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Unveiling the entrepreneurial mindset: exploring orientation and intentions among students of prominent engineering disciplines

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Abstract

The advent of Industry 4.0 presents a spectrum of challenges for entrepreneurs in India, demanding specific skills and resources. Within this transformative landscape, engineering disciplines assume a pivotal role in navigating the complexities of the new industrial revolution yet pose challenges in instilling entrepreneurial skills. While universities are recognised for fostering entrepreneurial skills, a gap persists in comprehending students' intentions to pursue entrepreneurship after completing their studies, especially within technical education systems. This emphasises the necessity for a comprehensive examination of variations in entrepreneurial orientation among diverse engineering disciplines. The study employed cross-sectional research and surveyed 370 final-year engineering students from leading engineering colleges in Karnataka, India. The data analysis included Exploratory Factor Analysis (EFA) and Structural Equation Modeling (SEM). The findings demonstrate a significant propensity for entrepreneurship among engineering students, highlighting attributes such as innovativeness, risk-taking, and proactiveness. However, contrary to expectations, the study does not discern distinct entrepreneurial orientations across different engineering disciplines. Importantly, it unveils that college education has minimal influence on students' entrepreneurial intentions.

Keywords: Engineering, Entrepreneurship, Entrepreneurial education, Engineering disciplines, Innovativeness, Proactiveness, Risk-taking, India

Introduction

Education plays a pivotal role in fostering the development of enterprising and innovative individuals, either by identifying and nurturing inherent talents or by instilling entrepreneurial intentions and behaviours (Ferreira & Trusko, 2018, p.2). Jimenez et al. (2015) have highlighted the positive impact of both secondary and tertiary education on formal entrepreneurship in their research. The crucial role of educational resources and entrepreneurial support in shaping students' entrepreneurial inclinations has been underscored, with studies demonstrating a positive correlation between access to these resources and entrepreneurial propensity (Sahoo & Panda, 2019).

Furthermore, entrepreneurship is not only seen as a catalyst for economic growth but also a viable solution to the issue of undergraduate unemployment (Koe, 2016). The impact of entrepreneurial education courses on indicators of entrepreneurial intention has garnered substantial attention, as evidenced by the works of Tantawy et al. (2021). According to Rauch and Hulsink (2015), the strength of entrepreneurial intentions is a crucial determinant of future entrepreneurial behaviour.

Amidst the burgeoning interest in entrepreneurial education, a myriad of articles has surfaced, evaluating its impact on fostering a culture of entrepreneurship (Belwal et al., 2015; Chhabra et al., 2021; Henry et al., 2005; Li & Liu, 2011; Solomon et al., 2008). However, a predominant focus of these studies lies in assessing whether participants' entrepreneurial intentions are fortified through their engagement with these courses, as observed in research by Van Ewijk and Belghiti-Mahut (2019). Rauch and Hulsink (2015, pp.187–188) have echoed prior findings, suggesting a positive influence of entrepreneurship education on attitudes and intentions toward starting a business.

The university ecosystem is recognised for its significant contribution to fostering entrepreneurial skills and competencies (Ferreira & Trusko, 2018). However, Basu and Virick, (2008)shed light on the inadequacies in understanding how students' enrollment in entrepreneurship courses at US universities correlates with their entrepreneurial aspirations. Belwal et al.(2015) delved into students' perspectives on entrepreneurship within the context of enterprise education in Oman. While students expressed optimism about entrepreneurship, their limited knowledge of business startups highlighted the pressing need for more robust enterprise education initiatives. This suggests a discrepancy between students' aspirations and the educational resources available to support their entrepreneurial endeavours. Singh et al. (2014) further emphasised the impact of education on students' entrepreneurial attitudes, revealing gender disparities and the inadequacy of the Indian technical education system in fostering entrepreneurial orientation. This raises questions about the effectiveness of current educational approaches in promoting entrepreneurship among Indian students as mentioned by Mukesh et al. (2018). On a related note, Khot (2015) emphasised the disparity between engineering and medical education in terms of orienting students towards entrepreneurship. Unlike medical education, which actively promotes entrepreneurial skills, engineering education falls short in this regard. While there has been significant research conducted on entrepreneurship education, there remains a gap in the exploration of how entrepreneurship courses can be tailored specifically for engineering students, particularly in developing countries (Swarupa & Goyal, 2020).

In light of these findings, it becomes imperative to examine whether current educational practices adequately prepare students across various disciplines for entrepreneurial endeavours prompting a critical inquiry: do entrepreneurial orientation and intention indeed vary across major engineering disciplines within technical education systems? This investigation is essential for designing tailored educational interventions that effectively cultivate entrepreneurial mindset among students of diverse academic disciplines. This study moreover contributes valuable insights from the perspective of a developing country like India, where employment poses significant challenges due to outdated curriculum, limited opportunities, intense competition, and skill-job requirement mismatches as highlighted by Shah (2023).

Theoretical background and hypotheses development

The exponential expansion of engineering education in the country has prompted significant concerns regarding the "research, innovation and entrepreneurship" outcomes of engineering graduates as noted by Khot (2015), with a substantial portion facing unemployment upon graduation (Dash & Bose, 2020; Nair, 2020; Pandey & Kamble, 2023). Data from various sources (See Tilak & Choudhury, 2021, p.2), including the All India Council for Technical Education and the National Sample Survey, indicate a significant gap between the number of graduates and their employability, with studies highlighting that a large percentage of engineering graduates lack the necessary skills for employment in the evolving knowledge economy.

Ylinenpaa (2009) observed that innovation and entrepreneurship stand as defining traits of highly developed and advanced economies. However, a significant proportion of individuals in India still prioritise wage employment over entrepreneurship for their livelihoods, as highlighted by Anwar and Saleem (2019) and (Roy and Das (2017). Thus, India requires a thriving entrepreneurial ecosystem to stimulate economic growth and alleviate unemployment. Mittal and Raghuvaran (2021)contends that fostering entrepreneurship skills enhances learners' competencies, enabling them to effectively apply knowledge and establish enterprises. Consequently, students equipped with entrepreneurial abilities possess improved employability skills, offering advantages to both the workforce and the broader community, ultimately contributing to the country's economy. Dubey (2022) opined that individuals with higher education tend to show a greater interest in entrepreneurial ventures, with engineering graduates often exploring avenues as either employees or creators of job opportunities, demonstrating their suitability for entrepreneurship. Huang-Saad et al. (2020) advocate that in the present era, engineers must embrace an entrepreneurial mindset and take proactive measures to foster technological advancements effectively. Pachnowski et al. (2023) suggested that integrating entrepreneurial concepts into engineering education can offer aspiring engineers a wider perspective and skill set.

Engineering education

Entrepreneurship education courses are often studied as key factors influencing entrepreneurial intentions (EI), aiming to raise awareness of entrepreneurship as a career choice and equip students with essential skills (Tantawy et al., 2021, p.1). Traditionally, entrepreneurship courses were primarily offered by business or management schools (Luryi et al., 2007). However, a significant shift occurred in the last decade, witnessing the integration of entrepreneurial education beyond business curricula in various institutions (Katz, 2003; Morris et al., 2013).

Universities are increasingly incorporating technology entrepreneurship into engineering curricula to align with the growing emphasis on engineering design education over the past few decades (Evans et al., 2007).

Within the academic discipline of engineering, the role of cultivating entrepreneurial skills is widely acknowledged (Hassan et al., 2021; Khan et al., 2019; Popli & Rao, 2010; Yang, 2020). Khot (2015) specifically advocates for engineering education to prioritise innovative thinking and entrepreneurship for the comprehensive development of students. Taks et al., (2016, p.56) articulate key elements integral to entrepreneurship education, encompassing business plan writing, self and peer assessment, time management, creative tasks, diverse learning methods, and problem-solving skills. Expanding on this, Chen et al. (2015) delve into critical thinking, practical knowledge, negotiation and leadership skills, and innovation management as essential components of effective entrepreneurship education. Emphasising the crucial role of institutions, Nabi et al. (2010) highlight the need for support systems like incubation centres and industry mentoring to foster and advance entrepreneurship education. These efforts have led to the emergence of a fresh domain within engineering education known as engineering entrepreneurship (Shekhar & Huang-Saad, 2021). Aadland and Aaboen (2020) noted the emergence of the entrepreneurial engineer, characterised by networking, teamwork, creativity, risk management, and discipline-specific skills, prompting the integration of entrepreneurship education into engineering curricula. Nair et al., (2020) emphasised the importance of engineering graduates acquiring entrepreneurial orientation (EO) to cope with the demands of the uncertain job market in India, advocating for its mandatory inclusion of engineering curriculum. Prior studies by Hassan et al. (2021) and Perez et al. (2024) have shown that entrepreneurship education enhances students' innovativeness, proactiveness, and risk-taking abilities. We anticipate that our study on engineering education will yield similar results, indicating a positive influence on these dimensions among the students surveyed.

Entrepreneurial orientation

The concept of Entrepreneurial Orientation (EO) stands as a focal point in entrepreneurial research (Covin et al., 1994), often regarded as the initial stride towards entrepreneurship (Gartner, 1988). Pradhan and Nath (2012) encapsulated EO as "a person's natural tendency or attitude towards entrepreneurship." Within the literature, Miller (1983) delineated three enduring dimensions of EO: innovation, risk-taking, and proactiveness. Lumpkin and Dess (1996) expanded this framework, proposing two additional dimensions, namely autonomy and competitive aggressiveness. Advocating for the infusion of entrepreneurial dimensions into engineering education, Khanduja et al. (2009) emphasised the evolving nature of EO.

While researchers have adopted either a three or five-dimensional structure of EO depending on the context (Bolton & Lane, 2012; Lyon et al., 2000; Okreglicka et al., 2021; Rauch et al., 2009), the dimensions persist as integral components. Yang (2020), for instance, applied the three-dimensional framework to scrutinise the entrepreneurial orientation of Korean and Chinese students. Despite the breadth of claims in the literature, a critical evaluation of these dimensions and their applicability to the entrepreneurial orientation of engineering students is notably absent. This deficiency underscores the need for a more discerning analysis, one that goes beyond mere presentation, to elucidate the implications of the various dimensions in the context of engineering education. Figure 1 illustrates the conceptual framework employed in this study.

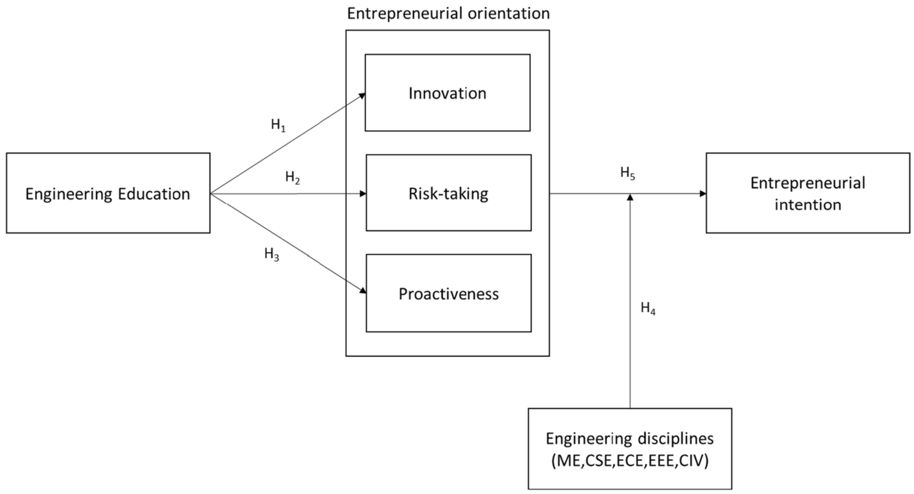


Fig. 1 Conceptual model

Innovation

The pivotal role of technology and innovation in driving economic growth has elevated entrepreneurship to the forefront of higher education (Huang-Saad et al., 2020). Innovativeness, characterised by an inclination for creativity and experimentation, is manifested through the introduction of novel products/services and technological leadership via research and development in new processes (Rauch et al., 2009). Within the realm of engineering, innovation is integral to the pursuit of designing faster, more cost-effective, and efficient methods, employing both novel and established approaches (Pech et al., 2016).

Innovation and entrepreneurship education emphasise fostering creative and critical thinking, the ability to innovate and take risks, self-management, teamwork, and practical skills among students (Zhao et al., 2019). However, numerous educational institutions often fall short of grasping the essence of innovation and fail to associate entrepreneurship education with entrepreneurial activities (Zhao et al., 2019). This deficiency is notably pronounced in the sphere of engineering education in India, where despite a large cohort of students pursuing engineering education in India, the outcomes in terms of innovation and entrepreneurship have been underwhelming (Khot, 2015). These circumstances raise questions about whether engineering institutions have provided meaningful academic inputs to foster innovativeness and shape the entrepreneurial orientation of students, a role anticipated based on existing literature. Consequently, the hypothesis is posited:

> *H1*: Engineering students possess innovative skills toward the end of their college education.

Risk-taking

Risk-taking orientation is acknowledged as a fundamental aspect of entrepreneurship (Antoncic et al., 2012, 2018), and plays a pivotal role in shaping an entrepreneur's trajectory. It necessitates a willingness to shoulder potential losses, demanding a proactive approach towards uncertainty (Shrader et al., 2000). Rauch et al. (2009) described risk-taking as "taking bold actions by venturing into the unknown, borrowing heavily, and/or committing significant resources to ventures in uncertain environments", a complex behaviour that has been a subject of scrutiny in entrepreneurial research.

Contrary to the perception that entrepreneurs embrace substantial risk, research at the individual level suggests that entrepreneurs tend to take relatively little risk (Naldi et al., 2007). This conservative approach can result in missed lucrative opportunities for those who shy away from substantial risk (Hughes & Morgan, 2007). Furthermore, the assumption by Brockhaus Sr. (1980) established that entrepreneurs possess a higher risk-taking tendency than their newer counterparts due to prolonged exposure to risk introduces a nuanced perspective on risk within entrepreneurial contexts.

In the context of engineering education, the cultivation of a risk-oriented mindset depends on the execution of pedagogical strategies (Dolinina et al., 2018). However, evidence suggests a conservative stance among engineering instructors, who are often hesitant to embrace innovative teaching approaches (Tekmen-Araci, 2019). This conservatism introduces ambiguity regarding the risk-taking ability of engineering students, contributing to the formulation of the hypothesis:

> *H2*: Engineering students possess risk-taking ability toward the end of their college education.

Proactiveness

The notion of proactiveness in engineering students, characterised by the introduction of new products and services ahead of competitors and anticipation of future demand to seize opportunities (Rauch et al., 2009), is subject to diverse influences. Millunchick et al. (2021) emphasise the role of individuals or institutions in shaping proactive behaviour, while Henderson et al. (2018) argue that pre-college characteristics and experiences predict such behaviour among engineering students. Nagahi et al. (2020) observe a positive relationship between proactive character and the ability of engineering students to adapt to change and uncertainty.

Although Gilmartin et al. (2019) emphasise that proactive behaviours influence the entrepreneurial intentions of engineering students, Chipeta and Surujlal (2017) present a contrasting view. Their findings suggest that proactive behaviour among university students does not necessarily contribute to the initiation of social enterprise but may facilitate a successful job search (Brown et al., 2006). The existing literature, however, does not conclusively establish a direct link between proactiveness among engineering students and the creation of enterprises, leaving a gap in our understanding of whether engineering education instils a proactive entrepreneurial mindset. Notably, Mwatsika and Sankhulani (2016) discovered a tenuous correlation in their study between entrepreneurship education and students' entrepreneurial orientation. In light of these perspectives, we posit the following hypothesis for investigation:

> *H3*: Engineering students possess proactive behaviour toward the end of their college education.

Engineering disciplines

The landscape of engineering education has transformed, with numerous institutions integrating technology and modern learning labs into their curricula (Jain, 2018). Within higher education, the quality of entrepreneurship education is shaped by entrepreneurial training, influencing entrepreneurial orientation (Jiang et al., 2017; Raza et al., 2021). Despite the presence of Entrepreneurship Development Cells and various activities in academic institutes, the outcomes have not yielded constructive results (Prabhu, 2020; Sao & Balpande, 2018). This observation highlights the need for a critical examination of the effectiveness of existing initiatives.

Disagreements within the literature surround the impact of engineering education on entrepreneurial orientation, particularly in the context of India. While previous studies have provided generic insights across all engineering streams, Singh et al. (2015) argue that the orientation may vary depending on the specific stream. Recognizing this variability, Alam et al. (2020) highlight the importance of considering inherent differences in engineering disciplines when studying entrepreneurial intentions. Duval-Couetil et al. (2012) further recommend an exploration of perceptual differences and attitudes among students in various engineering disciplines.

Nevertheless, despite these valuable insights, the current body of research lacks a comprehensive examination of whether and how distinct engineering disciplines influence the relationship between entrepreneurial orientation and entrepreneurial intention. To address this gap, this study hypothesises that:

> *H4*: Engineering students of different disciplines have varying entrepreneurial orientations.

Entrepreneurial intention

The concept of entrepreneurial intention, defined as the "desires to own or start a business" (Bae et al., 2014), is multifaceted within the context of engineering students. While a substantial number of engineering students express an interest in learning about entrepreneurship, a notable disparity exists in the translation of this interest into a concrete career pursuit (Duval-Couetil et al., 2012). The determinants of entrepreneurial intent are intricate, and influenced by individual characteristics, academic and social circumstances, and discipline-specific effects (Gilmartin et al., 2019). The realisation of positive outcomes from entrepreneurial efforts is a catalyst for inspiring students to develop entrepreneurial intentions (Roy & Das, 2022).

Existing literature presents divergent perspectives on the relationship between entrepreneurship education and entrepreneurial intentions. Barba-Sanchez and Atienza-Sahuquillo (2018) observed a positive association, suggesting that exposure to entrepreneurship education fosters entrepreneurial intentions. In contrast, Herman (2019) found no significant impact of entrepreneurship education on students' entrepreneurial intentions. However, entrepreneurial family backgrounds and inherent personality traits were identified as positive influencers on entrepreneurial intentions in Herman's study.

Abdullah Al-Suraihi et al. (2020) contributed insights into the role of entrepreneurial orientation dimensions in positively shaping the entrepreneurial intentions of undergraduate students. Against this backdrop of diverse findings, this study posits that:

> *H5*: Engineering students' entrepreneurial orientation induces their entrepreneurial intention.

Methodology

This study endeavours to investigate variations in entrepreneurial orientation (EO) and intention among final-year students in Karnataka state, India, across major engineering disciplines. The exploration centres on three key dimensions of EO i.e., innovativeness, risk-taking, and proactiveness, while also scrutinising their correlation with entrepreneurial intention. To secure a sample that aptly reflects the diversity of the student population, the study employed a proportionate stratified sampling method, as advocated by Daniel (2012). Accordingly, the final-year students from major engineering disciplines, namely Mechanical, Computer Science, Electronics and Communication, Electrical, and Civil, were included in the study.

Survey design

The questionnaire survey used in the research is divided into four major sections: profile of students, Area of entrepreneurial education, entrepreneurial orientation, and entrepreneurial intention of the students.

The first section of the questionnaire contains questions associated with the demographic profile of the students. The questions include the gender and engineering disciplines of the students. The study employed a nominal scale to obtain responses to demographic questions.

The second section comprises the area of entrepreneurial education with 20 statements for evaluating the area of entrepreneurial education using a five-point likert scale. The responses are coded from 1 to 5. Responses to individual items are then summed or averaged to provide an overall score.

The third section constitutes 3 factors contributing to entrepreneurial orientation: innovativeness, proactiveness and risk-taking. The factors contain nineteen statements for evaluating the entrepreneurial orientation using a semantic differential scale with bipolar questions. The responses are coded from 1 to 7. Responses to individual items are then summed or averaged to provide an overall score.

The fourth section covers the entrepreneurial intention of the students with five statements using a five-point likert scale. The responses are coded from 1 to 5. Responses to individual items are then summed or averaged to provide an overall score.

Sample size

The sample size was determined using the Yamane (1981) sample estimation formula, resulting in a dataset comprising responses from 370 participants out of a total population of 4616 engineering students in Karnataka state.

Instrumentation

The study identified various constructs such as entrepreneurial orientation, area of entrepreneurial education, and entrepreneurial intention through selecting a relevant item pool and careful examination. Subject experts were approached for the content validity of the questionnaire. For scale development, content specification is vital (Churchill, 1979; Delgado-Rico et al., 2012; Haladyna, 2012; Kaplan & Norton, 1996). The questionnaire employed a seven-point Likert scale, featuring a variety of statements, to gauge the entrepreneurial orientation of the students. This scale facilitated rapid comprehension and response, thereby aiding in the measurement of attitude intensity (Lundstrom & Lamont, 1976). A panel of experts and senior academicians assessed the content validity of the constructs. The dichotomous response category may satisfy the need to apprehend the presence or absence of an attribute among the population or sample. In the present research, dichotomous scaling techniques such as 'agree or disagree', were not adequate to describe the variability of the construct. So, a seven-point, Likert-type scale has been used. The convergent, divergent and reliability test of the constructs is estimated through Cronbach's alpha. The scale for area entrepreneurship education was adapted from the works of Chen et al. (2015), Nabi et al. (2010), and Taks et al. (2016). Additionally, the scales measuring EO dimensions—innovativeness, risk-taking, and proactiveness were adopted from Covin and Slevin (1989), Miller (1983), Naldi et al. (2007), Naman and Slevin (1993), and Zahra and Garvis (2000).

Confirmatory factor analysis (CFA) was utilised to ascertain the accuracy with which observed variables portrayed latent constructs, thereby evaluating the adequacy of the hypothesised model. Additionally, an ANOVA test was employed to explore the complex interplay among entrepreneurial orientation, education, and engineering disciplines. The statistical analysis serves to reveal any noteworthy disparities or correlations among the aforementioned variables, thereby enhancing the comprehension of the factors impacting entrepreneurial orientation and intention among final-year engineering students in Karnataka state.

Table 1 Convergent, divergent validity, and reliability

Path			Standardised regression weight loading	Convergent validity AVE	Divergent validity √AVE = DV	Reliability	
						CR	Cronbach alpha
Ent_Edu_leadership_skills	←	EDU	0.831	0.755	0.869	0.965	0.964
Ent_Edu_negotiation_skills	←	EDU	0.841				
Ent_Edu_practical_knowledge	←	EDU	0.910				
Ent_Edu_critical_thinking_skills	←	EDU	0.882				
Ent_Edu_Problem_solving_skills	←	EDU	0.961				
Ent_Edu_Creativity_skills	←	EDU	0.892				
Ent_Edu_Time_management	←	EDU	0.916				
Ent_Edu_self_peer_assessment	←	EDU	0.797				
Ent_Edu_Business_plan_writing	←	EDU	0.773				
EO_Inno_invest_process_consistency	←	INN	0.842	0.784	0.885	0.916	0.906
EO_Inno_maintaining_exisiting_technologies	←	INN	0.940				
EO_Inno_Adherence_to_process	←	INN	0.871				
EO_Pro_strategic_planning_competitive_advantage	←	PRO	0.909	0.796	0.892	0.959	0.957
EO_Pro_traditional_methods	←	PRO	0.903				
EO_Pro_charging_high_prices	←	PRO	0.894				
EO_Pro_benchmarking	←	PRO	0.917				
EO_Pro_avoid_competitive_clashes	←	PRO	0.793				
EO_Pro_special_effort	←	PRO	0.929				
EO_Inno_changes_in_existing_product_	←	INT	0.861	0.773	0.879	0.944	0.944
EO_Inno_strong_emphasis_marketing	←	INT	0.900				
EO_Inno_investment_in_new_product	←	INT	0.885				
EO_Inno_Adherence_to_process	←	INT	0.907				
EO_Inno_maintaining_exisiting_technologies	←	INT	0.841				
EO_Rt_low_risk_projects	←	RISK	0.693	0.515	0.717	0.807	0.783
EO_Rt_explore_business	←	RISK	0.604				
EO_Rt_wait_and_see	←	RISK	0.825				
EO_Rt_taking_action	←	RISK	0.730				

Table 2 Discriminant validity

	EDU	INNO	PRO	INT	RISK
EDU	0.869				
INNO	0.017	0.885			
PRO	0.016	0.358	0.892		
INT	0.006	0.176	0.206	0.879	
RISK	0.015	0.397	0.461	0.136	0.717

Table 3 Students' perceptions of entrepreneurial education across diverse engineering disciplines

Branch/discipline	Entrepreneurial education		
	Count	Mean	Standard deviation
Computer science and engineering	124	3.9	0.8
Mechanical engineering	93	3.8	1.0
Electronics and communication engineering	77	3.9	0.8
Electrical and electronics engineering	20	3.7	0.5
Civil engineering	56	3.9	0.9

Data analysis and interpretation

Confirmatory factor analysis

The Confirmatory factor analysis (CFA) is done with the help of AMOS.20. AMOS gives different indices to check the model fit and this study has taken indices like CMIN/DF, RMSEA, GFI, AGFI, NFI, CFI, and SRMR for checking the model fit (Baumgartner & Homburg, 1996; Gerpott et al., 2001; Hair et al., 2010).

Stage 1 confirmatory factor analysis did not result in a good model fit as some of the statements were loading low to the constructs.

Table 1 presents a comprehensive overview of the entrepreneurial orientation dimensions, encompassing convergent validity, divergent validity, and the reliability of each construct. The reliability of the Entrepreneurial Orientation (EO) construct is evaluated using Composite Reliability (CR) rather than Cronbach's alpha, as recommended by Chin (1998). Constructs are deemed reliable if CR exceeds 0.7 (Hair et al., 1998). Table 2 reveals that all constructs surpass the threshold of 0.7 for CR, affirming the overall reliability of the scale.

To assess the validity of the scale, both convergent and discriminant validity are crucial considerations (Hair et al., 2010). Convergent validity is established through the examination of CR and Average Variance Extracted (AVE), with values exceeding 0.7 signifying its presence (Hair et al., 2010). As observed in Table 1, the values of both CR and AVE surpass 0.7, thus confirming the convergent validity of the scale.

Discriminant validity, essential for ensuring that each construct is distinct, is determined through AVE comparisons. In our analysis, the values of Discriminant Validities (DVs) consistently exceed the respective Average Variance Extracted (AVE) values. This observation reinforces the scale's reliability and validity.

Table 2 presents the discriminant validity assessment for both entrepreneurial orientation and entrepreneurial education. The results indicate a robust discriminant validity, as evidenced by the square root of the Average Variance Extracted (AVE) exceeding the correlation between the latent variables. This signifies that the constructs are distinct and not conflated, reinforcing the reliability of our measurement model.

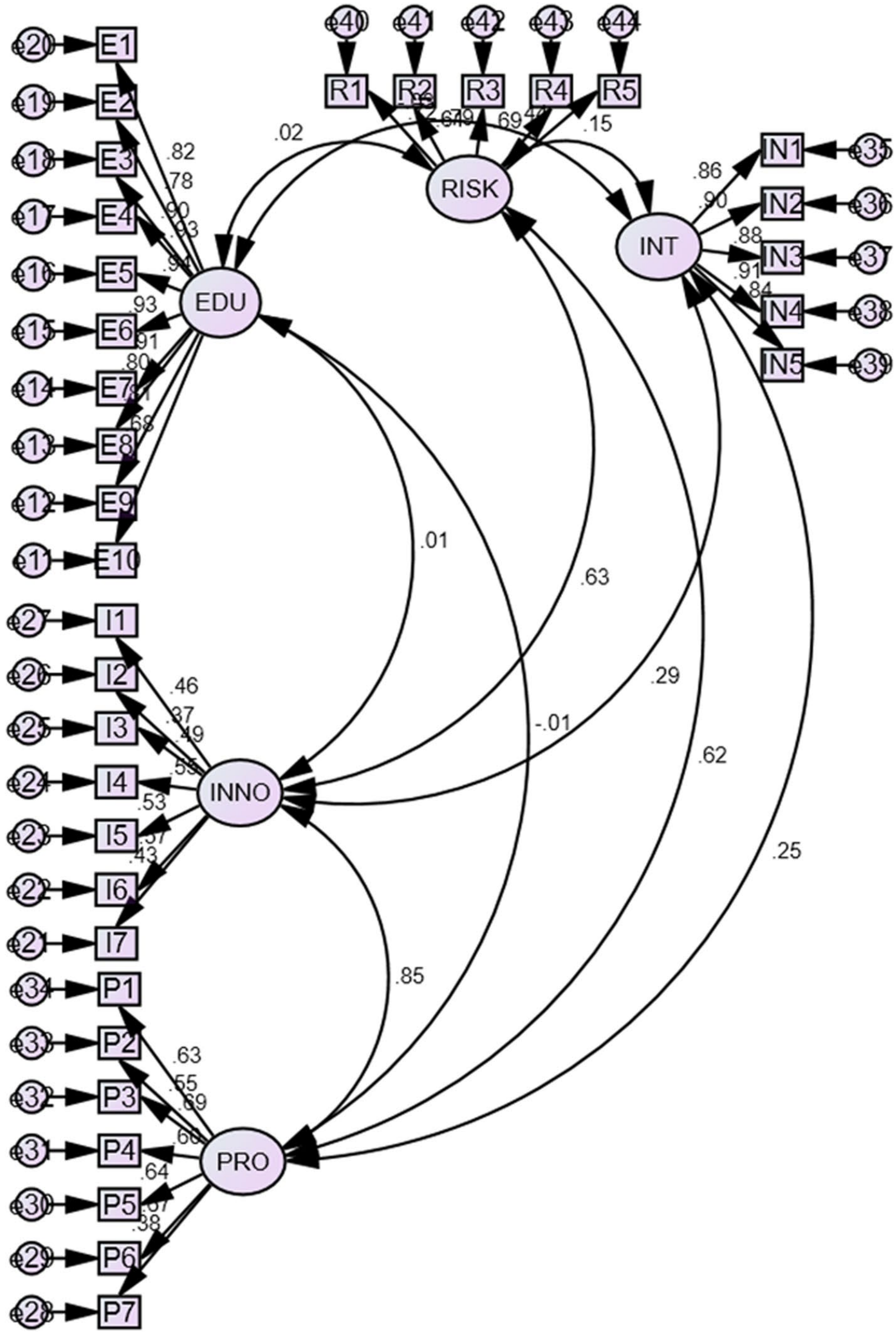
Table 3 reveals the analysis of entrepreneurial inputs across various engineering disciplines with distinct patterns. Computer Science & Engineering, with a mean rating of 3.9 ± 0.8, indicates a notably positive perception of the educational experience among its students, despite some variability in the ratings. Contrastingly, Mechanical Engineering, with a mean rating of 3.8 ± 1.0, shows slightly lower ratings than Computer Science & Engineering and demonstrates greater variability, indicating a wider range of opinions among students. Electronics and Communication Engineering shares a similar mean rating of 3.9 ± 0.8 with Computer Science & Engineering, indicating consistent perceptions among students. Electrical and Electronics Engineering reports a mean rating of 3.7 ± 0.5, slightly lower than other disciplines, with minimal variability indicated by its low standard deviation. Civil Engineering, like Computer Science & Engineering and Electronics and Communication Engineering, reports a mean rating of 3.9 ± 0.9, demonstrating moderate variability as indicated by the standard deviation.

Table 4 illustrates the analysis of variance concerning perceptions of entrepreneurial education among students in engineering disciplines. The analysis indicates no significant difference between groups ($F = 0.452$, $p = 0.771$). This indicates that mean perceptions of entrepreneurship education do not vary significantly across engineering disciplines. Furthermore, with a Levene statistic of 1.708 and a p-value of 0.147, the test indicates that variances among the engineering disciplines do not significantly differ regarding perceptions of entrepreneurial education. Consequently, the study does not provide support for H4, leading to the conclusion that there is insufficient evidence to assert substantial variations in entrepreneurial orientations among engineering students across different disciplines.

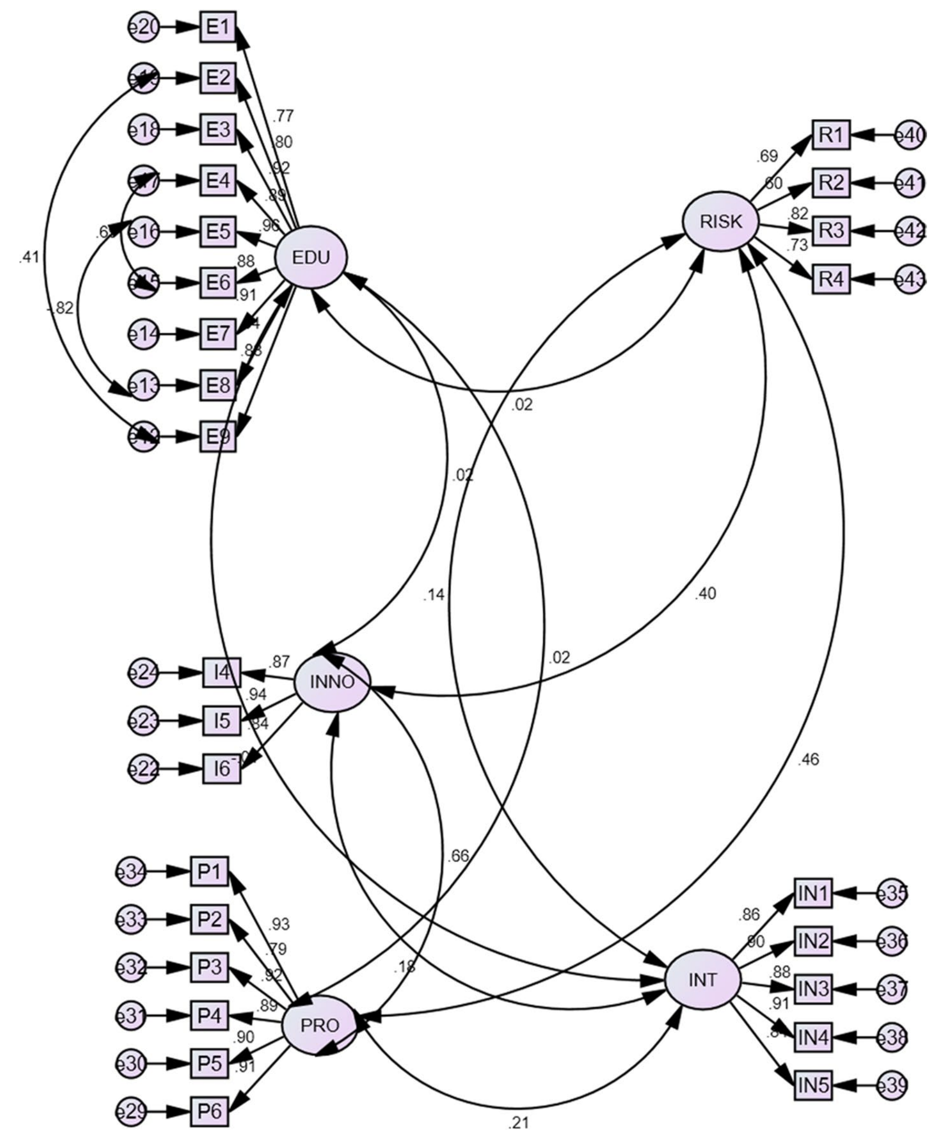
Table 4 Analysis of variance among engineering disciplines and entrepreneurial education

ANOVA					
Entrepreneurship education					
	Sum of Squares	**df**	**Mean Square**	**F**	**P value**
Between groups	1.273	4	0.318	0.452	0.771
Within groups	256.985	365	0.704		
Total	258.258	369			

Stage 1: confirmatory factor analysis



Stage 2: confirmatory factor analysis



Model fit

To gauge the adequacy of model fit, various indices, as recommended by scholars like Hair (1998) and Schumacker and Lomax (2004), are utilised in this study. Essential benchmarks encompass chi-square/d.f, GFI, AGFI, RMSEA, NFI, and CFI. For chi-square/d.f, the advocated range by Chin et al. (1997)and Salisbury et al. (2002) is between 1 and 5, with a preferable threshold below 3, indicating a favourable fit (Bentler & Bonett, 1980; Joreskog & Sorbom, 1993). Hadjistavropoulos et al. (1999) and Hair (1998) establish acceptable benchmarks for GFI and AGFI at values above 0.85 and 0.8, respectively. An RMSEA value below 1 is indicative of a good fit (Salisbury et al., 2002; Schumacker & Lomax, 2004), while NFI values should exceed 0.90

(Salisbury et al., 2002), although values greater than 0.80 are also considered acceptable (Hadjistavropoulos et al., 1999; Hair, 1998). Similarly, a recommended CFI value is above 0.90 (Bentler & Bonett, 1980; Salisbury et al., 2002). In the context of novel models and theories, Vassend and Skrondal (1997) suggest more lenient criteria as appropriate.

Table 5 presents the fit indicators for the structural model, offering insights into its overall adequacy. The model's Chi-square to degrees of freedom ratio exceeds the optimal threshold at 3.466, signalling a suboptimal fit. Additionally, the Goodness of Fit Index (GFI) falls below the acceptable level at 0.835 (< 0.85), while the Adjusted Goodness of Fit Index (AGFI) also fails to meet the desired standard at 0.888 (> 0.80). Conversely, the Root Mean Square Error of Approximation (RMSEA) is favourable at 0.082 (< 1), indicating a satisfactory fit. Furthermore, the Normed Fit Index (NFI) stands at an acceptable 0.900 (> 0.90), supporting the model's credibility. The Comparative Fit Index (CFI) is deemed appropriate for the structural model, recording a value of 0.927 (> 0.90). Although the model exhibits certain shortcomings in GFI and AGFI, the overall fit is supported by favourable values in RMSEA, NFI, and CFI.

The conceptual model depicted in Fig. 1 illustrates the framework utilized for the regression analysis. Tables 6 and 7 outline the variables employed in the study, along with the results of the multivariate analysis examining the relationship between entrepreneurial education, leadership skills, and student behaviour. The statistical findings indicate that entrepreneurial education does not have significant relationship with risk-taking behaviour ($\beta = 0.026$, $p = 0.658$), innovativeness ($\beta = 0.011$, $p = 0.835$), or proactive behaviour ($\beta = 0.003$, $p = 0.962$). The intention to become an entrepreneur also shows no significant influence on students' innovativeness ($\beta = 0.070$, $p = 0.204$) or risk-taking behaviour ($\beta = 0.042$, $p = 0.466$). However, a significant association is observed with proactive behaviour ($\beta = 0.149$, $p = 0.006$), highlighting a notable link between entrepreneurial intention and proactiveness.

Education significantly shapes various skills, including leadership ($\beta = 0.801$, $p = 0.000$), negotiation ($\beta = 0.803$, $p = 0.000$), practical knowledge ($\beta = 0.914$, $p = 0.000$), critical thinking ($\beta = 0.933$, $p = 0.000$), problem-solving ($\beta = 0.934$, $p = 0.000$), creativity ($\beta = 0.934$, $p = 0.000$), time management ($\beta = 0.898$, $p = 0.000$), self-peer assessment ($\beta = 0.762$, $p = 0.000$), and business plan writing ($\beta = 0.898$, $p = 0.000$). This emphasises a noteworthy association between education and skill development.

Table 5 Fit indicators of structural model

Fit indicators	Value
Chi-square/d.f	3.466
GFI	0.835
AGFI	0.888
RMSEA	0.082
NFI	0.900
CFI	0.927

Table 6 Standardized regression weights

			Estimate	P value
RISK-TAKING	←	EDU	0.026	0.658
INNOVATIVE	←	EDU	0.011	0.835
PROACTIVE	←	EDU	0.003	0.962
INTENTION	←	INNO	0.070	0.204
INTENTION	←	RISK	0.042	.0466
INTENTION	←	PRO	0.149	0.006**
Ent_Edu_leadership_skills	←	EDU	0.801	0.000***
Ent_Edu_negotiation_skills	←	EDU	0.803	0.000***
Ent_Edu_practical_knowledge	←	EDU	0.914	0.000***
Ent_Edu_critical_thinking_skills	←	EDU	0.933	0.000***
Ent_Edu_Problem_solving_skills	←	EDU	0.934	0.000***
Ent_Edu_Creativity_skills	←	EDU	0.934	0.000***
Ent_Edu_Time_management	←	EDU	0.898	0.000***
Ent_Edu_self_peer_assessment	←	EDU	0.762	0.000***
Ent_Edu_Business_plan_writing	←	EDU	0.827	0.000***
EO_Inno_invest_process_consistency	←	INNO	0.837	0.000***
EO_Inno_maintaining_exisiting_technologies	←	INNO	0.944	0.000***
EO_Inno_Adherence_to_process	←	INNO	0.870	0.000***
EO_Pro_strategic_planning_competitive_advantage	←	PRO	0.911	0.000***
EO_Pro_traditional_methods	←	PRO	0.901	0.000***
EO_Pro_charging_high_prices	←	PRO	0.894	0.000***
EO_Pro_benchmarking	←	PRO	0.920	0.000***
EO_Pro_avoid_competitive_clashes	←	PRO	0.789	0.000***
EO_Pro_special_effort	←	PRO	0.927	0.000***
EI_goal_become_entrepreneur	←	INT	0.859	0.000***
EI_serious_thought_starting_firm	←	INT	0.899	0.000***
EI_determined_create_firm	←	INT	0.883	0.000***
EI_make_every_effort_start_firm	←	INT	0.907	0.000***
EI_ready_to_anything_entrepreneur	←	INT	0.841	0.000***
EO_Rt_low_risk_projects	←	RISK	0.693	0.000***
EO_Rt_explore_business	←	RISK	0.604	0.000***
EO_Rt_wait_and_see	←	RISK	0.825	0.000***
EO_Rt_taking_action	←	RISK	0.730	0.000***

** indicates that the coefficient is statistically significant at the 5% level

*** indicates that the coefficient is statistically significant at the 1% level

Table 7 Variables

Independent variables	Dependent variables	Mediating variables	Outcome
Entrepreneurial education (20 Statements)	Entrepreneurial Orientation (Innovativeness, Proactiveness, Risk-taking)	Engineering Disciplines	Entrepreneurial Intention

Table 6 supports a significant association among students' innovativeness, risk-taking, and proactive behaviour ($p = 0.000$), validating Hypotheses H1, H2, and H3. Additionally, the intention to start a business significantly correlates with proactive behaviour ($p = 0.006$), confirming Hypothesis H5.

Discussion and conclusion

The primary objective of this study was to investigate potential variations in entrepreneurial orientation and intention across major engineering disciplines. To achieve this, we conducted a comprehensive analysis of 19 statements related to the entrepreneurial orientations of engineering students. Confirmatory factor analysis was employed, leading to the acceptance of 15 statements. These findings offer valuable insights into the complex interplay between entrepreneurial tendencies, educational experiences, and the likelihood of engineering students venturing into entrepreneurial endeavours.

The assessment of entrepreneurial aspirations involved scrutinising a set of five statements. Additionally, to measure the impact of entrepreneurial education, we considered ten specific skills. The study revealed a robust inclination towards entrepreneurship among students, showcasing heightened levels of innovativeness, a proclivity for risk-taking, and proactiveness.

However, a noteworthy revelation emerged as the study indicated that education provided by colleges did not significantly influence students' intentions to initiate their own businesses. Singh et al. (2014) argued for a necessary overhaul in the Indian education system to tailor its curriculum and foster a greater inclination towards entrepreneurial activities among engineering students.

Furthermore, the study revealed that students inherently possessed entrepreneurial traits, such as innovativeness and proactiveness, which were intrinsic to individual characteristics rather than a product of formal education. The survey indicated a lack of necessary encouragement, support, and knowledge from colleges for entrepreneurial ventures, leading to a scenario where campus placements became the primary focus, diverting students from their initial entrepreneurial intentions.

The study suggests that colleges fall short in recognising potential entrepreneurs, thus emphasising the importance of educational institutes designing curricula that specifically nurture an entrepreneurial mindset. Faculty involvement in identifying and encouraging potential entrepreneurs, coupled with consistent mentoring and counselling, is crucial. Additionally, the government is urged to play a significant role by developing training programs and offering financial aid to empower aspiring entrepreneurs.

Educational institutes play a pivotal role in shaping the future generation of entrepreneurs and driving positive transformations. The study's findings highlight the critical importance of these institutes in developing a curriculum that explicitly targets the cultivation of an entrepreneurial mindset. Faculty members bear the responsibility of identifying and fostering potential entrepreneurs among engineering students. To facilitate this, continuous mentoring and counselling by subject experts should be instituted to support these students on their entrepreneurial journey.

Furthermore, recognising the substantial impact that the government can have in instilling an entrepreneurial mindset among students, it becomes imperative for government agencies to take proactive measures. This includes the development of additional training programs and the provision of financial aid, aiming to strengthen and empower aspiring entrepreneurs. In essence, a collaborative effort between educational institutes and government bodies is essential to create an environment conducive to fostering entrepreneurial spirit and success among students.

Future research should prioritise the exploration of entrepreneurial orientation and intentions among non-engineering students. This emphasis aims to illuminate the specific entrepreneurial mindset and aspirations within this student cohort, providing valuable insights that contribute to a broader understanding of entrepreneurship beyond the confines of the engineering discipline.

It's essential to acknowledge that the current study's scope was confined to the southern region of India. To enhance the generalisability of empirical results, we recommend that future studies adopt a more comprehensive approach. This involves delving into the intricate entrepreneurial dynamics and isolating contextual factors influencing entrepreneurial tendencies across different regions of the country. Moreover, researchers are encouraged to consider cross-country comparisons among nations that share similar economic and social attributes as India. This comparative analysis could offer a nuanced understanding of the factors influencing entrepreneurial orientation in diverse socio-economic contexts. By expanding the geographical scope and contextual considerations, future research endeavours can contribute significantly to the broader discourse on entrepreneurial behaviour and its determinants.

Appendix

Questionnaire

1. Gender

o Male
o Female

2. Branch/Discipline

o Computer Science & Engineering
o Mechanical Engineering
o Electronics and Communication Engineering
o Electrical and Electronics Engineering
o Civil Engineering

3. Entrepreneurship Education in Engineering

Please share your agreement on the following entrepreneurial inputs you might have received during engineering education.

My institution provides entrepreneurship education through exposure to:

Areas of entrepreneurship education	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Business plan writing					
Self and peer-assessment skills					
Time management skills					
Creativity skills					
Problem-solving skills					
Critical thinking skills					
Practical knowledge					
Negotiation skills					
Leadership skills					
Incubation centres and industry mentoring					
Business plan writing					
Self and peer-assessment skills					
Time management skills					
Creativity skills					
Problem-solving skills					
Critical thinking skills					
Practical knowledge					
Negotiation skills					
Leadership skills					
Incubation centres and industry mentoring					

4. Entrepreneurial orientation (innovativeness)

Please select the number in each scale below that best describes your plan of business development:

Instructions: On a scale of 1 to 7 below,

1 indicates a strong inclination toward the statement on the left.

7 indicates a strong inclination toward the statement on the right.

4 indicates that both the statements are equally valid.

I prefer to promote:

Minor changes in existing product line/services offering	1 2 3 4 5 6 7	Significant changes in existing product line/services offering

I believe in endorsing

A strong emphasis on the marketing of tried and tested products or services	1 2 3 4 5 6 7	A strong emphasis on R&D, technology leadership and innovations

I will do:

Negligible investment in new product development	1 2 3 4 5 6 7	Considerable investment in new product development

I prefer to promote:

Adherence to the established process	1 2 3 4 5 6 7	New ways of doing things and seeking unusual, novel solutions

I believe in:

Maintaining existing technologies	1	2	3	4	5	6	7	Upgrading new technologies

I will:

Invest in the consistency of the process	1	2	3	4	5	6	7	Invest in process improvement

I will encourage:

People to think and behave thoroughly according to the system	1	2	3	4	5	6	7	People to think and behave in original and novel ways

5. Entrepreneurial orientation (Proactiveness)

Please select the number in each scale below that best describes your plan of business development

Instructions: On a scale of 1 to 7 below,

1 indicates a strong inclination toward the statement on the left.

7 indicates a strong inclination toward the statement on the right.

4 indicates that both the statements are equally valid.

In general,

I will make no special effort to take business from the competition	1	2	3	4	5	6	7	I will make my business very aggressive and intensely competitive

I will:

Typically seek to avoid competitive clashes, preferring a "live-and-let-live" posture	1	2	3	4	5	6	7	Typically adopt a very competitive "undo-the-competitors" posture

In General,

I do not consider benchmarking as an effective practice	1	2	3	4	5	6	7	I will regularly benchmark my business's activities against the best players in the industry

To me:

Charging higher prices for more profitability is of the highest importance	1	2	3	4	5	6	7	Capturing the maximum market share is the top priority and I will cut prices for it

I will:

Adopt traditional methods to face the competition	1	2	3	4	5	6	7	Adopt innovative methods to beat the competition

I will:

Not involved in strategic planning for competitive advantage	1	2	3	4	5	6	7	Engage in competitive intelligence to generate actionable foresight for strategy-making

I will focus on:

Self-sustainable model and less on competition	1	2	3	4	5	6	7	Indulging in competitor response modelling and war gaming exercises

6. Entrepreneurial orientation (Risk taking)

Please select the number in each scale below that best describes your plan of business development

Instruction: On a scale of 1 to 7 below,

1 indicates a strong inclination toward the statement on the left.

7 indicates a strong inclination toward the statement on the right.

4 indicates that both the statements are equally valid.

I have:

A strong tendency for low-risk projects with normal and certain rate of return	1	2	3	4	5	6	7	A strong tendency for high-risk projects with a high rate of return

I consider:

Owing to the nature of the environment, it is best to explore the business gradually via cautious, incremental behaviour	1	2	3	4	5	6	7	Owing to the nature of the environment, bold and wide-ranging acts are necessary to achieve the firm's objectives

I will:

Typically adopt a 'Wait and See Posture', to minimise the probability of making costly decisions	1	2	3	4	5	6	7	Typically adopt a 'Bold and Aggressive Posture', to maximise the probability of exploiting potential opportunities

According to me:

Avoid taking action without recourse to forethought and research	1	2	3	4	5	6	7	Risk-taking is powered by intuition and actions are taken without recourse to forethought and research

According to me:

If an employee takes a risk and fails, he or she should be punished	1	2	3	4	5	6	7	Risk-takers will be recognised and rewarded in my organization, whether they are successful or not

7. Entrepreneurial intention

(Your willingness and commitment to carry out new business)

Please select the response below that best describes your plan to start an enterprise

Plan	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Professional goals is to become entrepreneur					
Very serious thought of starting a firm					
Determined to create a firm in the future					
Make every effort to start and run own firm					
Ready to do anything to be an entrepreneur					

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