Using geometric mean to compute robust mixture designs

Agnieszka Kwapisz, Kregg Aytes, Scott Bryant, Brock J. LaMeres

Entrepreneurial Mindset and Intentions for Entrepreneurship and Intrapreneurship in Engineering and Business Students

Agnieszka Kwapisz, Ph.D.
Professor
Jake Jabs College of Business & Entrepreneurship
Montana State University
S 8th Ave, Bozeman, MT 59717
Email: akwapisz@montana.edu
ORCD: 0000-0002-1628-3186

Kregg Aytes, Ph.D.
Professor
Jake Jabs College of Business & Entrepreneurship
Montana State University
S 8th Ave, Bozeman, MT 59717
Email: kregg.aytes@montana.edu
ORCD: 0000-0001-5123-4710

Scott Bryant, Ph.D.
Professor
Jake Jabs College of Business & Entrepreneurship
Montana State University
S 8th Ave, Bozeman, MT 59717
Email: bryant@montana.edu
ORCD: 0000-0003-1125-9475

Brock J. LaMeres, Ph.D., PE
Professor
Boeing Professor of Engineering Education
Electrical & Computer Engineering
Montana State University
Director, Montana Engineering Education Research Center (MEERC)
Montana State University
316-C Norm Asbjornson Hall
Bozeman, MT 59717
Email: lameres@montana.edu
ORCD: 0000-0001-9388-4092

Entrepreneurial Mindset and Intentions for Entrepreneurship and Intrapreneurship in Engineering and Business Students

Abstract

With the shifting dynamics of the modern workforce, there is a growing recognition of the essential role that an entrepreneurial mindset (EM) plays in shaping future innovators, notably within engineering disciplines. Despite the acknowledged significance of EM, there remains a gap in understanding how it relates to entrepreneurial or intrapreneurial intentions (E/II). This research investigates the link between EM and E/II among business and engineering students. We also analyze how EM changes over time. Our findings indicate that in both domains, ideation correlated with entrepreneurial intentions (EI) and intrapreneurial intentions (II). In both domains, altruism was associated with II. Empathy and interest were related to EI in engineering students, distinct from their business counterparts, whereas open-mindedness and interest correlated with II. These differences emphasize the need for distinct educational strategies to prepare both business and engineering students for their entrepreneurial paths.

Keywords

entrepreneurship, intrapreneurship, entrepreneurial mindset, engineering, business

Introduction

In a rapidly evolving world where innovation is key to progress (Barba-Sánchez et al., 2022; Maheshwari et al., 2022; Duval-Couetil et al., 2021), understanding the relationship between entrepreneurial and intrapreneurial intentions (E/II) and the entrepreneurial mindset (EM) is crucial, particularly among business and engineering students (Gilmartin et al., 2019; Maresch et al., 2016). Unveiling this connection is essential (Pidduck et al., 2023; Kaffka & Krueger, 2018) because it underpins the foundation of entrepreneurial success, guiding the evolution of entrepreneurial education (EE) to not only just teach skills but also cultivate an EM that equips students with the resilience, creativity, and vision required for navigating and leading in the dynamic landscape of innovation and business (Maresch et al., 2016). As emphasized by Kaffka & Krueger (2018), this paradigm shift in EE is aimed at creating well-rounded entrepreneurs, equipped not just with temporary intentions but with a sustainable mindset for success in both startups and established organizations (Kaffka & Krueger, 2018; Krueger 2007; (Huang-Saad et al., 2018). However, verifying the connection between EM and E/II is vital, as this relationship is foundational to the effectiveness of this educational approach. This study's importance lies in its potential to transform EE by ensuring that students are imbued with the elements of EM that enable them to navigate and innovate within the entrepreneurial landscape effectively.

While EE has primarily been rooted in business schools, a domain where its methodologies and research on effectiveness are deeply ingrained (Maresch et al. 2016; Gilmartin et al., 2019; Sheppard et al., 2015), expanding our focus to include engineering student populations becomes imperative. Most research on students' EI focuses on business students or undefined student populations (Huang-Saad et al., 2018; Maresch et al., 2016; Bae et al., 2014; Martin et al., 2013). Huang-Saad et al. (2018) reported that 60% of studies focused on business

school students and 20% considered engineering students. This traditional focus overlooks potential differences in entrepreneurial tendencies among various student groups, indicating a significant area for exploration and contribution to understanding entrepreneurship across diverse educational backgrounds. Specifically, engineering students are attractive to study because of their technical background, which prepares them to start high-growth technology ventures (Souitaris et al., 2007). Gilmartin et al. (2019, p. 316) noted that "considering how engineering and business students have similar or different entrepreneurial interests can be illuminative, if not necessary, for program development".

Therefore, business students are an important group for comparison in this study because they have a long history of involvement in EE (Huang-Saad et al., 2018; Gilmartin et al., 2019; Maresch et al., 2016). This comparison reveals disparities in entrepreneurial perspectives across fields, highlighting engineering students' unique potential and emphasizing the importance of EE programs catering to varied academic backgrounds. By investigating E/II and EM among business and engineering students, the study hopes to inform the establishment of inclusive and interdisciplinary EE programs that respond to the individual needs and strengths of both groups.

Additionally, this research gives due prominence to intrapreneurship - a vital yet often underexplored aspect within the entrepreneurship spectrum, especially within the engineering context, addressing a significant gap in the current literature (Alam et al., 2020b; Rekha et al., 2015). This opens new avenues for theoretical development in understanding intrapreneurship phenomena in EE (Morris et al., 2010; Hisrich & Kearney, 2012). Furthermore, the relevance extends to the rapidly evolving global economy, where it is becoming more important to identify factors that relate to intra- and entrepreneurial ambitions. The knowledge gained is invaluable for

prospective business owners and institutions looking to foster creative cultures (Welter & Smallbone, 2011).

Given the significance of linking the EM to E/II as discussed above, our study focuses on the following three research questions:

Research Question 1: How do the elements of EM relate to EI among engineering and business students?

Research Question 2: How do the elements of EM relate to II among engineering and business students?

Research Question 3: How does the major (engineering versus business) moderate the relationship between the elements of EM and E/II?

In summary, our paper contributes to the EE literature in the following ways. First, we delve deeply into the connection between the EM and both EI and II. It's noteworthy that, while the latter is of growing importance in contemporary work scenarios, it has traditionally been underrepresented in scholarly discourse. Second, by highlighting the varying entrepreneurial orientations of engineering versus business students, we offer an invaluable comparative lens. This nuanced understanding is instrumental for educational institutions, as it paves the way for curricula and initiatives specifically designed to resonate with the unique aspirations inherent to each discipline. Lastly, we touch upon the dynamic nature of EM by presenting insights into its evolution over time. Collectively, the insights from our research hold wide-ranging implications, potentially influencing academic strategies, policy decisions, and the broader frameworks guiding entrepreneurship in today's globalized business landscape.

Theoretical Background

EI and II play a significant role in today's economy, ranging from starting new businesses to fostering innovation within existing institutions (Kautonen et al., 2015). The link between these intentions and EM has been established by previous research (Daspit et al., 2023; Pidduck et al., 2023; Larsen, 2022; Barba-Sánchez et al., 2022; Cao & Ngo, 2019; Kaffka and Krueger, 2018; Nabi et al., 2017). However, there is still considerable variation in how EM is conceptualized in existing research (Larsen, 2022; Neck & Corbett, 2018) and most studies focus on business students (Huang-Saad et al., 2018; Maresch et al., 2016; Bae et al., 2014; Martin et al., 2013). Accordingly, this study's theoretical framework comprises four concepts: EM, EI, II, and students' major (Figure 1).

Figure 1 around here

Entrepreneurial Mindset

In the recent literature review of EE, EM was elegantly framed by Larsen (2022) within three scholarly conceptualizations. The first explores the complex cognitive processes that underpin the paradigm of entrepreneurial cognition and decision-making, focusing on EM as cognition. The second, EM as a frame of mind, describes EM as a mental attitude that encompasses the motivational and attitudinal components essential to entrepreneurial pursuits. The third perspective views EM as a capability, in line with human capital theory, and sees EM as a collection of essential skills and competencies that form the basis of entrepreneurial efficacy. It categorizes EM into cognitive/psychological, social, and behavioral competencies and skills. Understanding EM as a capability involves recognizing a broad range of skills, both entrepreneurial and managerial, essential in shaping an individual's ability to engage in

entrepreneurial activities. These conceptualizations significantly influence and improve the educational strategies used to develop entrepreneurial skills.

The capability perspective of the EM is critical, as opposed to Larsen's other two perspectives—cognition and frame of mind—because it takes a complete approach to providing individuals with the tangible skills and abilities required for entrepreneurial activity and success. While the cognitive perspective focuses on the mental processes underlying entrepreneurial decision-making, and the frame of mind perspective stresses motivational and attitudinal factors, the capability perspective combines these elements into a practical skill set. This integration guarantees that individuals are not just motivated and cognitively prepared, but also have the practical skills to discover opportunities, innovate, and navigate the complexities of entrepreneurial endeavors.

The importance of the capability perspective lies in its alignment with the objectives of EE, which aim to prepare students for real-world entrepreneurial endeavors. It stresses the development of a wide range of skills, including cognitive/psychological, social, and behavioral competencies, which are essential for the entrepreneurial and intrapreneurial process. This perspective assumes a closer link between EM and entrepreneurial behavior, implying that developing these skills might lead to more direct and successful engagement in entrepreneurial activity. Furthermore, the capability perspective is especially important in today's rapidly changing and competitive global landscape, where entrepreneurs must adapt quickly, collaborate across disciplines, and generate value in novel ways. By emphasizing the development of these adaptable skills and abilities, the capability perspective assures that EE programs generate graduates who are not only equipped to start new businesses but also to contribute innovatively to existing ones.

Building on the foundation laid by Larsen (2022) regarding EM as a capability, the 3Cs framework—Curiosity, Connections, and Creating Value (as proposed by the Kern Engineering Entrepreneurship Network: KEEN, 2018; Brunhaver et al., 2018)—emerges as a practical application of this concept, particularly in engineering education. Curiosity, through Interest and Empathy, fosters the desire to investigate and comprehend, which is necessary for innovation and collaboration. Interest promotes openness to new experiences, whereas empathy is essential for interacting with others. Connections, made possible by Open-Mindedness and Help-Seeking, are critical for harnessing multiple views and recognizing the need for assistance. Creating Value through Ideation and Altruism emphasizes new solutions and societal benefits. Ideation stimulates unconventional thinking, whereas altruism seeks to favorably benefit society.

These dimensions—Interest, Empathy, Open-Mindedness, Help-Seeking, Ideation, and Altruism—illustrate the multifaceted nature of EM as a capability, aligning with Larsen's (2022) framework.

Engagement in a range of activities, which is a measure of *Interest*, is consistent with the idea of an EM as a capability as it reflects cognitive and psychological competencies in EM (Blenker et al., 2011). This dimension displays curiosity and openness to diverse experiences, which are essential for recognizing opportunities and coming up with original solutions to problems. Participating in a variety of activities shows a wide range of interests and an openness to learning, qualities that are crucial for entrepreneurial creativity and flexibility.

Empathy captures the capacity to recognize, comprehend, and anticipate the sentiments of others. This is especially true when considering EM as a capability (Bodnar & Hixson, 2018). This part of EM emphasizes the value of emotional intelligence in entrepreneurship and falls under the area of social skills and competencies. Empathy facilitates collaboration, efficient

communication, and the development of relationships—all crucial elements of successful entrepreneurship. Better team dynamics and customer relations are made possible by being sensitive to and understanding of others' sentiments. These are essential abilities in the complex and interpersonal field of entrepreneurship.

As demonstrated by a readiness to value and absorb other viewpoints and information, *Open-Mindedness* is also consistent with the idea of the EM as a capability (Solesvik et al., 2013; De Villiers Scheepers et al., 2018). This dimension, which falls under EM's social and cognitive skills category, emphasizes the value of inclusion and adaptation. Innovation and successful problem-solving in entrepreneurial endeavors depend on an ability to appreciate varied knowledge, be open to compromise, and recognize the worth of ideas from different backgrounds. Being open-minded makes it easier to collaborate and synthesize ideas, which is essential for navigating the complex and dynamic world of entrepreneurship.

As evidenced by questions regarding seeking outside help and asking for help, *Help-Seeking* is a crucial component of the EM viewed as capability (Solesvik et al., 2013). This dimension, which comes under behavioral skills in EM, emphasizes the need to accept responsibility for one's limitations as well as the benefits of working with others to solve problems. Asking for assistance when required shows a practical attitude to problem-solving, which is an essential ability in overseeing intricate entrepreneurial endeavors. An important aspect of successful entrepreneurial activity is the capacity to find and use outside resources.

The ability to tackle unclear challenges, exercise creativity, and question accepted answers are indicators of *Ideation*, which is also consistent with the notion of the EM as a capability (Bodnar & Hixson, 2018; De Villiers Scheepers et al., 2018; Blenker et al., 2011; Solesvik et al., 2013). This dimension highlights the creative and cognitive competencies within

EM, emphasizing the value of adaptability, flexibility, and inventive thinking in entrepreneurship. Success in entrepreneurial activities depends on one's ability to embrace change, reimagine preexisting concepts, and be willing to venture into unexplored territory. To successfully navigate the ambiguities and ever-changing challenges of the entrepreneurial world, ideation is a crucial ability.

The last element is *Altruism*, which is determined by a commitment to advancing society and finding solutions to significant problems. This component highlights a desire to contribute positively to society and a sense of social responsibility. It reflects the ethical and behavioral competencies within EM as a capability (João & Silva, 2020; Bodnar & Hixson, 2018; Outsios & Kittler, 2018; Ghalwash et al., 2017; Blenker et al., 2011). Such a focus on charitable giving highlights the importance of entrepreneurship that seeks to both make a profit and confront and solve societal issues. This point of view highlights the role that entrepreneurs play in fostering social change and advancement.

Our research aims to explore which aspects of EM as a capability are influential in the engineering discipline, focusing on their relationship with EI (Research Question 1) and II (Research Question 2). Additionally, we will compare these findings with similar relationships observed in business students (Figure 1).

Entrepreneurship Education: Engineering and Business Disciplines

Recent academic exploration, as exemplified by a 2015 survey among the American Society for Engineering Education (ASEE) members, indicates a unanimous agreement on the integration of EE within engineering curricula (Peterfreund et al., 2016). This consensus mirrors the burgeoning demand among students for programs that blend innovation with entrepreneurial acumen (Jackson et al., 2023). National frameworks, notably the National Science Foundation's

(NSF) Epicenter Pathways Initiative (Sheppard et al., 2015), NSF I-Corps Program (VentureWell, 2023; Duval-Couetil et al., 2021), and the Kern Entrepreneurship Engineering Network (KEEN, 2023), echo the institutional commitment towards this interdisciplinary confluence (Patel et al., 2006).

Distinguishing the pedagogical objectives of entrepreneurship programs within engineering and business schools is pivotal (Stenard, 2023). Historically, business schools have anchored their curriculum on foundational business creation skills, including but not limited to, marketing, accounting, and operations. Contrarily, engineering institutions have accentuated the significance of innovation, design, and problem-solving competencies, crucial for product and technology development (Dym et al., 2005). A critical evaluation by Huang-Saad et al. (2018) postulated that while engineering-based entrepreneurship programs invariably veer towards business-oriented outcomes, the essence of entrepreneurial success in engineering should be rooted in fostering the EM. This paradigm encompasses multifaceted attributes ranging from innovation and product development to collaborative frameworks, which are often marginalized in broader entrepreneurial studies. Distinct thematic concentrations characterize the curricula of entrepreneurship programs across both academic domains (Huang-Saad et al., 2018; Fernandez et al., 2015). The imperative to cultivate an authentic EM in engineering cohorts necessitates a revised approach to conventional pedagogy (Stenard, 2023; Bakrania, 2023). It requires the combination of agile methodologies, design thinking, and innovation into established engineering curricula.

Considering these distinctions in pedagogical approaches and objectives, it becomes crucial to understand how the relationship between EM and E/II might manifest differently for students in these two fields (Figure 1). This article delves deeper into this arena (Research

Question 3), addressing the gap in current literature by analyzing how these relationships are modulated by the discipline-specific nuances of business and engineering undergraduate programs.

Intrapreneurial Intentions

Intrapreneurship is the act of behaving like an entrepreneur within an existing organization or company (Ilonen & Hytönen, 2023). It is characterized by a focus on innovation and creativity to generate new ideas, products, or services that can benefit the organization (Carrier, 1996). Intrapreneurship differs from entrepreneurship in that the context in which the entrepreneurial act takes place is within an established organization rather than creating a new venture from scratch. This context generates differences in terms of autonomy, type of risk, and anticipated rewards for the actors involved. Firms that want to be competitive in today's increasingly globalized economy must continually innovate. Numerous writers (Carrier, 1996; Kraus et al., 2019; Antoncic & Hisrich, 2003; Alam et al., 2020b; Huang et al., 2021; Kuratko et al., 2023; Ilonen & Hytönen, 2023) have proposed intrapreneurship as a technique for promoting innovation and using workers' creative energy. Organizations now recognize the strategic significance of their employees' intrapreneurial behavior for their overall performance (Neessen et al., 2019). Intrapreneurship is especially important to engineering education but there is limited research on intrapreneurship among engineers (Alam, et al., 2020a; Menzel et al., 2007; Williamson, et al., 2013). As emphasized by Hylton et al. (2020, p.87): "In engineering, especially, pairing the technical skill set with the ability to recognize and pursue opportunities to add value to an organization and to society has been recognized as tremendously valuable." Also, engineers' roles within firms are increasingly requiring a more entrepreneurial skill set (Stenard, 2023; Rover, 2005; Nichols & Armstrong, 2003). However, this area of study is still in its early stages

and further exploration and testing of this phenomenon is necessary (Alam et al., 2020b). Additionally, engineers' future roles will increasingly focus on using their innovation and technological skills to address important global concerns, such as poverty alleviation, sustainable development, lower carbon emissions, and climate change. This dual focus emphasizes both global problem-solving and environmental responsibility (João & Silva, 2020).

Given the integral role of intrapreneurship in driving innovation within established entities, particularly within the engineering domain, there is a compelling need to understand the nexus between elements of EM and II. Addressing this, our study delves into the relationship between EM and both EI and II, with a special focus on the engineering sector. This emphasis not only underscores the inherent importance of intrapreneurship in engineering but also contributes to the emerging body of research in this pivotal area (Alam et al., 2020b).

Entrepreneurial Mindset and Intentions: Engineering and Business

Building upon the established definitions of EM and the importance of EE, particularly in engineering and intrapreneurship, this section explores their interconnections (Figure 1). Considering the diverse interpretations of EM in the literature (Pidduck et al., 2023), and the limited studies encompassing both engineering and business student populations with a focus on II, our study offers a unique perspective on EE.

Previous research (Daspit et al., 2023; Cao & Ngo, 2019; Kaffka & Krueger, 2018; Rekha et al., 2015) has established a link between EM and EI and behaviors. Literature reviews by Daspit et al. (2023), Rauch et al. (2009), and Wales et al. (2013) have explored these relationships. They discovered significant variations in the strength of this correlation, influenced by factors such as cultural context, business size, and industry type, particularly high-tech. The authors underscore the complexity of EM and its impact on entrepreneurial outcomes, suggesting

that a more nuanced approach, focusing on the specific dimensions of EM, might yield more insightful results. Specific elements of EM, including risk perceptions (Segal et al. 2005; Nabi and Liñán 2013; Asenge et al., 2018), intentional engagement (Fisher, 2012; Kaffka & Krueger, 2018), feedback seeking (Kaffka & Krueger, 2018), innovation orientation (Gilmartin et al., 2019; Asenge et al., 2018), and emotional intelligence (Kwapisz et al., 2022; Zampetakis et al., 2009), have been linked to EI and entrepreneurial behaviors (Daspit et al., 2023; Rauch et al., 2009; and Wales et al., 2013).

Focusing on business and engineering students, Gilmartin et al. (2019) discovered that business students were more likely to possess EI than their engineering counterparts. They also noted that engagement in entrepreneurship activities was a significant predictor of EI for engineering students, a trend not observed in business students. Furthermore, innovation orientation played a more crucial role in shaping EI among engineering students compared to those studying business. Maresch et al. (2016) found higher pro-entrepreneurial attitudes among business students while noting that subjective norms adversely affected the EI of science and engineering students. Specifically, they observed that a stronger emphasis on entrepreneurship by family and friends tended to lead to a greater rejection of entrepreneurial pursuits among these students. Conversely, Wu and Wu (2008) reported that, on average, engineering students exhibited higher EI and greater confidence in their entrepreneurial capabilities than business students. Lastly, Huang-Saad et al. (2018) in their literature review, emphasized the need for more research focusing on the distinctive aspects of entrepreneurship in engineering programs. They highlighted that, unlike business-focused programs, engineering EE may not primarily target business creation. Instead, these programs often aim to develop transferable skill sets

suitable for various settings, underscoring the importance of engineering-specific measures such as creativity, product development, opportunity identification, teamwork, and communication.

Sample and Methods

Data Collection

We collected data from a public university with a very high research Carnegie classification and targeted undergraduate first-year students in engineering and business at the start of the academic year. We specifically selected courses that are commonly taken by most first-year students in engineering and business. The original survey was conducted in 2019, and the follow-up survey was conducted three years later in September 2022. For the first study, students were given time in class to complete the survey to minimize selection bias. We gathered initial surveys from 469 engineering and 348 business students (2019). A follow-up email to the same students in 2022 yielded 77 fully completed responses: 54 from engineering and 23 from business students. We used the Qualtrics web-based survey platform and analyzed the data with Stata statistical software.

Entrepreneurial Mindset

Assessing the EM of engineering students can be a complex task as substantial dissimilarities exist between the outcomes of EE in business and engineering domains. Subsequently, studies used a variety of measures in business (Davis et al., 2016; Gallup, 2020) and engineering (Lichtenstein & Monroe-White, 2017; Park et al., 2020). According to Larsen (2022), EM as a capability is the most pertinent perspective for EE because it emphasizes the growth of students' capacities to take action and, in contrast to the other two perspectives, posits a closer relationship between EM and entrepreneurial conduct. In operationalizing KEEN's 3C framework—Curiosity, Connections, and Creating Value—we utilized the Engineering Student

Entrepreneurial Mindset Assessment (ESEMA), a survey tool developed and validated by Brunhaver et al. (2018). ESEMA has demonstrated high reliability in measuring the EM among engineering students, aligning closely with the conceptualization of EM as a capability. This alignment is supported by a broad base of literature (Larsen, 2022; João & Silva, 2020; De Villiers Scheepers et al., 2018; Bodnar & Hixson, 2018; Outsios & Kittler, 2018; Ghalwash et al., 2017; Solesvik et al., 2013; Blenker et al., 2011), emphasizing the instrument's effectiveness in capturing the essence of EM through its focus on a diverse range of skills and competencies.

The complete list of ESEMA's questions is provided in Appendix A. The ESEMA dimensions were assessed using a five-point Likert scale, ranging from "Never or only rarely true of me" to "Always or almost always true of me". The KEEN 3Cs framework has garnered considerable attention in academia and has been the foundation for numerous studies examining the entrepreneurial predispositions of engineering students (Zappe et al., 2023; Riley et al., 2023; Dinh et al., 2022; Jackson et al., 2022; Bailey et al., 2021; Kwapisz et al., 2022; Desing et al., 2020; Gorlewicz & Jayaram; 2020; Hylton et al., 2020; Huang-Saad et al., 2020; London et al., 2018). In their review of STEM (Science, Technology, Engineering, and Mathematics) entrepreneurship, Zappe et al. (2023) identified KEEN as a pivotal force, noting over 40% of studies were either KEEN-funded or utilized its 3Cs framework. Its widespread application and validation across various institutions underscore its credibility and effectiveness in delineating the facets of the EM in engineering contexts.

Entrepreneurial and Intrapreneurial Intention

We relate the EM concept to E/II: an individual's intention to become an entre/intrapreneur. To comprehensively measure the level of entrepreneurial intention we used a scale that asked students to rate the importance of starting or developing a business or organization and being

part of a team that starts a new business (Geldhof et al., 2014). We measure intrapreneurial intention by asking students how important it is to change the way a business or organization runs (Geldhof et al., 2014). Following the survey, we sourced demographic data and GPA of the students from official university records, with the approval of the university's Institutional Review Board.

Results

Table 1a presents descriptive statistics for the entire sample from the 2019 data collection. Table 1b provides statistics specifically for those students who participated in both the 2019 and 2022 surveys.

_____

Table 1a around here

_____

_____

Table 1b around here

_____

We have summarized the results of an ordered logit regression analysis in Table 2 for the model of EI and II among all 799 participants in the first survey. Since the EI and II dimensions were assessed using a five-point Likert scale, we used the Ordered Logit estimation approach.

_____

Table 2 around here

_____

The findings revealed that engineering students generally showcased a lower inclination towards both entrepreneurial (β =-1.457; $p < 0.01$) and intrapreneurial (β =-0.666; $p < 0.01$) intentions compared to their business counterparts. Notably, the gap narrowed considerably when it came

to intrapreneurship, aligning with our anticipations. The results also suggest that, in general, EI and II were significantly and positively related to many of the key EM constructs. Specifically, the constructs of Ideation, Interest, and Altruism were found to be positively associated with both EI and II for all students. Building on these findings, we will next conduct separate regression analyses for business and engineering students. This will allow us to address our initial two research questions, examining the specific dynamics between EM and E/II within each student major.

Entrepreneurial and Intrapreneurial Intentions among Business and Engineering Students

We used two ordered logit regression models presented in Tables 3a and 3b to investigate factors that might correlate with E/II in engineering versus business students.

_____

Table 3a around here

_____

_____

Table 3b around here

_____

Our analysis revealed that Ideation emerged as a significant EM factor associated with both EI and II for both student groups. For engineering students, the coefficients were $\beta=0.657$ ($p < 0.01$) and $\beta=0.336$ ($p < 0.01$) for EI (Table 3a) and II (Table 3b), respectively. Similarly, for business students, these were $\beta=0.666$ ($p < 0.01$) for EI (Table 3a) and $\beta=0.556$ ($p < 0.01$) for II (Table 3b). The findings emphasize the crucial role of creative problem-solving in influencing EI and II, as indicated by the Ideation metric. Business and engineering students who exhibit stronger capabilities in creative problem-solving are more likely to possess higher E/II.

Altruism emerged as a significant EM factor in association with II for both engineering and business students, as illustrated in Table 3b. Specifically, the results showed coefficients of $\beta=0.382$ ($p < 0.01$) for engineering students and $\beta=0.561$ ($p < 0.01$) for business students. However, when observing EI, the association of Altruism was only significant for business students, with a coefficient of $\beta=0.405$ ($p < 0.01$), and not statistically significant for engineering students, as shown in Table 3a. These results suggest that the altruistic desire to create societal value greatly relates to intrapreneurial tendencies across both fields. However, in the context of EI, it appears to be a distinctive trait predominantly for business students. The emphasis on creating societal value may motivate business students more intensively toward entrepreneurial ventures, while it universally drives intrapreneurial endeavors in both domains.

Additionally, for engineering students, both Interest ($\beta=0.258$; $p < 0.01$) and Empathy ($\beta=0.230$; $p < 0.01$) showed significant relationships with EI (Table 3a). Meanwhile, Interest ($\beta=0.181$; $p < 0.05$) and Open-Mindedness ($\beta=0.256$; $p < 0.1$) were correlated with II (Table 3b). These findings suggest that engineering students with expansive interests tend to also possess higher EI and II. Notably, their Empathy is strongly associated with EI, and their Open-Mindedness aligns with their II.

These findings underscore that distinct factors potentially shape EI and II in engineering compared to business. Such insights accentuate the necessity to integrate discipline-specific nuances when crafting EE programs, addressing our initial two research questions. Given the pronounced effects observed within the engineering group, it's further posited that the ESEMA's assessment of EM might serve as a particularly relevant measure in engineering contexts compared to business domains.

Interaction Effects: The Interplay of EM Across Disciplines

Having analyzed the distinct entrepreneurial tendencies within each discipline, we further delve into the interactive relationship between the fields of business and engineering. Addressing our third research question, we introduce interaction terms to examine how specific elements of EM differentially impact students based on their field of study. Through this approach, we discern not just the standalone influences of EM on intentions, but also how the potency of these factors varies when applied to engineering versus business students. The results from ordered logit regression models with interaction terms are presented in Table 4 and Figure 2.

_____

Table 4 around here

_____

_____

Figure 2 around here

_____

Our results shed light on the importance of Interest (β=0.320; $p < 0.05$) and Empathy (β=0.384; $p < 0.01$) for the EI in engineering students as compared to business students (Table 4; Figure 2). Additionally, the results show that Open-Mindedness (β=0. 0.526; $p < 0.05$) had a stronger positive relationship with II among engineering students compared to business students. This means engineering students with a diverse array of interests and a strong ability to empathize have a greater inclination towards starting their ventures compared to business students. Furthermore, those engineering students who are more open-minded and value learning from a myriad of sources are more drawn to innovate from within existing organizations than their business counterparts.

Longitudinal Shifts in EM Dimensions: A Supplementary Analysis

As a side note to our primary analysis, we examined the evolution of EM over time (from 2019 to 2022 survey). We used nonparametric paired tests to contrast the medians of EM factors across three years, sidestepping the need for distributional assumptions.

Table 5 around here

The overarching findings, as detailed in Table 5, show that throughout this period, most dimensions of EM remained relatively stable. However, at a modest 10% significance level, there were slight decreases for engineering students in two specific areas: their Open-Mindedness and their inclination towards Altruism. On the flip side, business students exhibited an uptick in their Altruism score over the same time interval. However, all these changes were only significant at the relaxed 10% significance level.

In Table 6, we synthesize our findings on EI and II from Tables 2-4. This table identifies the EM factors that hold a statistically significant relationship with both EI and II. Notably, all these associations are positive.

Table 6 around here

Summary and Discussion

Summary of Main Results

Our findings show a strong correlation between Ideation Ideation—a measure of innovative problem-solving abilities—and both entrepreneurial and intrapreneurial intentions across disciplines. This underscores the fundamental role of innovative problem-solving in entrepreneurship and intrapreneurship. The ability to respond creatively to difficulties is critical

in today's dynamic business environment, where adaptability and innovative strategizing are essential for optimizing resources and managing risks. Furthermore, in a culture that increasingly values innovation, the ability to think differently and develop unique solutions is critical for driving growth and competitiveness.

In our analysis, a marked sense of altruism corresponded to a heightened inclination towards intrapreneurship among both engineering and business students. This trend suggests that the structured, yet resource-rich environments of established organizations can appeal to those with altruistic tendencies. However, this altruistic drive towards entrepreneurship was more evident among business students, likely reflecting the focus of business curricula on societal impact and corporate social responsibility. As a result, business students with a heightened sense of altruism might view entrepreneurship as a potent avenue to create societal value. In contrast, engineering students, though equally altruistic, might channel their intentions more toward technical innovation.

Our findings revealed a strong correlation between Interest and Empathy and EI among engineering students, more so than their business counterparts. These findings show that engineering students' natural curiosity and empathy are major motivators for their entrepreneurial endeavors. Interest was also related to II, emphasizing the importance of engineers' general interest in driving innovation within established businesses. The emphasis on user-centric design and collaborative, interdisciplinary work in engineering education not only nurtures technical skills but also primes students for recognizing and exploiting market opportunities, highlighting how these traits align closely with successful entrepreneurial and intrapreneurial activities.

Our findings show that open-mindedness is highly connected to II among engineering students, a pattern that persists across analyses. This emphasizes open-mindedness as an important aspect in encouraging intrapreneurship in the engineering area, where complex problems benefit from multiple perspectives and interdisciplinary teamwork. Engineering students' willingness to consider new ideas and capacity to assimilate diverse inputs are critical to generating innovation in existing firms, reflecting the collaborative and inclusive mindset required for successful intrapreneurial activities.

Discussion: Implications for Education

Introducing EM education to engineering education aims to develop holistic engineers who are creative, curious, socially responsible, and focus on not only being technically adept but also capable of using their knowledge in real-world situations to create products, services, and solutions (Da Silva et al., 2015; Huang-Saad et al., 2020; Huang-Saad et al., 2018). To successfully undertake these responsibilities, students must cultivate a range of skills and attributes that extend beyond the traditional engineering skill set (Bilén et al., 2005; Mendelson, 2001; Standish-Kuon & Rice, 2002; Sullivan et al., 2001; Täks et al., 2014; Wang & Kleppe, 2001). Consequently, many engineering education programs adopt the model of EE used by business schools, but it remains uncertain whether this is an appropriate approach (Katz, 2003; Morris et al., 2014). Gilmartin et al. (2019) have shown that the development of EI is discipline-specific, with differences between engineering and business students in terms of what drives them toward entrepreneurship. For instance, innovation orientation and entrepreneurship activities were found to be more predictive of intent in engineering than in business. In our study, we delve deeper into the aspects of the EM that are most important for enhancing EI in engineering versus business students. Additionally, we extend the current state of research to

consider settings within existing organizations by examining II, which are particularly relevant to engineering education. However, unlike EI, II are rarely discussed in engineering education (Alam, et al., 2020a; Menzel et al., 2007; Williamson, et al., 2013). Our work follows calls from Kuratko et al. (2023, p. 148) who noted, "One thing is certain, and that is a multitude of questions regarding the entrepreneurial mindset within corporations are open for deeper examinations."

Compared to business students, engineering students were found to have both lower EI and II. This aligns with previous work that discussed EI in both disciplines (Gilmartin et al., 2019; Jin et al., 2014; Guerrero et al., 2018; Polin, 2023). However, the present study shows that this effect is much smaller in intrapreneurship, something that was not documented before. Notably, both groups of students showed no significant change in their EM throughout their undergraduate studies. This may suggest that pursuing business studies does not necessarily increase the likelihood of becoming an entrepreneur. It is crucial to consider that students choose their academic discipline based on their interests, traits, and personality. This was also emphasized by Polin (2023). Therefore, it is possible that the higher level of EM among business students may be attributed to self-selection rather than the effect of the curriculum itself. Overall, our study highlights the importance of understanding the individual factors that contribute to an EM, as well as the limitations of formal education in promoting entrepreneurship.

In terms of similarities between the two disciplines, we identified the concept of Ideation to be correlated to business and engineering students' EI and II. We show that students who possess a deep understanding of the value-creation process are more likely to intend to pursue entrepreneurial or intrapreneurial endeavors. In our study, we used a measure of value creation in intrapreneurship that can be compared to Johnson's (2001) "Career Values—Challenge" scale,

which was also utilized by Gilmartin et al. (2019) and yielded similar results. Furthermore, we found that altruism, the capacity to generate social value, is associated with II in both fields. These findings contrast with those of Gilmartin et al. (2019) who found the link to be positive but not statistically significant in their use of Johnson's (2001) "Career Value—Social" scale.

In terms of distinct elements that relate to E/II among business and engineering majors, there is a significant positive link between Interest (curiosity) and both EI and II and empathy and EI among engineering students. Students who are curious may be more inclined to explore new ideas and opportunities, which can be advantageous in both entrepreneurial and intrapreneurial ventures. These results may relate to Gilmartin et al. (2019), who used a scale of "innovation orientation" and found it to be more predictive of intent in engineering than in business.

While the Open Mindedness factor, which involves integrating knowledge to develop new solutions, was found to be favorable for II among engineering students, it may not be as valuable for business students. This may be because business education often focuses on developing knowledge and skills related to managing and organizing existing resources and processes rather than creating new ones (Huang-Saad et al., 2018). Business students are more likely to be trained in managing and optimizing current operations rather than developing new solutions from scratch, which is the domain of engineers. Additionally, business students may have more limited technical knowledge and may not be as adept at identifying innovative solutions to technical problems as observed by Fleaca & Stanciu (2019). Thus, while the Open Mindedness factor may be important for engineering students who need to apply their technical expertise to solve problems within existing organizations (Huang-Saad et al., 2018), it may not

be as relevant or valuable for business students who are focused on managing and optimizing existing resources and processes.

Our contribution adds to the body of work (Gilmartin et al., 2019; Huang-Saad et al., 2018) that discusses the importance of considering discipline-specific characteristics when designing EE programs. Our study underscores the imperative of discipline-specific education programs. Generic approaches may not fully tap into the inherent strengths and propensities of students from varied fields, potentially leaving valuable attributes underdeveloped. By pinpointing the unique factors contributing to EI and II across disciplines, educators can curate curricula that resonate more deeply with students' natural inclinations and the demands of their chosen fields. For engineering students, in particular, our findings highlight the pivotal roles of interest and open-mindedness. These elements not only foster technical prowess but also facilitate holistic problem-solving, interdisciplinary collaboration, and effective engagement in diverse teams. By emphasizing these aspects in engineering education, we can better equip these students for the multifaceted challenges of the contemporary professional landscape. However, instilling these traits and mindsets is no trivial endeavor. Our longitudinal analysis indicates a certain inertia in EM factors over time which is consistent with previous studies on changing mindsets (Polin, 2023). This suggests that while the identification of these crucial attributes is a foundational step, the path to genuinely embedding them in students' mindsets may require sustained, innovative, and immersive educational strategies. It is a call to educators to be both persistent and creative, to ensure that students not only understand but deeply internalize these entrepreneurial and intrapreneurial attributes, making them second nature as they navigate their future careers. Empirical evidence suggests that incorporating strategic educational interventions

can effectively enhance students' proficiency in entrepreneurship-related subjects (Dinh et al., 2022; Balachandra, 2019; Laukkanen, 2000; Secundo et al., 2016; Pfeifer et al., 2016).

Additionally, in light of our findings, there is a pressing need to promote interdisciplinary collaboration. Merging the strengths of both business and engineering students, for instance, can yield holistic entrepreneurial endeavors, blending technical prowess with market intuition. This integration suggests a broader implication: the significance of providing students with tangible, real-world experiences. While classroom teachings lay a foundational understanding, supplementing them with internships or project-based learning can deeply embed the EM. Yet, the relative constancy of entrepreneurial attributes over time implies the benefit of continuous feedback, be it through self-assessments, peer reviews, or mentorship. Equally pivotal is the professional development of educators, ensuring they are equipped to cultivate these mindsets in their students. This tailored approach extends beyond the classroom; institutions should consider custom extracurricular opportunities, like workshops and competitions, that nurture discipline-specific entrepreneurial attributes. Regular curriculum reviews, in tandem with stakeholder engagement, can ensure educational programs remain relevant, responsive, and aligned with the evolving entrepreneurial landscape.

There are strategies that educators and institutions can implement to effectively achieve the balance between interdisciplinary collaboration with discipline-specific approaches in fostering an EM. First, the development of an integrated curriculum that includes both interdisciplinary projects and discipline-focused courses can encourage the synthesis of diverse perspectives, enriching students' learning experiences. Second, encouraging students to take electives outside their major area of study can further enhance their understanding of complementary disciplines, thereby fostering a more holistic approach to problem-solving.

Third, conducting professional development workshops for educators can equip them with the necessary tools to facilitate cross-disciplinary learning effectively, ensuring that they can guide students in integrating and applying their varied skills and knowledge in collaborative settings. Finally, forging partnerships with industry can provide students with practical, real-world challenges that necessitate interdisciplinary solutions, thus preparing them for the complexities of the contemporary professional landscape. Implementing these strategies can help educational institutions cultivate an environment that not only values but actively promotes the development of entrepreneurial capabilities across and within various academic disciplines.

In essence, fostering an entrepreneurial and intrapreneurial mindset demands a dynamic, multifaceted, and student-centric strategy, nuanced by each discipline's unique needs.

Discussion: Theoretical Contributions

Our study makes a significant theoretical contribution by expanding the understanding of the EM as defined by Larsen (2022), with a particular focus on its perspective as a capability within the distinct educational environments of engineering and business disciplines. By validating constructs such as Ideation, Interest, Empathy, Altruism, and Open-Mindedness, we not only align with Larsen's conceptualization but also extend the comprehensive framework efforts by Pidduck et al. (2023), which encapsulate cognitive, emotional, and behavioral components of EM.

Crucially, our exploration extends into the realm of II, a subject less frequently addressed in academic research compared to EI. By shedding light on intrapreneurship—a vital aspect of EM often overlooked in literature (Alam et al., 2020b; Rekha et al., 2015)—our study not only contributes to filling a gap in the existing discourse but also underscores the complexity of EM's impact across educational disciplines. This focus on intrapreneurship opens new pathways for

theoretical exploration within EE, encouraging a deeper understanding of intrapreneurial phenomena as emphasized by scholars such as Morris et al. (2010) and Hisrich & Kearney (2012).

Our research points to the importance of the cultural environment as a critical factor in the development and application of EM, suggesting that the unique academic, professional, and societal cultures within engineering and business disciplines significantly shape the relation of EM to E/II. This acknowledgment of the cultural environment enriches the theoretical landscape by proposing that the cultivation of an entrepreneurial mindset is not merely an individual endeavor but is deeply embedded within and influenced by a complex web of cultural influences. Other authors also found that context cannot be ignored while studying EM (Maresch et al. 2016; Gilmartin et al., 2019; Sheppard et al., 2015; Huang-Saad et al., 2018).

Our findings propel the theoretical debate forward, positing that the cultivation of EM, especially as a capability, warrants further theoretical refinement and exploration. We advocate for research that delves into tailored theoretical frameworks capable of addressing the diverse needs and nuances of students across various cultural environments.

Limitations and Further Research

While our study leverages the insights from longitudinal data to understand the evolution of EM among engineering students, there are some limitations to consider. Our follow-up sample in 2021 was relatively small, which may restrict the generalizability of our findings. Capturing changes over time is inherently challenging, requiring resources and commitment. Additionally, our research was conducted within a single institution, which may not represent wider trends across different universities. It is worth mentioning that our surveys were administered both before and after the emergence of the COVID-19 pandemic. This unprecedented global event

introduced significant disruptions in the academic and personal spheres, possibly influencing students' survey responses. The pandemic's potential impact on students' EM and their survey engagement cannot be overlooked.

Furthermore, the alignment of the 3C's elements—Interest, Empathy, Open-Mindedness, Help-Seeking, Ideation, and Altruism—with Larsen's (2022) view of the EM as a capability highlights another limitation. While ESEMA is a useful paradigm for examining essential characteristics of EM among engineering students, it may not encompass the complete range of cognitive processes, motivational attitudes, and subtle competencies identified by Larsen as critical to entrepreneurial success. ESEMA's emphasis on these constructs may ignore underlying cognitive factors involved in opportunity perception and evaluation, as well as the motivational dynamics that drive entrepreneurial activity. For example, the ESEMA assessment may not adequately address the resilience, adaptability, and ongoing learning that are required to navigate the entrepreneurial path. This limitation suggests an avenue for future research, emphasizing the need to broaden the measurement of EM to include these crucial characteristics. Future research could benefit from developing measurements that better represent the complex interplay between cognitive ability, motivational drives, and the practical skills required for entrepreneurship.

Given our findings suggest the potential stability of the EM over time, it is critical to investigate tangible measures and other research avenues to better understand and perhaps affect this phenomenon. To address this, educational programs tailored specifically to improve features of EM should be extensively examined for efficacy over time. These interventions could include focused workshops, mentorship programs, and experiential learning opportunities that are deliberately designed to foster entrepreneurial skills and mindsets. Investigating the factors that

contribute to EM's stability could provide insight into how educational programs and surroundings can be tailored to promote its dynamic development. Consequently, this research may lead to the creation of more dynamic and responsive educational models capable of nurturing and evolving students' entrepreneurial capacities at various stages of their educational journey.

Looking forward, there is a pressing need for more extensive longitudinal studies involving larger and more diverse samples to enhance our findings' generalizability. Emphasis should be placed on evaluating specific interventions aiming to bolster EM among engineering students. Such studies can help establish evidence-based practices in engineering education. There is also a need for alternative conceptualizations of EM. Moreover, the effects of significant external events, like the COVID-19 pandemic, on students' entrepreneurial perspectives deserve more thorough exploration.

Conclusions

The existing literature has not extensively explored the EM factors related to the EI and II of engineering students, how these intentions diverge from those of their business counterparts, or how the EM evolves over time. Addressing this gap, we utilized the EM as a capability framework and the ESEMA survey instrument in our investigation. Our findings underscored the centrality of Ideation for all students. However, Interest and Open Mindedness emerged as particularly pivotal for engineering students. Additionally, our study suggests that the EM might remain relatively stable over time.

REFERENCES

Alam, M. Z., Kousar, S., Shabbir, A., & Kaleem, M. A. (2020a). Personality traits and intrapreneurial behaviour: Moderated role of knowledge sharing behaviour in diverse group of employees in developing country. *Asia Pacific Journal of Innovation and Entrepreneurship*, 14(1), 31-46.

Alam, M. Z., Nasir, N., & Rehman, C. (2020b). Intrapreneurship concepts for engineers: a systematic review of the literature on its theoretical foundations and agenda for future research. *Journal of Innovation and Entrepreneurship*, 9(1), 1-21.

Antoncic, B., & Hisrich, R. D. (2003). Clarifying the intrapreneurship concept. *Journal of small business and enterprise development*, 10(1), 7-24.

Asenge, E. L., Diaka, H. S., & Soom, A. T. (2018). Entrepreneurial mindset and performance of small and medium scale enterprises in Makurdi Metropolis, Benue State-Nigeria. *International Journal of Innovation*, 6(2), 124-146.

Audretsch, D. B., Cunningham, J. A., Kuratko, D. F., Lehmann, E. E., & Menter, M. (2019). Entrepreneurial ecosystems: economic, technological, and societal impacts. *The Journal of Technology Transfer*, 44, 313-325.

Bae, T. J., Qian, S., Miao, C., & Fiet, J. O. (2014). The Relationship Between Entrepreneurship Education and Entrepreneurial Intentions: A Meta-Analytic Review. *Entrepreneurship: Theory & Practice*, 38(2), 217-254. doi:10.1111/etap.12095

Bailey, J., Read, J., Linder, B., & Neeley, L. (2021). Interdisciplinary team-based learning: An integrated opportunity recognition and evaluation model for teaching business, engineering and design students. *Entrepreneurship Education and Pedagogy*, 4(2), 143-168.

Bakrania, S. (2023). Toying With Engineering: Teaching Engineers to Be Entrepreneurial by Developing a Toy. *Entrepreneurship Education and Pedagogy*, 6(1), 202-210.

Balachandra, L. (2019). The improvisational entrepreneur: Improvisation training in entrepreneurship education. *Journal of Small Business Management*, 57, 60-77.

Barba-Sánchez, V., Mitre-Aranda, M., & del Brío-González, J. (2022). The entrepreneurial intention of university students: An environmental perspective. *European Research on Management and Business Economics*, 28(2), 100184.

Bilén, S. G., Kisenwether, E. C., Rzasa, S. E., & Wise, J. C. (2005). Developing and assessing students' entrepreneurial skills and mind-set. *Journal of Engineering Education*, 94(2), 233-243.

Blenker, P., Korsgaard, S., Neergaard, H., & Thrane, C. (2011). The questions we care about: paradigms and progression in entrepreneurship education. *Industry and Higher Education*, 25(6), 417-427.

Bodnar, C. A., & Hixson, C. (2018). Capturing Students' Perception of Entrepreneurial Mindset: Tools for What and Why. *Advances in Engineering Education*, 7(1), n1.

Brunhaver, S. R., Bekki, J. M., Carberry, A. R., London, J. S., & McKenna, A. F. (2018). Development of the Engineering Student Entrepreneurial Mindset Assessment (ESEMA). *Advances in Engineering Education*, 7(1), n1.

Cao, V. Q., & Ngo, T. T. T. (2019). Linking entrepreneurial intentions and mindset models: A comparative study of public and private universities in Vietnam. *Gadjah Mada International Journal of Business*, 21(2), 115-133.

Carrier, C. (1996). Intrapreneurship in small businesses: an exploratory study. *Entrepreneurship Theory and Practice,* 21(1), 5-20.

Da Silva, G. B., Costa, H. G., & De Barros, M. D. (2015). Entrepreneurship in engineering education: A literature review. *International Journal of Engineering Education,* 31(6), 1701-1710.

Daspit, J. J., Fox, C. J., & Findley, S. K. (2023). Entrepreneurial mindset: An integrated definition, a review of current insights, and directions for future research. *Journal of Small Business Management*, 61(1), 12-44.

Davis, M. H., Hall, J. A., & Mayer, P. S. (2016). Developing a new measure of entrepreneurial mindset: Reliability, validity, and implications for practitioners. *Consulting Psychology Journal: Practice and Research*, 68(1), 21–48. https://doi.org/10.1037/cpb0000045

Desing, R. M., Kajfez, R. L., Kecskemety, K. M., & Grzybowski, D. M. (2022). Intersections between entrepreneurial minded learning, identity, and motivation in engineering. *Int. J. Eng. Educ*, 38(5).

De Villiers Scheepers, M. J., Barnes, R., Clements, M., & Stubbs, A. J. (2018). Preparing future-ready graduates through experiential entrepreneurship. *Education+ Training*, 60(4), 303-317.

Dinh, A., Oberrauch, L & Dewalt, S. (2022). What's in a mindset? Exploring the entrepreneurial mindset. *Journal of Entrepreneurship Education*, 25(4),1-24.

Duval-Couetil, N., Huang-Saad, A., & Wheadon, M. (2021). Training Faculty in Entrepreneurship and Innovation: An Evaluation of the National Science Foundation Innovation-Corps™ Program. *Entrepreneurship Education and Pedagogy*, 4(4), 583-608.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education*, 94(1), 103-120.

Fernandez, T. M., Sliva Coutinho, G., Wilson, M. D., & Hoffmann, S. R. (2015). Development of entrepreneurial attitudes assessment instrument for freshman students. The 122nd ASEE Annual Conference & Exposition. Seattle, WA.

Fisher, G. (2012). Effectuation, causation, and bricolage: A behavioral comparison of emerging theories in entrepreneurship research. *Entrepreneurship Theory and Practice*, 36(5), 1019-1051.

Fleaca, E., & Stanciu, R. D. (2019). Digital-age learning and business engineering education–a pilot study on students' E-skills. *Procedia manufacturing*, 32, 1051-1057.

Gallup, (2020). Builder profile 10. Retrieved Oct 4, 2023, from https://www.gallup.com/products/170990/entrepreneurial-strengthsfinder.aspx.

Geldhof, G. J., Weiner, M., Agans, J. P., Mueller, M. K., & Lerner, R. M. (2014). Understanding entrepreneurial intent in late adolescence: The role of intentional self-regulation and innovation. *Journal of youth and adolescence*, 43, 81-91.

Ghalwash, S., Tolba, A., & Ismail, A. (2017). What motivates social entrepreneurs to start social ventures? An exploratory study in the context of a developing economy. Social Enterprise Journal, 13(3), 268-298.

Gilmartin, S. K., Thompson, M. E., Morton, E., Jin, Q., Chen, H. L., Colby, A., & Sheppard, S. D. (2019). Entrepreneurial intent of engineering and business undergraduate students. *Journal of Engineering Education*, 108(3), 316-336.

Gorlewicz, J. L., & Jayaram, S. (2020). Instilling curiosity, connections, and creating value in entrepreneurial minded engineering: Concepts for a course sequence in dynamics and controls. *Entrepreneurship Education and Pedagogy*, 3(1), 60-85.

Guerrero, M., Urbano, D., Cunningham, J. A., & Gajón, E. (2018). Determinants of graduates' start-ups creation across a multi-campus entrepreneurial university: The case of

Monterrey Institute of Technology and Higher Education. *Journal of Small Business Management*, 56(1), 150-178.
Hisrich, R. D., & Kearney, C. (2012). Corporate entrepreneurship: How to create a thriving entrepreneurial spirit throughout your company. New York: McGraw-Hill.
Huang, L. Y., Yang Lin, S. M., & Hsieh, Y. J. (2021). Cultivation of intrapreneurship: A framework and challenges. *Frontiers in Psychology*, 12, 731990.
Huang-Saad, A., Bodnar, C., & Carberry, A. (2020). Examining current practice in engineering entrepreneurship education. *Entrepreneurship Education and Pedagogy*, 3(1), 4-13.
Huang-Saad, A. Y., Morton, C. S., & Libarkin, J. C. (2018). Entrepreneurship assessment in higher education: A research review for engineering education researchers. *Journal of Engineering Education*, 107(2), 263-290.
Hylton, J. B., Mikesell, D., Yoder, J. D., & LeBlanc, H. (2020). Working to instill the entrepreneurial mindset across the curriculum. *Entrepreneurship Education and Pedagogy*, 3(1), 86-106.
Jackson, A., Mawson, C., & Bodnar, C. A. (2022). Faculty motivation for pursuit of entrepreneurial mindset professional development. *Entrepreneurship Education and Pedagogy*, 5(3), 320-346.
Jackson, A., Resnick, S., Hansson, R., Burgess, K., & Bodnar, C. A. (2023). Exploration of the experiences that shape engineering students' entrepreneurial mindset development. *Entrepreneurship Education and Pedagogy*, 6(1), 60-86.
Jin, Q., Gilmartin, S. K., Sheppard, S. D., & Chen, H. L. (2014, June). Comparing engineering and business undergraduate students' entrepreneurial interests and characteristics. In *2014 ASEE Annual Conference & Exposition* (pp. 24-295).
João, I. M., & Silva, J. M. (2020). Developing an entrepreneurial mindset among engineering students: encouraging entrepreneurship into engineering education. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, 15(3), 138-147.
Johnson, M. K. (2001). Job values in the young adult transition: Change and stability with age. *Social Psychology Quarterly*, 297-317.
Kaffka, G., & Krueger, N. (2018). The entrepreneurial 'mindset': Entrepreneurial intentions from the entrepreneurial event to neuroentrepreneurship. Foundational Research in Entrepreneurship Studies: Insightful Contributions and Future Pathways, 203-224.
Katz, J. A. (2003). The chronology and intellectual trajectory of American entrepreneurship education 1876–1999. *Journal of Business Venturing*, 18(2), 283–300. doi:10.1016/S0883-9026(02)00098-8
Kautonen, T., Van Gelderen, M., & Fink, M. (2015). Robustness of the theory of planned behavior in predicting entrepreneurial intentions and actions. *Entrepreneurship Theory and Practice*, 39(3), 655-674.
KEEN, (2023). KEEN: The Kern Entrepreneurial Engineering Network. Retrieved Oct 4, 2023, from https://engineeringunleashed.com/what-is-keen
Kraus, S., Breier, M., Jones, P., & Hughes, M. (2019). Individual entrepreneurial orientation and intrapreneurship in the public sector. *International Entrepreneurship and Management Journal*, 15, 1247-1268.
Krueger Jr, N. F. (2007). What lies beneath? The experiential essence of entrepreneurial thinking. Entrepreneurship Theory and Practice, 31(1), 123-138.

Kuratko, D. F., Hornsby, J. S., & McKelvie, A. (2023). Entrepreneurial mindset in corporate entrepreneurship: Forms, impediments, and actions for research. *Journal of Small Business Management*, 61(1), 132-154.

Kwapisz, A., Schell, W. J., Aytes, K., & Bryant, S. (2022). Entrepreneurial action and intention: the role of entrepreneurial mindset, emotional intelligence, and grit. *Entrepreneurship Education and Pedagogy*, 5(3), 375-405.

Ilonen, S., & Hytönen, K. (2023). Why should I become an intrapreneur? Introducing the concept of intrapreneurial outcome expectations. *Entrepreneurship Education and Pedagogy*, 6(2), 251-275.

Larsen, I. B. (2022). Fostering an entrepreneurial mindset: A typology for aligning instructional strategies with three dominant entrepreneurial mindset conceptualizations. *Industry and Higher Education*, 36(3), 236-251.

Laukkanen, M. (2000). Exploring alternative approaches in high-level entrepreneurship education: creating micromechanisms for endogenous regional growth. *Entrepreneurship & Regional Development*, 12(1), 25-47.

Lichtenstein, G., & Monroe-White, T. (2017). Entrepreneurial mindset. Assessment reviews. Cit, 5(03), 2018. https://venturewell.org/wp-content/uploads/EMAR-v1.pdf (Accessed on Oct 4, 2023)

Liñán, F., & Fayolle, A. (2015). A systematic literature review on entrepreneurial intentions: citation, thematic analyses, and research agenda. *International Entrepreneurship and Management Journal*, 11, 907-933.

Linton, J. D., & Xu, W. (2021). Research on science and technological entrepreneurship education: What needs to happen next?. *The Journal of Technology Transfer*, 46, 393-406.

London, J. S., Bekki, J. M., Brunhaver, S. R., Carberry, A. R., & McKenna, A. F. (2018). A Framework for Entrepreneurial Mindsets and Behaviors in Undergraduate Engineering Students: Operationalizing the Kern Family Foundation's "3Cs". *Advances in Engineering Education*, 7(1), n1.

Maheshwari, G., Kha, K. L., & Arokiasamy, A. R. A. (2022). Factors affecting students' entrepreneurial intentions: a systematic review (2005–2022) for future directions in theory and practice. *Management Review Quarterly*, 1-68.

Martin, B. C., McNally, J. J., & Kay, M. J. (2013). Examining the formation of human capital in entrepreneurship: A meta-analysis of entrepreneurship education outcomes. *Journal of Business Venturing*, 28(2), 211-224.

Maresch, D., Harms, R., Kailer, N., & Wimmer-Wurm, B. (2016). The impact of entrepreneurship education on the entrepreneurial intention of students in science and engineering versus business studies university programs. *Technological Forecasting and Social Change*, 104, 172-179.

Mendelson, M. I. (2001). Entrepreneurship in a graduate engineering program. *Journal of Engineering Education*, 90(4), 601-607.

Menzel, H. C., Aaltio, I., & Ulijn, J. M. (2007). On the way to creativity: Engineers as intrapreneurs in organizations. *Technovation*, 27(12), 732–743.

Morris, M. H., Kuratko, D. F., & Covin, J. G. (2010). Corporate entrepreneurship & innovation. Cengage Learning.

Morris, N. M., Kuratko, D. F., & Pryor, C. G. (2014). Building blocks for the development of university-wide entrepreneurship. *Entrepreneurship Research Journal*, 4(1), 45–68. doi:10.1515/erj-2013-0047

Nabi, G., & Liñán, F. (2013). Considering business start-up in recession time: The role of risk perception and economic context in shaping the entrepreneurial intent. *International Journal of Entrepreneurial Behavior & Research*, 19(6), 633-655.

Neck, H. M., & Corbett, A. C. (2018). The scholarship of teaching and learning entrepreneurship. *Entrepreneurship Education and Pedagogy*, 1(1), 8-41.

Neessen, P. C., Caniëls, M. C., Vos, B., & De Jong, J. P. (2019). The intrapreneurial employee: toward an integrated model of intrapreneurship and research agenda. *International Entrepreneurship and Management Journal,* 15, 545-571.

Nichols, S. P., & Armstrong, N. E. (2003). Engineering entrepreneurship: Does entrepreneurship have a role in engineering education?. *IEEE Antennas and Propagation Magazine*, 45(1), 134-138.

Outsios, G., & Kittler, M. (2018). The mindset of UK environmental entrepreneurs: A habitus perspective. *International Small Business Journal*, 36(3), 285-306.

Park, E., Leonard, A., Delano, J. S., Tang, X., & Grzybowski, D. M. (2020). Rubric-Based Assessment of Entrepreneurial Minded Learning in Engineering Education: A Review. *International Journal of Engineering Education,* 36(6), 2015-2029.

Patel, M., & Basu, A. (2006, June). How to weave entrepreneurship into engineering education: The experience at San Jose State University. In 2006 Annual Conference & Exposition (pp. 11-703).

Peterfreund, A. R., & Costache, E., & Chen, H. L., & Gilmartin, S. K., & Sheppard, S. (2016, June), Infusing Innovation and Entrepreneurship into Engineering Education: Looking for Change as Seen by ASEE Members, 2012 to 2015 Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.25691

Pfeifer, S., Šarlija, N., & Zekić Sušac, M. (2016). Shaping the entrepreneurial mindset: Entrepreneurial intentions of business students in Croatia. *Journal of Small Business Management*, 54(1), 102-117.

Pidduck, R. J., Clark, D. R., & Lumpkin, G. T. (2023). Entrepreneurial mindset: Dispositional beliefs, opportunity beliefs, and entrepreneurial behavior. *Journal of Small Business Management*, 61(1), 45-79.

Polin, B. A. (2023). Disentangling the roles of academic major and gender in determining entrepreneurial intentions among students. *Education+ Training*, 65(1), 22-43.

Rae, D., & Melton, D. E. (2017). Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project. *The Journal of Engineering Entrepreneurship*, 7(3).

Rauch, A., Wiklund, J., Lumpkin, G. T., & Frese, M. (2009). Entrepreneurial orientation and business performance: An assessment of past research and suggestions for the future. *Entrepreneurship Theory and Practice*, 33(3), 761-787.

Rekha, S. K., Ramesh, S., & JayaBharathi, S. (2015). Empherical study on the relationship between entrepreneurial mindset and the factors affecting intrapreneurship: A study in Indian context. *International Journal of Entrepreneurship*, 19, 53.

Riley, D. R., Shuster, H. M., LeMasney, C. A., Silvestri, C. E., & Mallouk, K. E. (2023). First-year engineering students' conceptualization of entrepreneurial mindset. *Entrepreneurship Education and Pedagogy*, 6(1), 87-109.

Rover, D. T. (2005). New economy, new engineer. *Journal of Engineering Education*, 94(4), 427.

Secundo, G., Ndou, V., & Del Vecchio, P. (2016). Challenges for instilling entrepreneurial mindset in scientists and engineers: what works in European universities? *International Journal of Innovation and Technology Management*, 13(05), 1640012.

Segal, G., Borgia, D., & Schoenfeld, J. (2005). The motivation to become an entrepreneur. *International Journal of Entrepreneurial Behavior & Research*, 11(1), 42-57.

Sheppard, S., & Gilmartin, S., & Chen, H. L., & Besterfield-Sacre, M. E., & Duval-Couetil, N., & Shartrand, A., & Moore, L., & Costache, E., & Fintoc, A. M., & Jin, Q., & Ling, C., & Lintl, F. M., & Britos Cavagnaro, L. C., & Fasihuddin, H., & Breed, A. K. (2015, June), Exploring What We Don't Know About Entrepreneurship Education for Engineers. Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.24083

Solesvik, M. Z., Westhead, P., Matlay, H., & Parsyak, V. N. (2013). Entrepreneurial assets and mindsets: benefit from university entrepreneurship education investment. *Education+ Training*, 55(8-9), 748-762.

Souitaris, V., Zerbinati, S., & Al-Laham, A. (2007). Do entrepreneurship programmes raise entrepreneurial intention of science and engineering students? The effect of learning, inspiration and resources. *Journal of Business Venturing*, 22(4), 566-591.

Standish-Kuon, T., & Rice, M. P. (2002). Introducing engineering and science students to entrepreneurship: Models and influential factors at six American universities. *Journal of Engineering Education*, 91(1), 33-39.

Stenard, B. S. (2023). Interdisciplinary skills for STEAM entrepreneurship education. *Entrepreneurship Education and Pedagogy*, 6(1), 32-59.

Sullivan, J. F., Carlson, L. E., & Carlson, D. W. (2001). Developing aspiring engineers into budding entrepreneurs: An invention and innovation course. *Journal of Engineering Education*, 90(4), 571-576.

Täks, M., Tynjälä, P., Toding, M., Kukemelk, H., & Venesaar, U. (2014). Engineering students' experiences in studying entrepreneurship. *Journal of Engineering Education*, 103(4), 573-598.

Unger, J. M., Rauch, A., Frese, M., & Rosenbusch, N. (2011). Human capital and entrepreneurial success: A meta-analytical review. *Journal of Business Venturing*, 26(3), 341-358.

VentureWell, (2023). Directory of I-CorpsTM Nodes and Sites. Retrieved Oct 4, 2023 from https://venturewell.org/i-corps/directory-corps-nodes-sites/.

Wales, W. J., Gupta, V. K., & Mousa, F. T. (2013). Empirical research on entrepreneurial orientation: An assessment and suggestions for future research. *International Small Business Journal*, 31(4), 357-383.

Wang, E. L., & Kleppe, J. A. (2001). Teaching invention, innovation, and entrepreneurship in engineering. *Journal of Engineering Education*, 90(4), 565-570.

Welter, F., & Smallbone, D. (2011). Institutional perspectives on entrepreneurial behavior in challenging environments. *Journal of Small Business Management*, 49(1), 107-125.

Williamson, J. M., Lounsbury, J. W., & Han, L. D. (2013). Key personality traits of engineers for innovation and technology development. *Journal of Engineering and Technology Management,* 30(2), 157–168.

Wu, S., & Wu, L. (2008). The impact of higher education on entrepreneurial intentions of university students in China. *Journal of Small Business and Enterprise Development*, 15(4), 752-774.

Yi, S., & Duval-Couetil, N. (2018). What drives engineering students to be entrepreneurs? Evidence of validity for an entrepreneurial motivation scale. *Journal of Engineering Education*, 107(2), 291-317.

Zampetakis, L. A., Kafetsios, K., Bouranta, N., Dewett, T., & Moustakis, V. S. (2009). On the relationship between emotional intelligence and entrepreneurial attitudes and intentions. *International Journal of Entrepreneurial Behavior & Research,* 15(6), 595-618.

Zappe, S. E., Cutler, S. L., & Gase, L. (2023). A systematic review of the impacts of entrepreneurial support programs in science, technology, engineering, and math fields. *Entrepreneurship Education and Pedagogy*, 6(1), 3-31.

Tables and Figures

TABLE 1a Descriptive Statistics for the 2019 Student Sample

Variable	Mean	Std. Dev.	Min	Max	Count
Engineering (1) / Business (0)	0.574	0.495	0	1	817
Male (1) / Female (0)	0.716	0.451	0	1	974
GPA	3.221	1.648	0.93	4	980
Entrepreneurial Intention (EI)	13.61	3.337	0	20	980
Intrapreneurial Intention (II)	3.727	0.877	1	5	976
Altruism	3.921	0.83	1	5	971
Empathy	3.635	1.067	1	5	971
Help Seeking	3.351	1.054	1	5	971
Ideation	3.246	0.847	1	5	965
Interest	3.509	1.122	1	5	958
Open Mindedness	4.449	0.642	1	5	958

TABLE 1b Descriptive Statistics for Students Participating in Both 2019 and 2022 Surveys

Variable	Mean	Std. Dev.	Min	Max	Count
Engineering (1) / Business (0)	0.636	0.483	0	1	99
Male (1) / Female (0)	0.559	0.499	0	1	118
GPA	3.438	0.434	1.96	4	118
2019 answers					
Entrepreneurial Intention (EI)	13.153	3.716	4	20	118
Intrapreneurial Intention (II)	3.873	0.822	1	5	118
Altruism	4.013	0.815	2	5	118
Empathy	3.653	1.135	1	5	118
Help Seeking	3.449	1.051	1	5	118
Ideation	3.280	0.905	1	5	118
Interest	3.678	1.053	1	5	118
Open Mindedness	4.581	0.527	3	5	118
2022 answers					
Entrepreneurial Intention (EI)	9.703	6.199	0	20	118
Intrapreneurial Intention (II)	3.644	0.952	1	5	90
Altruism	3.929	0.822	1	5	84
Empathy	3.714	1.082	1	5	84
Help Seeking	3.381	1.074	1	5	84
Ideation	3.183	0.904	1	5	82
Interest	3.577	1.179	1	5	78
Open Mindedness	4.474	0.639	2	5	78

TABLE 2 Ordered logit regression results for all students (2019) with entrepreneurial and intrapreneurial intention as the dependent variable

Variable	Entrepreneurial Intent (EI)		Intrapreneurial Intent (II)	
	Coeff	SE	Coeff	SE
Male	0.692***	0.153	-0.154	0.165
GPA	0.126***	0.042	0.192***	0.045
Ideation	0.656***	0.086	0.419***	0.091
Open Mindedness	-0.175	0.106	0.060	0.117
Interest	0.149**	0.063	0.142**	0.068
Altruism	0.269***	0.086	0.474***	0.093
Empathy	0.111*	0.065	0.052	0.069
Help Seeking	0.067	0.062	0.106	0.066
Engineering Student	-1.457***	0.148	-0.666***	0.153
Mean dependent variable	13.733		3.768	
Pseudo r-squared	0.060		0.071	
Number of observations	799		799	
Chi-square	235.007		143.033	
Prob > chi2	0.000		0.000	
Akaike crit. (AIC)	3732.247		1890.871	
Bayesian crit. (BIC)	3849.331		1951.754	

*Significance Level: *** < 0.01; **<0.05; *<0.1*

TABLE 3a Ordered logit regression results with Entrepreneurial Intention (EI) as the dependent variable

Variable	Engineering		Business	
	Coeff	SE	Coeff	SE
Male	0.768***	0.215	0.630***	0.225
GPA	0.184***	0.052	0.012	0.073
Ideation	0.657***	0.113	0.666***	0.135
Open Mindedness	-0.190	0.142	-0.002	0.169
Interest	0.258***	0.083	-0.052	0.104
Altruism	0.145	0.116	0.405***	0.133
Empathy	0.230***	0.081	-0.168	0.110
Help Seeking	0.011	0.080	0.151	0.096
Mean dependent variable	12.882		14.871	
Pseudo r-squared	0.048		0.038	
Number of observations	457		342	
Chi-square	108.352		57.898	
Prob > chi2	0.000		0.000	
Akaike crit. (AIC)	2192.989		1528.573	
Bayesian crit. (BIC)	2291.982		1612.939	

*Significance Level: *** < 0.01; **<0.05; *<0.1*

TABLE 3b Ordered logit regression results with Intrapreneurial Intention (II) as the dependent variable

Variable	Engineering		Business	
	Coeff	SE	Coeff	SE
Male	-0.246	0.226	-0.142	0.247
GPA	0.247***	0.056	0.099	0.077
Ideation	0.336***	0.118	0.556***	0.147
Open Mindedness	0.256*	0.154	-0.228	0.186
Interest	0.181**	0.087	0.123	0.112
Altruism	0.382***	0.122	0.561***	0.145
Empathy	-0.033	0.086	0.222*	0.119
Help Seeking	0.099	0.086	0.134	0.104
Mean dependent variable	3.683		3.883	
Pseudo r-squared	0.072		0.075	
Number of observations	457		342	
Chi-square	85.245		60.881	
Prob > chi2	0.000		0.000	
Akaike crit. (AIC)	1126.630		770.117	
Bayesian crit. (BIC)	1176.126		816.135	

*Significance Level: *** < 0.01; **<0.05; *<0.1*

TABLE 4 Ordered logit regression results for all students with Entrepreneurial and Intrapreneurial Intention as the dependent variable

Variable	Entrepreneurial Intention (EI)		Intrapreneurial Intention (II)	
	Coeff	SE	Coeff	SE
Male	0.708***	0.154	-0.181	0.167
GPA	0.133***	0.042	0.199***	0.045
Ideation	0.601***	0.127	0.552***	0.140
Open Mindedness	-0.017	0.162	-0.247	0.179
Interest	-0.047	0.101	0.119	0.110
Altruism	0.379***	0.127	0.523***	0.139
Empathy	-0.143	0.106	0.210*	0.116
Help Seeking	0.122	0.093	0.105	0.102
Engineering Student	-2.447**	1.018	-1.236	1.107
Engineering x Ideation	0.118	0.167	-0.218	0.180
Engineering x Open Mindedness	-0.184	0.216	0.526**	0.237
Engineering x Interest	0.320**	0.131	0.059	0.141
Engineering x Altruism	-0.214	0.171	-0.107	0.183
Engineering x Empathy	0.384***	0.133	-0.237	0.144
Engineering x Help Seeking	-0.101	0.124	0.004	0.134
Mean dependent variable	13.733		3.768	
Pseudo r-squared	0.064		0.075	
Number of observations	799		799	
Chi-square	251.992		151.336	
Prob > chi2	0.000		0.000	
Akaike crit. (AIC)	3727.262		1894.567	
Bayesian crit. (BIC)	3872.446		1983.551	

*Significance Level: *** < 0.01; **<0.05; *<0.1*

TABLE 5 Nonparametric Paired tests p-values results for engineering and business students across three years in all EM Dimensions

EM Dimension	Engineering (significance of the one-sided test) N=49	Business (significance of the one-sided test) N=25
Ideation	> 0.10	> 0.10
Open Mindedness	<0.1* (-)	> 0.10
Interest	> 0.10	> 0.10
Altruism	<0.1* (-)	<0.1* (+)
Empathy	> 0.10	> 0.10
Help Seeking	> 0.10	> 0.10

*Significance Level: *** < 0.01; **<0.05; *<0.1*

TABLE 6 Summary of positive and significant effects at significance Level: * < 0.01; **<0.05; *<0.1 (EI = Entrepreneurial Intention; II = Intrapreneurial Intention)**

Variable	All students Table 2		Separate samples Table 3 (a and b)				Interaction: comparative effect Table 4	
	All EI	All II	Eng EI	Eng II	Bus EI	Bus II	Eng EI	Eng II
Ideation	***	***	***	***	***	***		
Altruism	***	***		***	***	***		
Interest	**	**	***	**			**	
Empathy	*		***				***	
Open Mindedness				*				**
Help Seeking								

FIGURE 1 Theoretical framework of the study

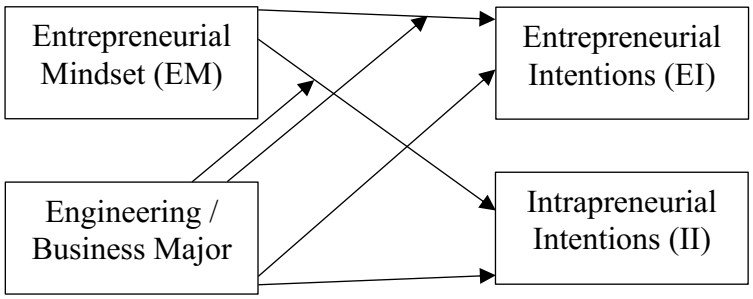
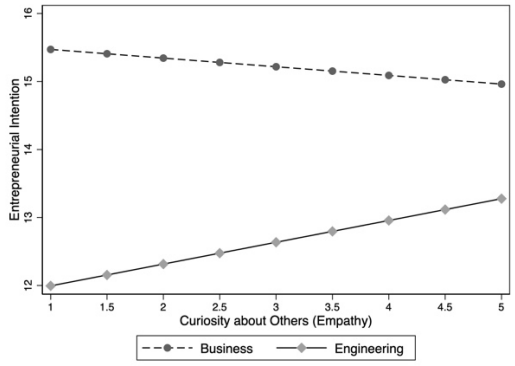
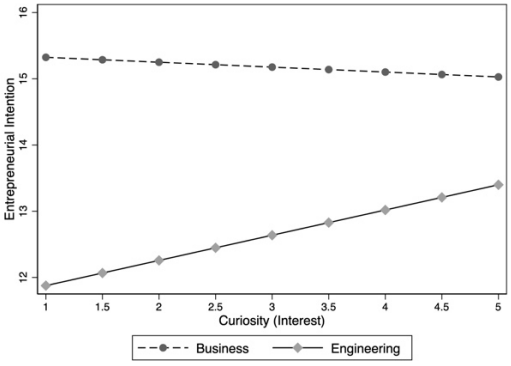
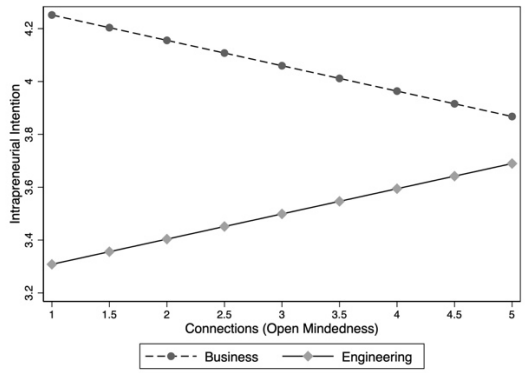


FIGURE 2 Significant interaction effects between Engineering Major and EM with Entrepreneurial and Intrapreneurial Intention as the dependent variable







APPENDIX A: The ESEMA Scale

As you answer the following questions, think about your past experiences. Please respond to each question by indicating how true each of the following statements are to you (1 = Never or only rarely true of me; 2 = Sometimes true of me; 3 = True of me about half the time; 4 = Frequently true of me; 5 = Always or almost always true of me).

ESEMA Name	Question
Interest	I tend to get involved in a variety of activities
Interest	I participate in a wide range of activities
Interest	I enjoy being involved in a variety of activities
Empathy	Other people tell me I am good at understanding their feelings
Empathy	I can easily tune into how someone else feels
Empathy	I am good at predicting how someone will feel
Open Mindedness	I recognize that people with different backgrounds from my own might have better ideas than I do
Open Mindedness	I am willing to compromise if another idea seems better than my own
Open Mindedness	I recognize the importance of different fields of study even if I don't know much about them
Open Mindedness	I am willing to learn from others who have different areas of expertise
Open Mindedness	I appreciate the value that different kinds of knowledge can bring to a project
Open Mindedness	I am willing to update my plans in response to new information
Open Mindedness	I appreciate the value that individuals with different strengths bring to a team
Open Mindedness	I am willing to consider an idea put forth by someone with a different background than my own
Help Seeking	I ask for help when I need it
Help Seeking	I am comfortable asking others for help
Help Seeking	If I am struggling on a task, I ask for help
Help Seeking	I seek outside support when I am stuck
Help Seeking	I know when I need to ask for help
Ideation	I tend to work on problems that do not have clear solutions
Ideation	I typically develop new ideas by improving existing solutions
Ideation	I would rather work with what is unfamiliar than what is familiar
Ideation	I like to think of wild and crazy ideas
Ideation	I prefer tasks that are not well-defined
Ideation	I like to reimagine existing ideas
Ideation	Other people tell me I am good at thinking outside the box
Ideation	I like to think about ways to improve accepted solutions
Ideation	I am likely to change directions on a project even after putting forth a lot of effort
Ideation	I tend to embrace change

Ideation	I prefer to challenge adopted solutions rather than blindly accept them
Altruism	I am driven to do things that improve the lives of others
Altruism	I care about solving problems important to society
Altruism	It is important to me to contribute to the good of society
Altruism	I believe it is important I do things that fix problems in the world