efficacy Components

Question	Factor loading	C.R	P.Value
ESE1	0.843		Significant
ESE2	0.902	21.243	Significant
ESE3	0.673	15.083	Significant
ESE4	0.732	16.868	Significant

4.6.4 Structural Evaluation of EI Components Using AMOS

The factor analysis revealed strong correlations between the items and the EI construct, as evidenced by high factor loadings. Excellent Composite Reliability (CR) values confirmed the reliability of these items. All items were statistically significant, demonstrating their effectiveness in measuring key components of EI. This analysis confirms the questionnaire's ability to accurately capture the essential dimensions of EI (see Figure 4.4 and Table 4.17). The findings show that EI was consistently and reliably measured, bolstering confidence in its role as the central outcome variable in this study.

Figure 4.4: AMOS Model – Entrepreneurial Intention Components

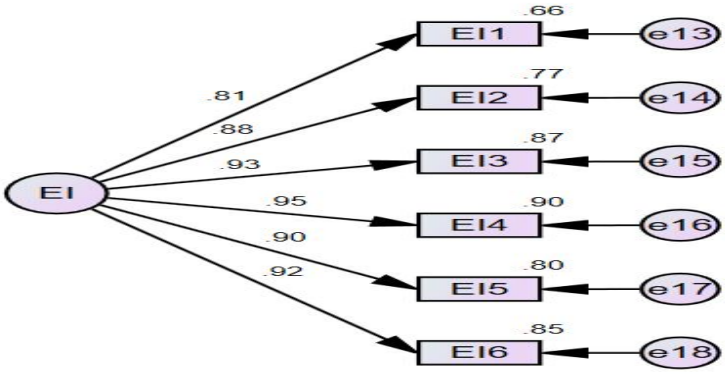

Table 4.17: Statistical Results of AMOS Analysis for Entrepreneurial Intention Components

Question	Factor loading	C.R	P.Value
EI1	0.811		Significant
EI2	0.876	22.419	Significant
EI3	0.933	24.803	Significant
EI4	0.949	25.559	Significant
EI5	0.896	23.241	Significant
EI6	0.921	24.304	Significant

4.6.5 Exploring the Relationships Between EE and EI Using Structural Equation Modeling

The model demonstrated a good fit to the data. Several fit indices supported this conclusion: The Comparative Fit Index (CFI = 0.994), Tucker-Lewis Index (TLI = 0.989), Incremental Fit Index (IFI = 0.994), Relative Fit Index (RFI = 0.977), and Normed Fit Index (NFI = 0.988) all exceeded the 0.90 threshold, indicating an excellent fit. The model demonstrates good fit and statistical significance with a Root Mean Square Error of Approximation (RMSEA) of 0.048 and a significant p-value. This supports Hypothesis 1, suggesting that EE positively influences EI among engineering students (see Figure 4.5 and Table 4.18).

Figure 4.5: Structural Model Connecting Education Components to Entrepreneurial Intention

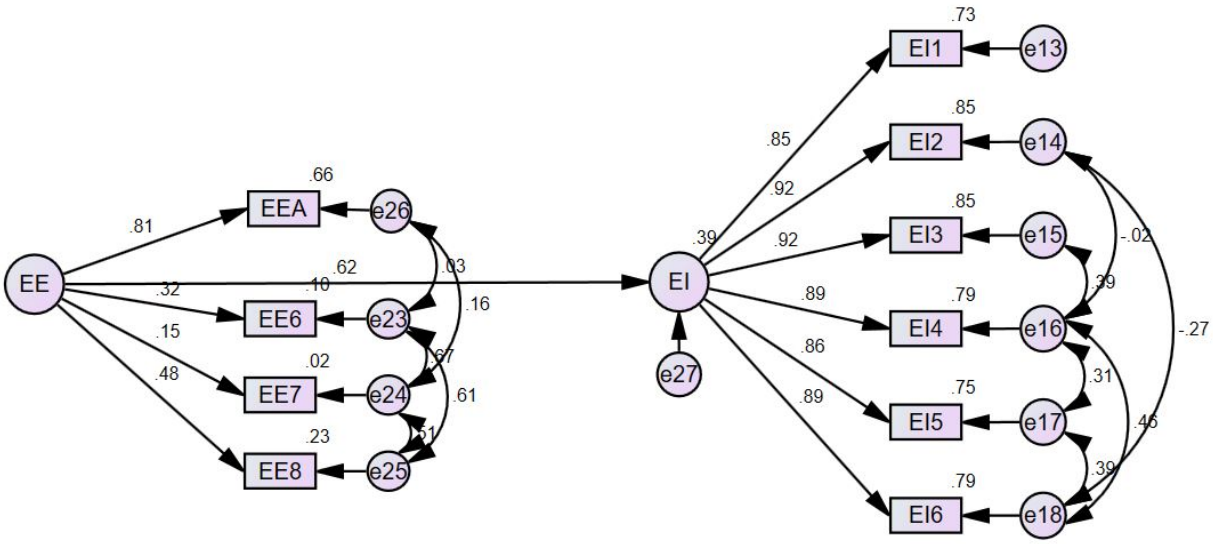

Table 4.18: Statistical Analysis of Entrepreneurship Education and Entrepreneurial Intention Model

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
45.563	23	1.981	0.994	0.989	0.994	0.977	0.988	0.106	0.048	Significant

4.6.6 Assessing the Mediating Role of EM Between EE and EI

The model demonstrates a good fit to the data, supported by several goodness-of-fit indices. A significant Chi-square value of 927.319 with 362 degrees of freedom indicates a good fit. This is further supported by the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Incremental Fit Index (IFI), which all exceed 0.9, suggesting a strong model fit. The Root Mean Square Error of Approximation (RMSEA) is 0.045, a value considered excellent as it falls below the 0.05 threshold, further confirming the model's goodness-of-fit (see Figure 4.6 and Table 4.19). These results robustly support Hypothesis 2, demonstrating that an EM acts as a positive mediator in the relationship between EE and EI.

Figure 4.6: Structural Equation Model – Education, Mindset, and Intention

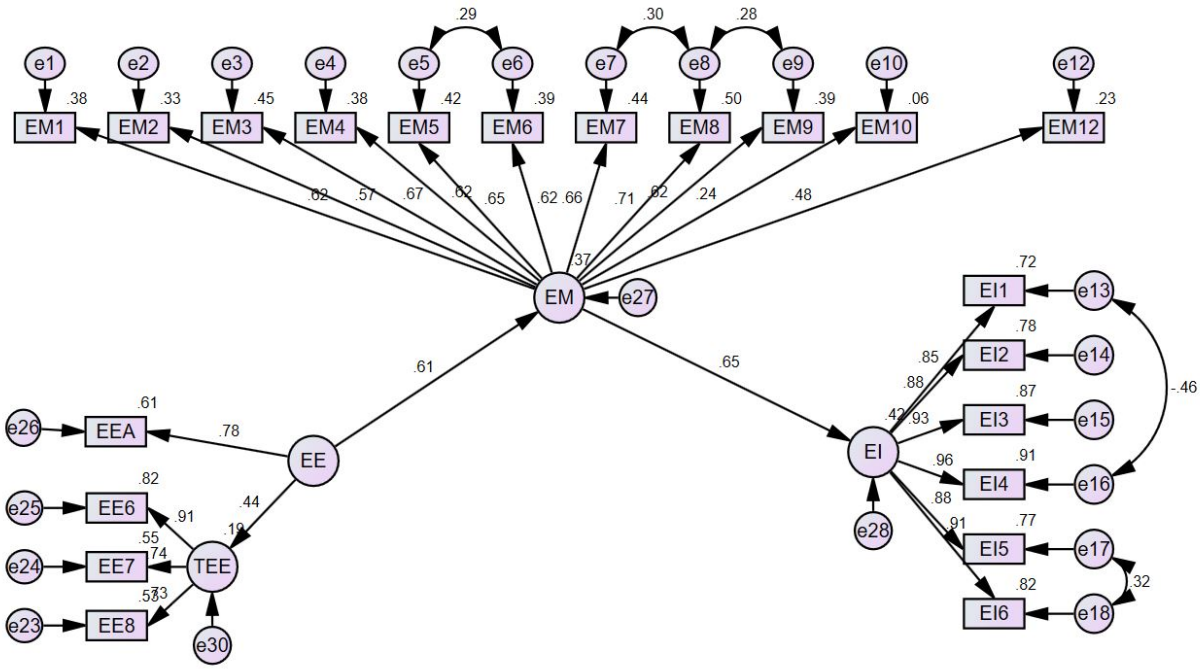

Table 4.19: SEM Model Summary: Path Coefficients and Goodness-of-Fit Indices for EE, EM, and EI

CMIN	DF	CMIN / DF	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
927.319	362	2.562	0.944	0.935	0.944	0.897	0.911	1.223	0.045	Significant

4.6.7 Assessing the Mediating Role of ESE Between EE and EI

The model demonstrates a good fit with the data, as evidenced by multiple goodness-of-fit indices. The Chi-Square value (CMIN) is 363.372 with 138 degrees of freedom, resulting in a Chi-Square to degrees of freedom ratio of 2.633, which indicates a reasonably good fit. Furthermore, key indices such as the Comparative Fit Index (CFI = 0.958), Tucker-Lewis Index (TLI = 0.951), and Incremental Fit Index (IFI = 0.958) all exceed 0.95, demonstrating a strong fit. The Root Mean Square Error of Approximation (RMSEA) is 0.046, falling below the 0.05 threshold, which suggests a close fit between the model and the observed data. The model's statistical significance is confirmed by a significant P-value. Overall, these results indicate that the model effectively represents the relationships within the data, satisfying conventional fit criteria (see Figure 4.7 and Table 4.20). These indices provide substantial evidence supporting Hypothesis 3, which posits that ESE positively mediates the relationship between EE and EI.

Figure 4.7: Structural Equation Model – Education, Self-Efficacy, and Intention

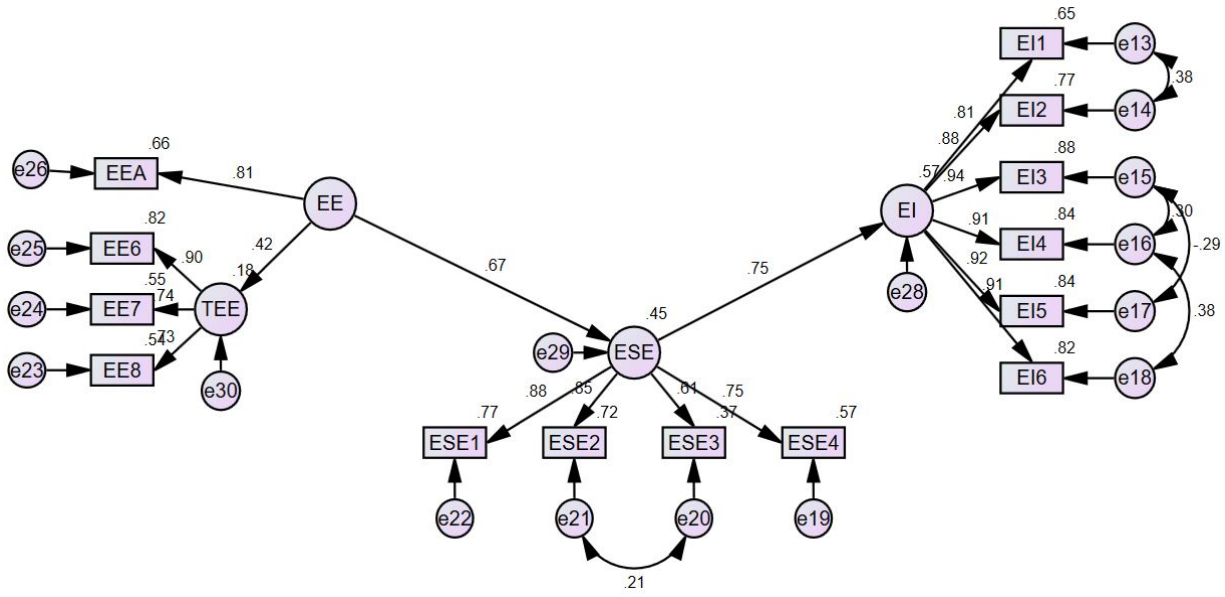

Table 4.20: SEM Model Summary: Path Coefficients and Goodness-of-Fit Indices for EE, ESE, and EI

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
363.372	138	2.633	0.975	0.967	0.975	0.947	0.960	0.479	0.046	Significant

4.7 Supplementary Analyses

4.7.1 Exploring the Relationships Between EE and EM Using Structural Equation Modeling

The chi-square statistic (χ^2) is 242.675 with 81 degrees of freedom, indicating the overall fit of the model. The Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Incremental Fit Index (IFI) values are 0.930, 0.909, and 0.930, respectively, suggesting a good fit as these values are close to 1. The Root Mean Square Error of Approximation (RMSEA) is 0.068, which falls within an acceptable range, typically considered good if below 0.08. The model shows significant results, suggesting that the hypothesized model adequately fits the data according to the indices provided (see Figure 4.8 and Table 4.21). EE is found to have a significant direct impact on EM, which supports EE's role in influencing students' ways of thinking.

Figure 4.8: Structural Model – Education and Entrepreneurial Mindset

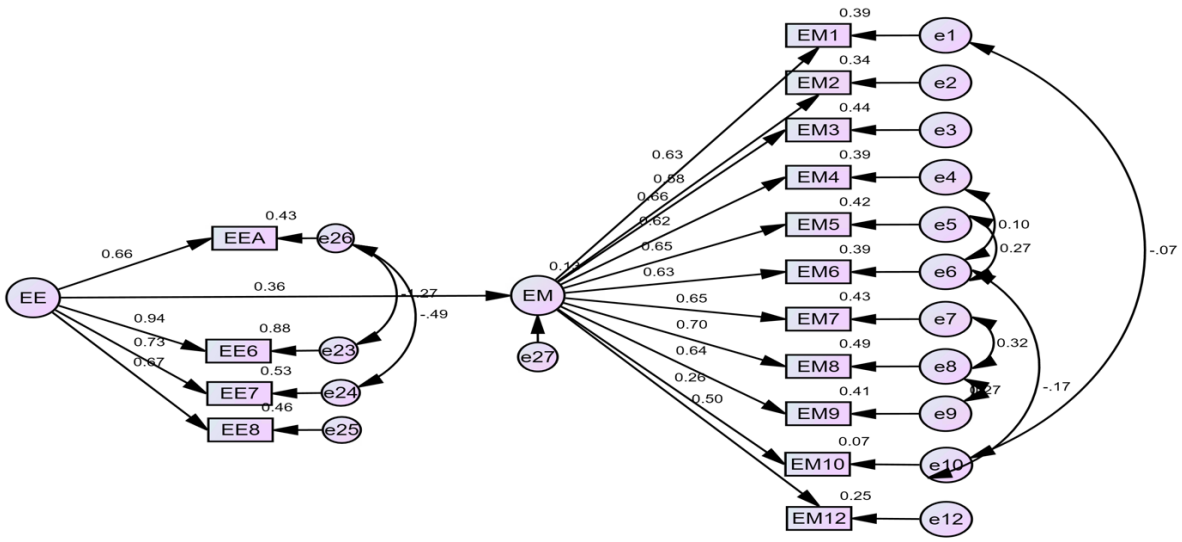

Table 4.21: Statistical Analysis of Entrepreneurship Education and Entrepreneurial Mindset Model

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
242.675	81	2.996	0.930	0.909	0.930	0.869	0.899	0.564	0.068	Significant

4.7.2 Exploring the Relationships Between EE and ESE Using Structural Equation Modeling

The significant chi-square statistic (χ^2 = 88.032) with 15 degrees of freedom indicates that the model fits the data well, although the chi-square/degrees of freedom ratio (CMIN/DF) of 5.869 is somewhat high. Several fit indices support the model's goodness-of-fit: the Comparative Fit Index (CFI = 0.954), Tucker-Lewis Index (TLI = 0.931), Incremental Fit Index (IFI = 0.954), Relative Fit Index (RFI = 0.897), and Normed Fit Index (NFI = 0.944) all exceed the acceptable threshold of 0.90. However, the Root Mean Square Error of Approximation (RMSEA = 0.106) is higher than the desired level. Overall, the model shows a good fit across most indices (see Figure 4.9 and Table 4.22). The analysis demonstrates that EE significantly boosts ESE, confirming that educational experiences increase students' confidence in their entrepreneurial abilities.

Figure 4.9: Structural Model – Education and Entrepreneurial Self-Efficacy

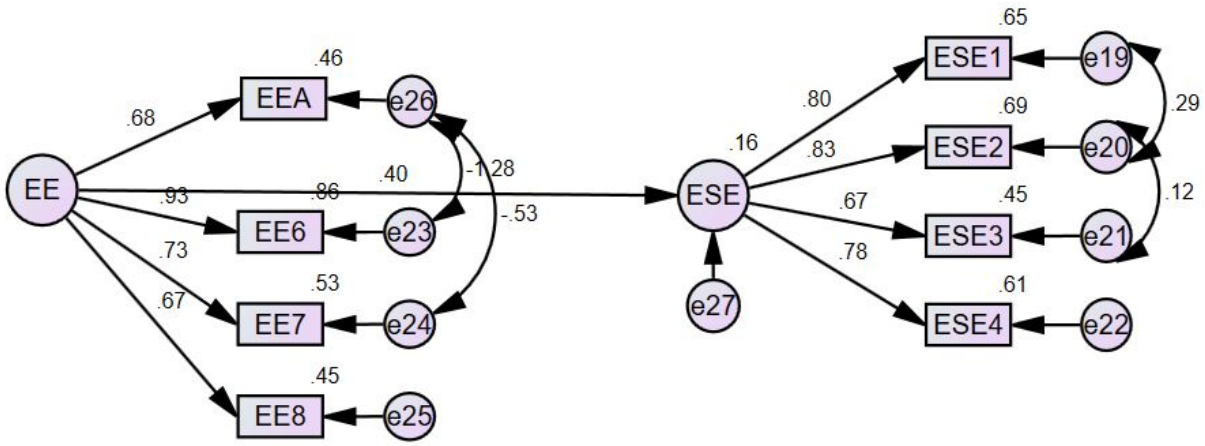

Table 4.22: Statistical Analysis of Entrepreneurship Education and Entrepreneurial Self-Efficacy Model

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
88.032	15	5.869	0.954	0.913	0.954	0.897	0.945	0.205	0.106	Significant

4.7.3 Exploring the Relationships Between EM and EI Using Structural Equation Modeling

The model demonstrates a good fit to the data, as evidenced by various goodness-of-fit indices. With a chi-square value of 286.286 and 103 degrees of freedom, the chi-square/df ratio is 2.779, indicating a reasonable fit. Furthermore, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Incremental Fit Index (IFI), Relative Fit Index (RFI), and Normed Fit Index (NFI) all show values close to or above 0.9, further supporting the model's goodness-of-fit. The Root Mean Square Error of Approximation (RMSEA) is 0.064, which falls within the acceptable range, and the model's statistical significance is confirmed by a significant p-value. Overall, these results suggest that the model adequately represents the relationships within the data (see Figure 4.10 and Table 4.23). The findings indicate a strong positive relationship between EM and EI, emphasizing the role of mindset as a crucial factor in shaping students' EI.

Figure 4.10: Structural Model – Mindset and Entrepreneurial Intention

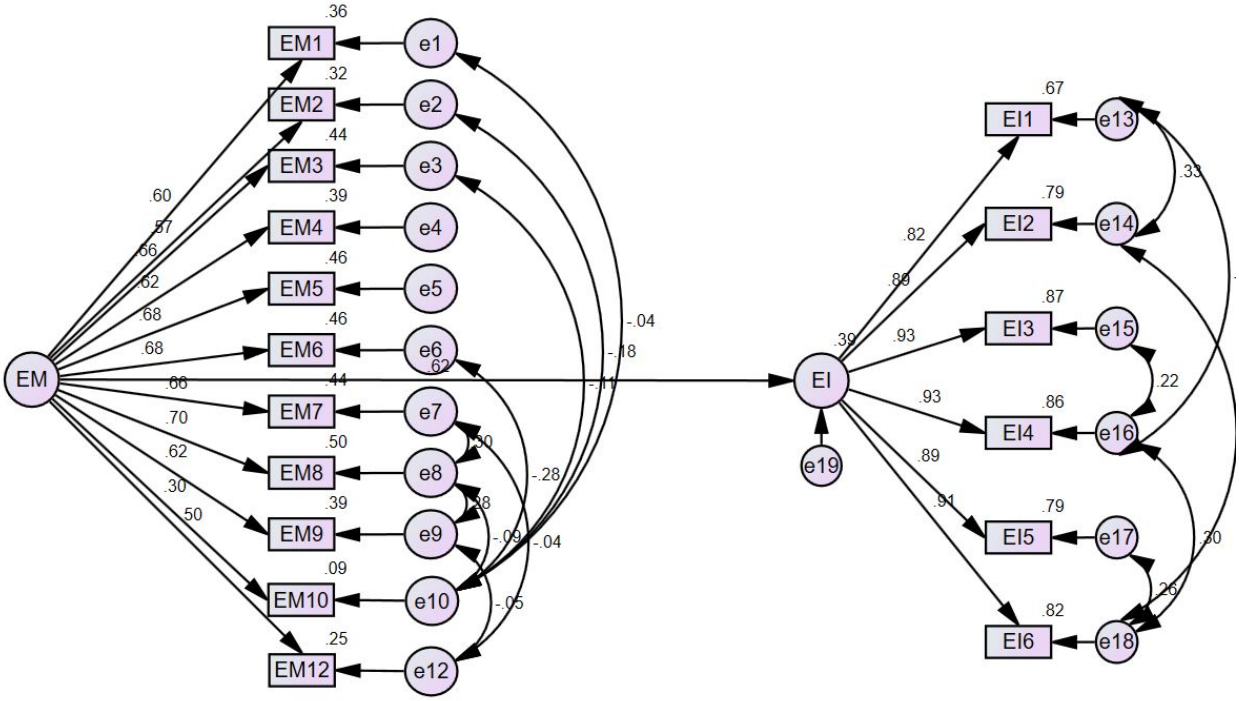

Table 4.23: Statistical Analysis of Entrepreneurial Mindset and Entrepreneurial Intention

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
286.286	103	2.779	0.963	0.951	0.963	0926	0.944	0.666	0.064	Significant

4.7.4 Exploring the Relationships Between ESE and EI Using Structural Equation Modeling

The model exhibits a good fit to the observed data, supported by several goodness-of-fit indices. While the Chi-Square value of 286.286 with 103 degrees of freedom suggests a moderate fit, other indices indicate a stronger fit. The Comparative Fit Index (CFI = 0.963), Tucker-Lewis Index (TLI = 0.951), and Incremental Fit Index (IFI = 0.963) all demonstrate very good to excellent model fit. The Relative Fit Index (RFI = 0.926) and Normed Fit Index (NFI = 0.944) also fall within a good range. Furthermore, the Root Mean Square Error of Approximation (RMSEA = 0.064) is considered good, and its significance further supports a satisfactory model fit. Overall, these indices collectively suggest that the model effectively represents the relationships within the data (see Figure 4.11 and Table 4.24). The study shows that higher ESE significantly predicts stronger EI, emphasizing the importance of self-belief in entrepreneurial pursuits.

Figure 4.11: Structural Model – Self-Efficacy and Entrepreneurial Intention

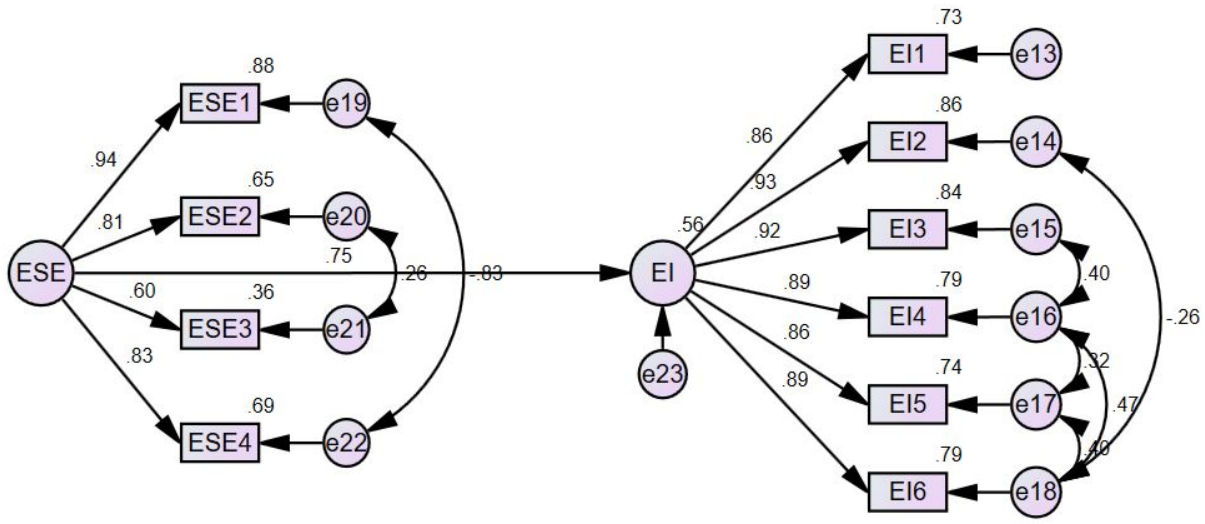

Table 4.24: Statistical Analysis of Entrepreneurial Self-Efficacy and Entrepreneurial Intention

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
68.802	27	2.548	0.990	0.984	0.990	0.974	0.984	0.160	0.060	Significant

4.7.5 Comprehensive Structural Equation Modeling of the Interrelationships Between EE, EM, ESE, and EI in Engineering

The structural equation model (SEM) demonstrated a good fit to the data. A Chi-Square value (CMIN) of 1519.762 with 536 degrees of freedom resulted in a CMIN/DF ratio of 2.835, indicating a reasonable fit. The Comparative Fit Index (CFI = 0.921) and Tucker-Lewis Index (TLI = 0.912) were both close to the 0.90 threshold, suggesting a robust model. The Incremental Fit Index (IFI = 0.921) and Normed Fit Index (NFI = 0.870) also showed satisfactory results. Furthermore, the Root Mean Square Error of Approximation (RMSEA = 0.049), well below the 0.08 threshold, indicated a very good fit. These results validate the SEM model's accuracy in capturing the relationships among the variables within the engineering student population (see Figure 4.12 and Table 4.25). This comprehensive model demonstrates the interconnected nature of EE, EM, ESE,

and EI, revealing that both mindset and self-efficacy act as crucial pathways connecting education to intention.

Figure 4.12: Detailed Model – EE, EM, ESE, and EI in Engineering Students

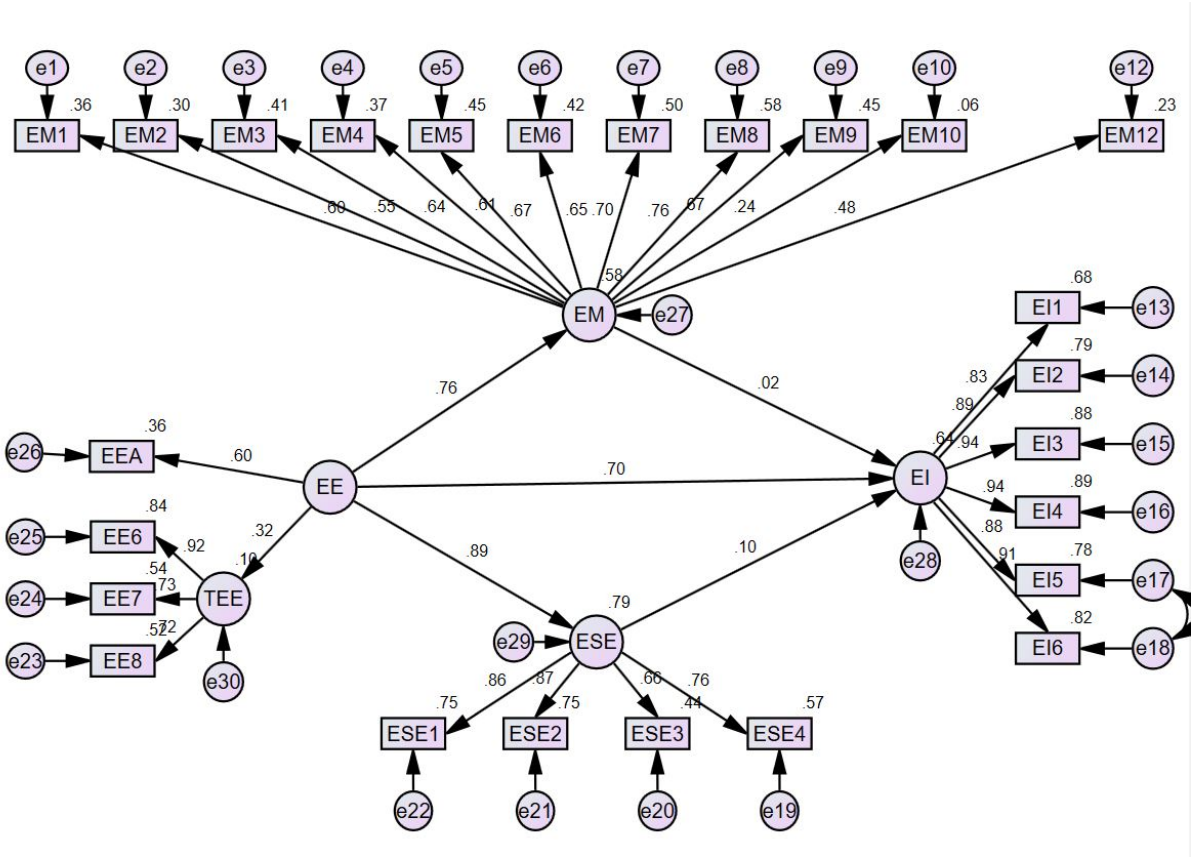

Table 4.25: SEM Analysis Results: Path Coefficients, Mediation Effects, and Fit Statistics for the Comprehensive Model

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
1519.762	536	2.835	0.921	0.912	0.921	0.870	0.884	2.005	0.049	Significant

4.7.6 Comprehensive Structural Equation Modeling of the Interrelationships Between EE, EM, ESE, and EI in Engineering Students Involved in Entrepreneurial Activity

The adequacy of the structural equation model was assessed using a range of fit indices. The model demonstrated an acceptable fit, as indicated by a Root Mean Square Error of Approximation

(RMSEA) of 0.049. Furthermore, the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Incremental Fit Index (IFI) all met or exceeded the commonly accepted criterion of 0.90, suggesting a good fit to the data. The model's overall significance was supported by a p-value of 0.049, indicating statistically significant associations between the hypothesized relationships between educational components and entrepreneurial outcomes among engineering students (see Figure 4.13 and Table 4.26). The model indicates that for students involved in entrepreneurship activities, the relationships among EE, EM, ESE, and EI are stronger, suggesting that experiential learning enhances the educational impact.

Figure 4.13: Detailed Model – EE, EM, ESE, and EI in Students Engaged in EEA

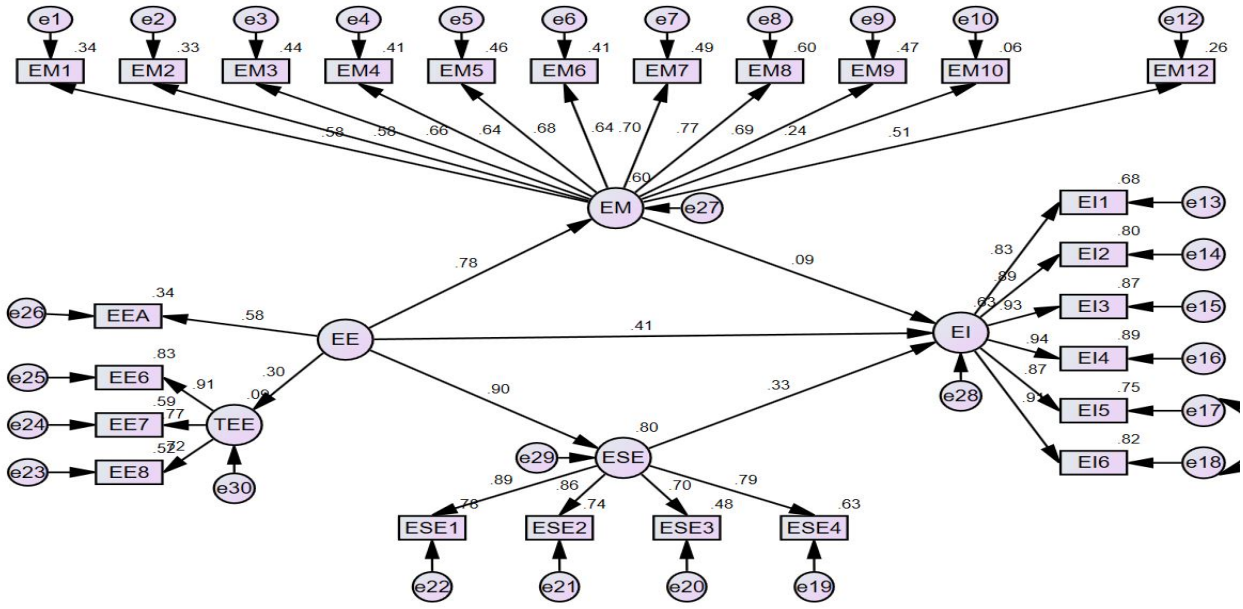

Table 4.26: SEM Analysis Results: Path Coefficients, Mediation Effects, and Fit Statistics for the Comprehensive Model

CMIN	DF	CMIN / DF	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
1519.762	536	2.835	0.921	0.912	0.921	0.870	0.884	2.005	0.049	Significant

4.7.7 Comprehensive Structural Equation Modeling of the Interrelationships Between EE, EM, ESE, and EI in Engineering Students Not Involved in Entrepreneurial Activity

The model generally demonstrates a good fit to the data, although some indices suggest potential areas for improvement. The chi-square value of 363.822 with 243 degrees of freedom results in a CMIN/DF ratio of 1.497, indicating a reasonable fit. Several fit indices support the model's goodness-of-fit: the Comparative Fit Index (CFI = 0.902), Tucker-Lewis Index (TLI = 0.891), and Incremental Fit Index (IFI = 0.903) are all above 0.89, suggesting a good fit. The Root Mean Square Error of Approximation (RMSEA = 0.070) with a significant p-value also supports the model's adequacy. However, the Relative Fit Index (RFI = 0.728) and Normed Fit Index (NFI = 0.760) are relatively low, indicating that some aspects of the model could be refined to improve its fit (see Figure 4.14 and Table 4.27). Among students who haven't yet participated in entrepreneurial activities, the relationships between the studied variables are still significant but less strong, suggesting that practical experience may amplify the influence of EE on mindset, self-efficacy, and intention.

Figure 4.14: Detailed Model – EE, EM, ESE, and EI in Students Not Engaged in EEA

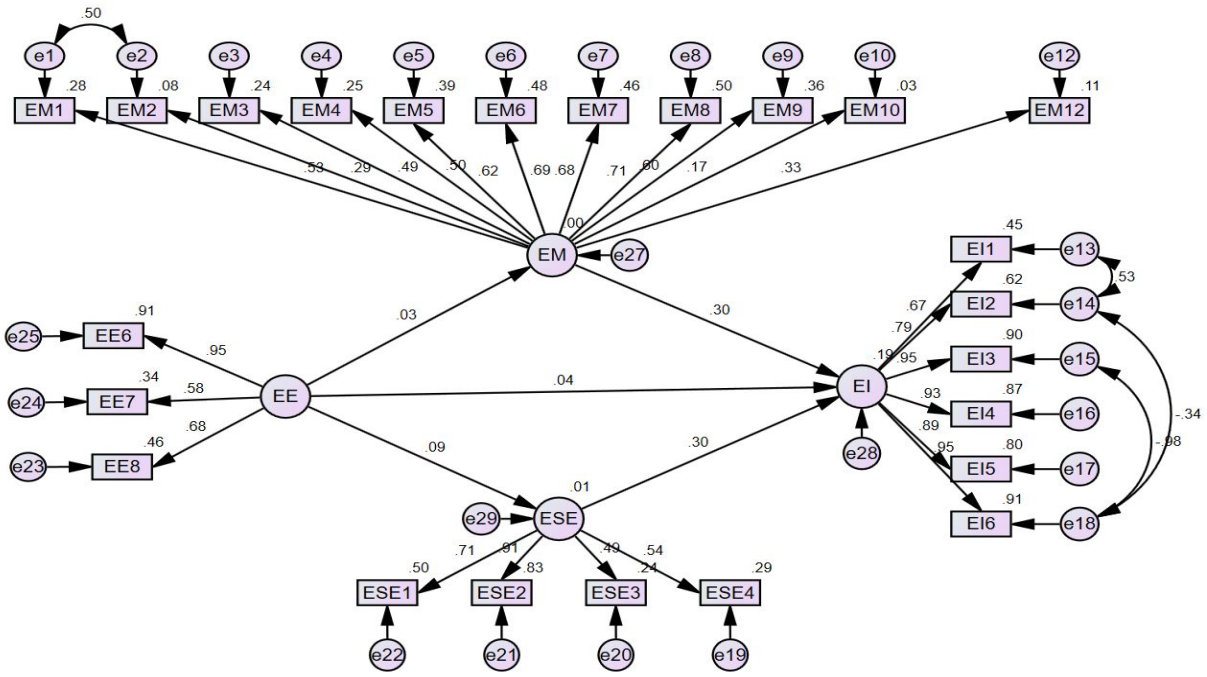

Table 4.27: SEM Analysis Results: Path Coefficients, Mediation Effects, and Fit Statistics for the Comprehensive Model

CMIN	DF	$\frac{\text{CMIN}}{\text{DF}}$	CFI	TLI	IFI	RFI	NFI	FMIN	RMSEA	P.Value
363.822	243	1.497	0.903	0.890	0.905	0.728	0.760	3.602	0.070	Significant

4.8 Summary of Structural Equation Modeling Results

The structural equation modeling (SEM) analyses' key results are concisely summarized in the following tables. Each result is briefly explained, and the hypotheses are mapped to relevant sections for clarity. (Tables 4.28 and 4.29)

Table 4.28 Quick Summary Table of Results Interpretation

Section	Figure & Table	Key Takeaway (1–2 Sentences)
4.6.1	Figure 4.1 / Table 4.14	EE components are statistically valid and confirm EE as a multi-dimensional construct.
4.6.2	Figure 4.2 / Table 4.15	EM components form a coherent, reliable construct supporting its mediating role.
4.6.3	Figure 4.3 / Table 4.16	ESE is validated as a distinct, measurable factor in the model.
4.6.4	Figure 4.4 / Table 4.17	EI is consistently and robustly measured, confirming it as a key outcome.
4.6.5	Figure 4.5 / Table 4.18	H1 is supported: EE has a significant positive direct effect on EI.
4.6.6	Figure 4.6 / Table 4.19	H2 is supported: EM significantly mediates the EE–EI relationship.
4.6.7	Figure 4.7 / Table 4.20	H3 is supported: ESE partially mediates the EE–EI relationship.

4.7.1	Figure 4.8 / Table 4.21	EE significantly impacts EM directly, reinforcing its role in mindset development.
4.7.2	Figure 4.9 / Table 4.22	EE significantly enhances ESE, boosting students' entrepreneurial confidence.
4.7.3	Figure 4.10 / Table 4.23	EM strongly and positively influences EI, showing mindset drives intention.
4.7.4	Figure 4.11 / Table 4.24	Higher ESE predicts stronger EI, emphasizing the role of self-confidence.
4.7.5	Figure 4.12 / Table 4.25	Comprehensive SEM confirms interconnectedness: EE influences EI via EM and ESE.
4.7.6	Figure 4.13 / Table 4.26	For entrepreneurial students, EE–EM–ESE–EI relationships are stronger, highlighting experiential learning effects.
4.7.7	Figure 4.14 / Table 4.27	For non-entrepreneurial students, relationships exist but are weaker, suggesting experience amplifies EE's impact.

Table 4.29 Mapping of Results to Hypotheses and Supplementary Questions

Hypothesis / Supplementary Question	**Relevant Section(s)**	**Outcome**
H1: EE directly impacts EI	4.6.5	Supported: Significant positive direct effect.
H2: EM mediates EE to EI	4.6.6	Supported: EM significantly mediates.
H3: ESE mediates EE to EI	4.6.7	Supported: ESE partially mediates.
Supplementary 1: EE impacts EM	4.7.1	Confirmed: EE directly enhances EM.
Supplementary 2: EE impacts ESE	4.7.2	Confirmed: EE directly enhances ESE.
Supplementary 3: EM impacts EI	4.7.3	Confirmed: EM strongly predicts EI.

Supplementary 4: ESE impacts EI	4.7.4	Confirmed: Higher ESE predicts stronger EI.
Supplementary 5: Overall comprehensive model for all students	4.7.5	Confirmed interconnectedness between EE, EM, ESE, and EI.
Supplementary 6: Entrepreneurial students	4.7.6	Stronger relationships; experiential learning effect observed.
Supplementary 7: Non-entrepreneurial students	4.7.7	Relationships present but weaker; experience moderates impact.

5. Discussion

This study, rooted in a robust quantitative methodology, examines the impact of EE on fostering EI among engineering students, focusing on the mediating roles of EM and ESE.

This methodology employed a survey distributed to 431 engineering students at York University's Lassonde School of Engineering. Established measurement scales were used to assess EE, EM, ESE, and EI. Structural equation modeling was utilized to test the hypothesized relationships, providing a detailed understanding of the interactions among these variables.

The study's results confirm a strong positive influence of EE on students' EIs, supporting the first hypothesis. This observation is consistent with prior research, which highlights the significant impact of educational programs in cultivating students' EIs (Bae et al., 2014; Barba-Sánchez & Atienza-Sahuquillo, 2018; Burrows & Wragg, 2013; Chang et al., 2014; Haddoud et al., 2022; Jiatong et al., 2021; Nowiński et al., 2019; Rauch & Hulsink, 2015). The analysis demonstrates a statistically significant mediating role of EM in the relationship between EE and EIs, confirming the second hypothesis. This finding is supported by research from the authors (Hussain & Norashidah, 2015; Walter & Block, 2016). Similarly, ESE significantly mediated the impact of EE on EIs, supporting the third hypothesis. This is in line with the research by the authors (Fuller et al., 2018; C. Li et al., 2020; Mei et al., 2020; Newman et al., 2019; Wardana et al., 2020; L. Wu et al., 2022; Zhao et al., 2005).

The supplementary analyses in this study offer strong empirical support for the proposed conceptual framework, providing a more nuanced understanding of the mechanisms through which EE influences EI among engineering students. Specifically, the structural equation modeling

results confirm that both EM and ESE act as significant mediating variables in this relationship. This suggests that the impact of EE goes beyond simply transferring knowledge; it operates by fostering crucial internal psychological attributes—namely, mindset and self-belief—that are essential for effective entrepreneurial decision-making and action.

Furthermore, the subgroup analyses reveal a significant finding: students who actively participate in entrepreneurial activities benefit more substantially from EE, as evidenced by higher path coefficients and improved model fit indices. This underscores the critical importance of experiential learning in reinforcing and amplifying the impact of formal education on achieving positive entrepreneurial outcomes. Students engaged in entrepreneurial activities beyond their formal coursework showed stronger relationships between EE, EM, ESE, and EI. This implies that extracurricular activities could be as influential, or even more so, than traditional classroom instruction in fostering entrepreneurial intentions.

These findings carry significant implications for the design and delivery of EE programs, particularly within engineering faculties. The results indicate that to effectively cultivate entrepreneurial intention, educational initiatives should be complemented by co-curricular and experiential components that actively help students build confidence and develop a proactive, opportunity-oriented mindset. The demonstrated mediating roles of EM and ESE suggest that EE programs should intentionally integrate activities that cultivate these key psychological attributes for entrepreneurial engagement. By doing so, educational institutions can more effectively prepare engineering students for entrepreneurship, equipping them not only with the necessary technical knowledge but also with the psychological readiness to successfully engage in innovation-driven careers.

This study contributes to the existing body of knowledge by offering empirical evidence that clarifies the specific mediating roles of EM and ESE in the relationship between EE and EI.

The subsequent (table 4.28) provides a summary of the specific analytical models employed for each hypothesis, detailing the pathways investigated and the corresponding figures and tables presenting the findings. This systematic approach ensures a clear connection between the theoretical arguments and the statistical analysis conducted.

Table 4.30: Link Between Hypotheses and Analysis

Hypothesis	Path	Analysis Type
H1	EE → EI	SEM - Direct path (Figure 4.5) (Table 4.18)
H2	EE → EM → EI	SEM - Mediated Model (Figure 4.6) (Table 4.19)
H3	EE → ESE → EI	SEM - Mediated Model (Figure 4.7) (Table 4.20)

Research indicates that an EM – a way of thinking that helps recognize opportunities – and ESE– confidence in performing entrepreneurial tasks – significantly influence how EE leads to EI, especially in engineering. Simply teaching entrepreneurship content is insufficient; to effectively boost students' entrepreneurial drive, educational programs must develop mindset and self-efficacy through hands-on experiences, reflection, and interdisciplinary learning.

This research carries significant implications for stakeholders committed to advancing entrepreneurial capacity within engineering education. It highlights the need for a pedagogical shift—viewing entrepreneurship not merely as a body of content, but as a practice. Embedding experiential learning, project-based assignments, real-world challenges, design thinking, and reflective methodologies into engineering curricula can effectively nurture both the EM and ESE, making entrepreneurship more tangible and actionable for students.

For curriculum designers and academic program leaders, the findings advocate for integrating EE into the core curriculum, rather than relegating it to electives. Interdisciplinary modules that combine technical expertise with innovation, marketing, and business acumen can significantly enhance entrepreneurial outcomes. Structured learning pathways that progressively build EM and ESE throughout a student's academic journey are essential.

Prospective students benefit from understanding how such educational approaches cultivate entrepreneurial skills and prepare them for dynamic, innovation-driven career paths. For researchers, the study offers a testable hypothesis: that EM and ESE mediate the relationship between EI and EE, opening promising directions for future inquiry.

University educators and academic advisors are encouraged to adopt more interactive, personalized teaching approaches, guiding students toward curricular and co-curricular activities that strengthen entrepreneurial competencies. Career services teams can position EE as a strategic advantage, helping students align their academic pursuits with long-term professional goals.

Policymakers and university administrators should consider this evidence in support of increased investment in EE, recognizing its potential to enhance graduate employability, foster innovation,

and strengthen regional economic resilience. Funding priorities might include startup incubators, innovation hubs, and industry-linked design challenges—not just to support new ventures, but to cultivate entrepreneurial capabilities across disciplines.

Finally, industry leaders and employers are urged to align recruitment, training, and internship programs with these educational insights. Valuing entrepreneurial competence—even in traditionally non-entrepreneurial roles—can foster a workforce equipped to address complex societal and economic challenges with creativity and adaptability.

Ultimately, by intentionally designing educational systems that develop both mindset and self-efficacy, all stakeholders can play a role in empowering the next generation of technically skilled, entrepreneurial innovators.

6. Limitations of the Study

This study examined a sample of undergraduate and graduate engineering students at York University's Lassonde School of Engineering, providing a focused analysis of the impact of entrepreneurship education. However, while it is likely that the findings are generalizable, the magnitude of specific effects may be exaggerated by the fact that all students enrolled at Lassonde, are exposed to the Bergeron Entrepreneurs in Science & Technology (BEST) Program, a technology entrepreneurship hub, actively promotes entrepreneurial thinking and the development of entrepreneurial mindsets and ventures through the deployment of resources, support, and curricular and co-curricular programming embedded into multiple courses and activities throughout the student's experience. This distinctive environment may result in attracting students more interested in entrepreneurship, or through greater exposure, stimulating more enthusiasm for entrepreneurship. The effects observed may be influenced by this and may need to be considered in future research or program design.

Also, this research employed a cross-sectional survey design, collecting data at one specific time. This methodology limits the capacity to establish causal relationships between EE, EM, SE, and EIs. Longitudinal studies are recommended for future studies to track these variables over time and more effectively ascertain causality. Additionally, experimental or quasi-experimental designs, including intervention studies with pre- and post-testing, could be used to better establish causal links regarding the impact of entrepreneurship education interventions.

The data collected in this study relied on self-reported measures, a common practice in educational and psychological research. However, this approach introduces the potential for biases, including social desirability, where participants may present themselves in a more positive light. Consequently, the accuracy of the data regarding participants' true EIs and underlying psychological states may be affected. To address this, future research could employ multi-method approaches, such as combining self-report data with behavioral observations, peer evaluations, or objective performance measures, to reduce bias and validate findings based on self-reporting. While the study employed recognized scales for assessing EM, SE, and EIs, a limitation lies in the potential for these instruments to incompletely capture the multifaceted nature of these constructs. Moreover, the interpretation of scale items can differ across cultural or academic settings.

7. Future Research

This study's findings deepen our understanding of how EE influences EIs among engineering students. To build upon this research and address the identified limitations, the following areas are suggested for future investigation:

Future research could expand upon the current findings by exploring additional mediators, such as innovation readiness and risk propensity. Furthermore, investigating moderators like economic conditions, industry connections, and the university's entrepreneurship ecosystem could provide valuable insights into the conditions that enhance the effectiveness of EE in fostering EI.

Integrating qualitative research methods, such as interviews or focus groups, in future studies could provide richer, more nuanced insights into students' experiences with EE. This approach would facilitate a deeper understanding of the motivational and psychological processes that influence their EIs. Future research should definitely explore the two-way relationship among the variables we studied. While our research looked at how EE influences EI, EM, and ESE, feedback from students and reviewers highlights that the relationship between variables are not just in one direction, and that they might change or reinforce each other over time. For instance, an individual's entrepreneurial self-efficacy or intention might actually motivate them to seek out EE. Further, the impact of different types of EE on these relationships is worth further investigation. Specifically, it is clear that experiential education has a different impact than typical entrepreneurship classes on participants, but the effect may depend of the personality or expectations of the student. Scholars should use a broad range of techniques to capture these

insights and break down the larger models into subsets to better understand differences in impact (and even causality). In addition, methods like longitudinal designs, cross-lagged models, or structural equation modeling can be used to analyze the results and better understand these reciprocal connections.

Future research could also enhance the generalizability of the current findings by including a more diverse sample of engineering students from various engineering schools, disciplines, and cultural backgrounds. Examining the impact of EE in different educational settings, such as community colleges, private universities, and international institutions, each with potentially unique resources and approaches, could offer valuable perspectives on how contextual factors influence the development of an EM and intention.

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Appendix

Dear Participant,

Thank you for taking the time to participate in this research study aimed at understanding the impact of entrepreneurship education on fostering an entrepreneurial mindset and intentions among students. The insights gathered from this questionnaire will contribute significantly to academic knowledge in entrepreneurship education and its effectiveness in inspiring future students to embark on entrepreneurial ventures.

Your responses will be kept confidential and used solely for research purposes.

Age: ……. Gender: Male/Female …… level of study: …….

Field of Study: ……. Year of Study: ……

Please indicate your student status: International student/Domestic student.

Have you ever seriously considered becoming an entrepreneur? Yes/No

Have you initiated a new business venture? Yes/No

Do you feel prepared to start entrepreneurial activities in five years? Yes / No

Have you taken any courses or participated in any activity that could be considered entrepreneurial? Yes/No

Which entrepreneurship course(s) or activities have you taken?

General Courses - Entrepreneurship Courses - Business Courses - Hackathon- Entrepreneurial Activities- Entrepreneurial Events.

Entrepreneurship Education

Please indicate your involvement in the following entrepreneurial education activities. If you have not been involved in an activity, please choose [0].

Otherwise, indicate the extent to which you benefited from each activity using a Likert Scale from 1 to 7 (1 = "Lowest benefit", 7 = "Highest benefit"):

Activity								
1.Entrepreneurship clubs	0	1	2	3	4	5	6	7
2.Interaction with Entrepreneurs: (Includes Successful Entrepreneur's Speech, Enterprise Visit or Internship, Face-to-face Communication with an Entrepreneur)	0	1	2	3	4	5	6	7
3.Entrepreneurial Incubation Project	0	1	2	3	4	5	6	7
4.Entrepreneurial Activity of Resourcing or Networking	0	1	2	3	4	5	6	7
5.Entrepreneurial Spirit and Values Transmitted by the University or Colleges	0	1	2	3	4	5	6	7

Please indicate your level of agreement with the following statements, where 1 = Strongly Disagree and 5= Strongly Agree.

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
1. My university's entrepreneurship course or activity prepares students very well for entrepreneurial careers.	1	2	3	4	5	6	7
2. The university provides resources/ support to assist student entrepreneurs.	1	2	3	4	5	6	7
3. I was able to develop entrepreneurial knowledge, skills and competencies through the entrepreneurship subjects that I attended.	1	2	3	4	5	6	7

Entrepreneurial Mindset

Please indicate your level of agreement with the following statements:

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
1. I like to take on a new challenge.	1	2	3	4	5	6	7
2. I try to work in a novel way.	1	2	3	4	5	6	7
3. I persistently try to come up with outstanding ideas.	1	2	3	4	5	6	7
4. I act aggressively to achieve a goal.	1	2	3	4	5	6	7
5. I am more passionate than others.	1	2	3	4	5	6	7
6. I have a strong will to achieve something.	1	2	3	4	5	6	7
7. I tend to push forward something with high expected value even with high risk.	1	2	3	4	5	6	7
8. I tend to take risks for new opportunities.	1	2	3	4	5	6	7
9. I tend to take challenges even when there is a risk of failure.	1	2	3	4	5	6	7
10.I am reluctant to receive outside aid.	1	2	3	4	5	6	7
11.I prefer solving problems independently.	1	2	3	4	5	6	7
12. I plan and act in advance rather than waiting for something to be given.	1	2	3	4	5	6	7

Entrepreneurial Self-Efficacy

Please indicate your level of agreement with the following statements:

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
1.I am convinced that I can successfully discover new business opportunities.	1	2	3	4	5	6	7
2.I am convinced that I can successfully create new products.	1	2	3	4	5	6	7
3.I am convinced that I can think creatively.	1	2	3	4	5	6	7
4.I am convinced that I can successfully commercialize ideas.	1	2	3	4	5	6	7

Entrepreneurial Intention

Please indicate your level of agreement with the following statements:

Questions	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
1. I am ready to do anything to be an entrepreneur.	1	2	3	4	5	6	7
2. My professional goal is to become an entrepreneur.	1	2	3	4	5	6	7
3. I will make every effort to start and run my own firm.	1	2	3	4	5	6	7
4. I am determined to create a firm in the future.	1	2	3	4	5	6	7
5. I have very seriously thought of starting a firm	1	2	3	4	5	6	7
6. I have the firm intention to start a firm someday.	1	2	3	4	5	6	7