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Investigating Cognitive Structures of Entrepreneurship Among Senior ENG and ENT Students at a Rural Institution

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Abstract
Engineering (ENG) and engineering technology (ENT) programs provide distinct educational pathways that shape how students perceive and develop professional competencies. This study utilizes situated cognition theory to investigate the entrepreneurial self-efficacy (ESE) of senior ENG and ENT students at a rural Midwestern university. Using a sample of 144 students, the research employed Mann-Whitney U tests and group-specific exploratory and confirmatory factor analyses to compare entrepreneurial tendencies and cognitive structures. While no statistically significant differences were found in overall ESE scores, the factor structures diverged significantly between groups. Results indicate that while ENG students view searching and planning as distinct phases, ENT students possess a more integrated, practice-based view of entrepreneurship rooted in technical implementation. These findings suggest that entrepreneurship education should be tailored to disciplinary contexts to better prepare graduates for diverse career trajectories.

Keywords: entrepreneurial self-efficacy, situated cognition, engineering design, curriculum change

1. Introduction

Engineering entrepreneurship has become increasingly important as communities rely on new ventures for innovation, employment, and economic growth. Engineering students, with strong technical and problem-solving skills, are well positioned to create such ventures, and many studies show that they often report high entrepreneurial intentions, supported by self-efficacy, curiosity, entrepreneurship education, authentic problem solving, and industry engagement [1–5]. As industry expectations and societal challenges evolve, engineering curricula have shifted from a purely technical focus toward integrating entrepreneurial thinking, communication, ethics, and leadership. Accreditation frameworks such as ABET now emphasize not only technical competence but also interpersonal skills, ethical reasoning, project management, and entrepreneurial orientation, and many institutions embed entrepreneurship through problem- and innovation-based learning [6–8]. Global data indicate that an increasing share of engineering graduates view entrepreneurship as a viable career path, with sizable proportions intending to start ventures soon after graduation and within five years.

In the U.S., undergraduate engineering education follows two distinct pathways: engineering (ENG) and engineering technology (ENT) programs. Although both are grounded in engineering disciplines, they differ markedly in curricular emphasis, skill development, and career preparation. ENG programs prioritize theoretical foundations, advanced mathematics, and design analysis, typically preparing students for research, development, and innovation-focused careers; these programs increasingly integrate entrepreneurship through coursework in product ideation, market research, and business planning. By contrast, ENT programs emphasize practical, hands-on learning and technical implementation for industrial applications, creating strong potential for entrepreneurial skill development in applied settings. Researchers emphasize that entrepreneurship education should be discipline-specific, given students' varying motivations, capabilities, and entrepreneurial exposures across fields [9, 10]. For instance, engineering students demonstrate distinct engagement, attitudes, and outcomes in entrepreneurship education compared to other disciplines, underscoring the need for tailored engineering approaches. Broader reviews similarly advocate adapting entrepreneurship teaching models to contextual factors such as discipline, program goals, and learner characteristics [9, 11].

Within this landscape, situated cognition provides a useful lens for examining how engineering (ENG) and engineering technology (ENT) students at University of Wisconsin Stout (UW Stout) engage with entrepreneurship. It emphasizes that learning and self-efficacy emerge from participation in real activities, social interactions, and disciplinary settings. The Entrepreneurial Self-Efficacy (ESE) scale by McGee et al. (2009) [12] focuses on

context-bound tasks such as opportunity recognition, planning, and marshaling resources, rather than abstract traits. Because ENG and ENT students encounter entrepreneurship through different curricula, pedagogies, and degrees of applied, industry-based problem solving, situated cognition helps explain why their ESE factor structures and item loadings may diverge. ENG and ENT students' entrepreneurial self-efficacy reflects the specific practices through which entrepreneurial thinking is enacted and reinforced within each program.
Engineering and engineering technology programs in the United States also differ historically and structurally. Traditional engineering (ENG) programs, rooted in 19th- and early 20th-century developments, emphasize mathematics, physics, and engineering science, often at the expense of application-focused laboratory work. Engineering technology (ENT) programs emerged later in response to industry demand for practice-oriented professionals and now play a key role in the technical workforce. Two-year ENT programs prepare technicians for testing, maintenance, troubleshooting, quality control, and data collection, while four-year ENT programs, pioneered by institutions such as Purdue, Texas A&M, and Virginia Tech, prepare technologists to integrate systems, manage projects, design products, and supervise technical staff. For clarity, the terms engineering and engineering technology are used in two distinct ways in this study. As adjectives (e.g., "engineering practices," "engineering technology curriculum"), they refer broadly to the field of engineering and its educational practices. However, when denoting specific academic programs, engineering (ENG) refers to calculus-based, theory-oriented curricula, while engineering technology (ENT) refers to algebra-based, application-oriented programs

This study aims to investigate the perceptions of senior engineering students at UW Stout regarding their entrepreneurial self-efficacy, and factors that influence their entrepreneurial self-efficacy.

Specifically, the study focuses on the following research questions:
1) Are there any differences in entrepreneurial measures between ENG and ENT students?
2) How do the latent factor structures of entrepreneurial self-efficacy (ESE) differ between engineering (ENG) and engineering technology (ENT) students as revealed by exploratory factor analysis?
3) To what extent does the original five-factor ESE model fit ENG and ENT students differently in confirmatory factor analysis?

2. Literature Review

2.1 Entrepreneurship Education and the Entrepreneurial Mindset

The conceptualization of entrepreneurship education is often bifurcated into narrow and wide definitions. Narrowly defined, entrepreneurship centers on opportunity identification, business development, self-employment, and venture growth [9]. Conversely, a wider definition encompasses personal development, creativity, self-reliance, and action orientation. Prior scholarship indicates that the chosen definition profoundly shapes educational objectives, target audiences, teaching methods, and assessment procedures [9, 11]. While some educators advocate for a narrow focus on company startup, others prioritize fostering innovative and opportunity-oriented thinking; regardless of the approach, both share the goal of training students to create value for others. Curricular timing is also critical, as many authors encourage starting with a wide definition in early childhood education, while complementing secondary and post-secondary levels with a business-focused approach [13].

Central to this pedagogical shift is the cultivation of an entrepreneurial mindset, characterized by the ability to identify opportunities and persist through uncertainty or failure. In the specific context of engineering education, KEEN defines entrepreneurially minded engineers as professionals who integrate technical expertise with business and social science insights to solve societal problems [14]. Cultivating this mindset requires engineering programs to move beyond traditional theoretical problem-solving [1] by incorporating experiential and project-based learning methods that foster critical thinking and business acumen. Despite historical neglect of soft skills in technical tracks, numerous studies affirm that entrepreneurship can be taught, offering pathways to integrate these competencies into engineering curricula [9, 11].

2.2 Entrepreneurship in Engineering and Engineering Technology Education

Undergraduate technical education in the U.S. follows two distinct pathways: engineering (ENG) and engineering technology (ENT). While both are rooted in technical disciplines, they differ in professional orientation; ENG programs emphasize theoretical foundations and design analysis, whereas ENT programs prioritize practical, hands-on applications and systems implementation. These differences suggest that entrepreneurship education must be tailored to discipline-specific contexts [10, 11]. Research has shown that the attitudes and outcomes of engineering students in entrepreneurship education differ significantly from those in other disciplines, reinforcing the need for specialized curricular approaches [1]. Consequently, teaching models must be adapted to reflect specific program objectives and learner needs [9, 11].

2.3 Situated Cognition in Technical Learning

Situated cognition theory provides a framework for understanding how a learner's cognition is shaped by the context of learning activities [15]. This perspective is particularly influential in engineering education, where learning occurs in practice-rich environments. The theory emphasizes that knowledge, identity, and action are co-developed through participation in social and physical contexts rather than being acquired as decontextualized facts. This aligns with communities-of-practice frameworks, where students adopt professional norms and problem-solving practices through gradual participation. Johri (2013) [16] argues that engineering learning is fundamentally social, highlighting the importance of material context, interactions, and identity. For instance, hands-on product dissection has been framed as a situated activity that supports deeper understanding and creativity compared to abstract instruction [15]. Integrating authentic tools and teamwork into the curriculum ensures that students' cognitive structures more closely approximate professional engineering work.

2.4 Context and Purpose of the Study

This study is situated in the School of Engineering (SOE) at the UW Stout and examines the entrepreneurial tendencies of students in ENG and ENT programs. The SOE enrolls approximately 1,100 students across Bachelor of Science programs in Computer and Electronic Engineering, Manufacturing Engineering, Mechanical Engineering, and Plastics Engineering, alongside an ENT program with concentrations in Mechanical Design, Product Operation, Industrial Automation, Plastics, and Packaging. Despite overlapping technical foundations, relatively few studies have directly compared entrepreneurial self-efficacy between engineering and engineering technology students. Prior work suggests that ENG students often display strong entrepreneurial interest [6, 14], but much less is known about ENT students' entrepreneurial profiles. Given the distinct educational emphases and professional preparation pathways of the ENG and ENT programs, understanding potential differences between these groups can inform the design of entrepreneurship education and support structures tailored to their specific needs, thereby enhancing entrepreneurship development and preparing graduates for a wider range of career trajectories [17].

3. Methodology and Data Collection

The study uses a descriptive research design and an online survey to collect data on senior engineering students at the campus, aiming to understand their perceptions of entrepreneurship, entrepreneurial activities, and the role of entrepreneurship in their career plans. Data was collected via an online survey administered to senior-level students, mostly from capstone design courses, in the SOE at UW Stout during Spring 2023, Fall 2023, and Fall 2024 semesters. The complete survey instrument, consisting of 48 questions (see Appendix I), took participants approximately 15–20 minutes to complete. Participation was entirely voluntary, and students could withdraw from the study at any time. Students were not asked to provide names or other personally identifiable information when completing the survey. As an incentive to participate in the survey, students who completed it in full were entered into a draw for various gifts valued at up to $20. The study utilizes the assessment tool Entrepreneurial Self-Efficacy (ESE) by [12] McGee et al (2009) that measures entrepreneurship self-efficacy. The general questions were adapted from the Engineering Entrepreneurship Survey (EES) developed by [1]. Compared to the original EES, the survey instrument in this study includes several minor changes to the names of entrepreneurial activities, types of career services, and professional development supports to better suit the context at UW Stout.

Entrepreneurial Self-Efficacy (ESE) Scale

The core entrepreneurship questions used ESE developed by [12] based on the four-phase venture creation model. The four phases of a venture creation process include searching, planning, marshaling, and implementing. In the searching phase, entrepreneurs developed different ways of how things work, innovate unique ideas, or identified a special opportunity. During the planning phase, entrepreneurs created a feasible business plan based on the data gathered from the first phase. Planning could be in verbal or written forms, but all ideas or business concepts must have a chance to be evaluated. The entrepreneur combined all resources (plan, capital, labor, customers, and suppliers) in the marshaling phase and deployed the business into physical entities. In the final implementing phase, entrepreneurs organized the system, managed and trained people, and maintained the financial records and financial assets. On a five-point Likert-type scale, the ESE has responses ranging from 1="Not confident at all," to 5="Very confident" and was reported to have solid reliability, with Cronbach alphas above 0.80 for all subconstructs in study [12] and obtained 0.93 in the current study. Nineteen statements of ESE scale are listed in Appendix II.

4. Resultss

Descriptive statistics, including means, medians, skewness, and kurtosis, were calculated for each variable. The assumption of normality was assessed using both the Kolmogorov-Smirnov and Shapiro-Wilk tests. Results from the Shapiro-Wilk test indicated that all measured variables, including ESE and its composite scores, significantly violated the assumption of normality ($p < 0.05$). Additionally, skewness and kurtosis values confirmed the non-normal distribution of the data. As a result, all subsequent analyses were conducted using non-parametric statistical methods, including Mann-Whitney U tests for group comparisons. Analyses were performed using IBM SPSS Statistics, version 29, with statistical significance set at $p < 0.05$.

4.1. Demographic and common entrepreneurial characteristics of engineering students at UW Stout.

Of the 168 senior engineering students who accessed the survey, data from 24 participants were excluded due to incomplete responses, resulting in a final sample of 144 students. This sample (Table 1) was predominantly male (76.4%) compared to female (23.6%). A slight majority were enrolled in ENG programs (56.3%), while the remainder were in ENT programs (43.7%). In terms of racial identity, the majority of participants identified as White (83.3%), followed by Asian (7.7%) and American Indian (6.3%). None of the participants identified as Hispanic, and one as African American and the majority were under 25 years old (91.6%) at the time of the survey.

Table 1 - Descriptive Statistics of Participants

Description	n	%
Programs		
Engineering (ENG)	89	56.3
Computer and Electrical Engineering	20	13.9
Manufacturing Engineering	16	11.1
Mechanical Engineering	45	31.3
Plastics Engineering	8	5.6
Engineering Technology (ENT)	55	43.7
Engineering Technology	32	22.2
Packaging	23	16.0
Total students in all programs	**144**	**100.00**
Gender		
Female	34	23.6
Engineering	17	11.8
Engineering Technology	17	11.8
Male	110	76.4
Engineering	72	50.0
Engineering Technology	38	26.4
Total students in all genders	**144**	**100.0**
Ethnicity		
African American/Black	1	0.7
American Indian or Alaska Native	9	6.3
Asian	11	7.7
Hispanic or Latino	0	0.0
Multiracial	3	2.0
White	120	83.3
Total students in all ethnicities	**144**	**100.0**
Ages		
Under 25	132	91.6
26-29	2	1.4

30-39	4	2.8
40 and over	6	4.2
Total students of all ages	**144**	**100.0**

4.2. Research question 1: Are there any differences in entrepreneurial self-efficacy between engineering (ENG) and engineering technology (ENT) students?

Mann-Whitney U tests were conducted to examine differences between ENG and ENT students across composite median-based variables: “Searching,” “Planning,” “Marshalling,” “Implementing” (People and Finance) of the ESE, CSE, and RPS. As shown in Table 2, there were no statistically significant differences between the two groups for any of the composite variables (all p-values > 0.05). Although differences were not statistically significant, ENT students consistently showed slightly higher mean ranks than ENG students across all seven dimensions. For example, ENT students reported higher confidence in the Searching subscale (mean = 3.65, median = 4) compared to ENG students (mean = 3.60, median = 4). Similar patterns were observed for “Planning,” “Marshalling,” and “Implementing” dimensions, with ENT students reporting slightly higher central tendencies.

Table 2 - Mann-Whitney U Test Results Comparing Engineering and Engineering Technology Students on Entrepreneurial Tendencies

Dependent Variable	U	n1	n2	p	ENG Mean	ENT Mean	ENG Median	ENT Median	ENG Mean Rank	ENT Mean Rank
Searching	2289.5	89	55	0.479	3.60	3.65	4	4	70.72	75.37
Planning	2083.5	89	55	0.120	2.66	2.88	3	3	68.41	79.12
Marshalling	2124.5	89	55	0.167	3.12	3.39	3	3	68.87	78.37
Implementing People	2088.5	89	55	0.133	3.54	3.69	3.5	4	68.47	79.03
Implementing Finance	2384.5	89	55	0.791	2.96	2.98	3	3	71.79	73.65

A series of Mann-Whitney U tests were also conducted at the item level (19 individual items). None yielded statistically significant differences (p > 0.05), although ENT students demonstrated higher mean ranks on 16 of 19 items. This pattern suggests a consistent, albeit not statistically significant, trend indicating higher entrepreneurial tendencies among ENT students. Guided by situated cognition theory, this study examined the emergent factor structures of entrepreneurial self-efficacy using exploratory factor analysis (Research question 2) and then evaluated the extent to which the original ESE model aligned with these structures through confirmatory factor analysis across engineering and engineering technology students (Research question 3).

4.3. Research question 2: How do the latent factor structures of entrepreneurial self-efficacy (ESE) differ between engineering (ENG) and engineering technology (ENT) students as revealed by exploratory factor analysis?

This research question examines whether entrepreneurial self-efficacy (ESE) is cognitively organized differently across ENG and ENT students prior to imposing a predefined theoretical model. To explore potential structural differences, group-specific Exploratory Factor Analyses (EFAs) were conducted separately for Engineering (ENG) and Engineering Technology (ENT) students. The objective was to determine whether the instrument’s original factor structure remained consistent across disciplinary contexts or whether distinct configurations emerged that reflect differences in students’ learning environments and professional orientations.

The analysis proceeded in two stages. First, a Principal Component Analysis (PCA) using the Kaiser criterion (eigenvalues > 1.0) was conducted to identify the minimum number of factors required to account for shared variance among the 19 ESE items. This step assessed whether the items were clustered as originally proposed by

McGee et al. (2009). Based on these results, a four-factor solution was retained for both ENG and ENT groups. Both ENG and ENT groups demonstrated strong sampling adequacy and factorability (Table 3). Kaiser-Meyer-Olkin (KMO) values exceeded 0.80 (ENG = 0.847; ENT = 0.869), indicating suitability for factor analysis. Bartlett's tests of sphericity were statistically significant for both groups (ENG: $\chi^2 = 1062.60$, $p < 0.001$; ENT: $\chi^2 = 797.25$, $p < 0.001$), confirming that the correlation matrices were appropriate for extraction.

Table 3 - KMO and Bartlett's Test

		ENG	ENT
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.847	0.869
Bartlett's Test of Sphericity	Approx. Chi-Square	1062.60	794.25
	df	171	171
	Sig.	<0.001	<0.001

Second, EFAs were performed independently for each subsample using Principal Axis Factoring (PAF) and oblique (Oblimin) rotation (Table 4). Only factors demonstrating coherent content and theoretically meaningful loading patterns were retained for interpretation. The resulting factor loadings indicate that ENG and ENT students organize ESE dimensions differently, consistent with variation in disciplinary learning contexts.

Table 4. Comparison of ESE Item Loadings for ENG and ENT groups from Exploratory Factor Analysis (PAF, Oblimin) ($|\lambda| \geq .40$)

ENG	Factor			
	1	2	3	4
ESE13	.831			
ESE12	0.748			
ESE16	0.746			
ESE15	0.690			
ESE14	0.689			
ESE11	0.658			
ESE9	0.565			
ESE18		-0.925		
ESE17		-0.925		
ESE19		-0.721		
ESE8		-0.453		
ESE2			0.761	
ESE1			0.721	
ESE3			0.400	
ESE10				
ESE6				0.828
ESE7				0.613
ESE5				0.549
ESE4			0.484	0.492

ENT	Factor			
1	2	3	4	
0.832				ESE18
0.716				ESE6
0.707				ESE19
0.694				ESE17
0.596				ESE5
	0.925			ESE1
	0.623			ESE2
	0.575			ESE3
	0.521			ESE4
		0.830		ESE14
		0.807		ESE15
		0.726		ESE16
		0.697		ESE13
0.434		0.585		ESE12
		0.577		ESE11
			0.689	ESE9
			0.644	ESE7
			0.640	ESE10
			0.472	ESE8

For ENT students, "Searching" and "Planning" are highly integrated (ESEs 1, 2, 3, and 4, Factor 2, ENT, Table 4). This suggests they view finding an idea and planning its execution as a concurrent process, whereas ENG students view ideation as a distinct creative phase before planning begins (ESEs 1, 2, and 3, Factor 3, ENG, Table 4). Also, the Marshaling item (ESE8, *Get others to identify with and believe in my vision and plans for a new business*) exhibited a negative loading for ENG students ($\lambda = -0.453$) and a positive loading for ENT students ($\lambda = 0.472$). This difference might indicate that influencing others to support a business idea plays a different role in how each group understands entrepreneurship.

4.4. Research question 3: To what extent does the original five-factor ESE model fit ENG and ENT students differently in confirmatory factor analysis?

This research question examines why the CFA results differ across ENG and ENT groups and interprets these differences. The CFA results for the 15 McGee items indicate acceptable overall model fit for both groups, with some differences in the structure of the subscales. These differences are consistent with how ENG and ENT students at UW Stout develop entrepreneurial self-efficacy within situated project-based learning environments. As shown in Table 5 and Figure 2, the ENG model demonstrated a strong fit (CFI = 0.948, CMIN/DF = 1.467, RMSEA = 0.073) for the four-factor structure. The ENT model also met acceptable thresholds (CFI = 0.900, CMIN/DF = 1.714, RMSEA = 0.095), although the fit was slightly weaker. While both models meet conventional standards, the lower fit indices for the ENT group suggest that the dimensions of entrepreneurship may be less distinct for ENT students than for ENG students.

Table 5 – Confirmatory Factor Analysis results

Student Group	Chi-square	CMIN/DF	CFI	RMSEA
ENG	χ^2 (84) = 123.23, p =0.003	1.467	0.948	0.073
ENT	χ^2 (84) = 150.87, p <0.001	1.796	0.914	0.095

Figure 1 presents the standardized CFA loadings for ENG and ENT students. Although the original five-factor structure proposed by McGee et al. (2009) shows acceptable overall fit, the pattern of item loadings differs across groups. Several items load differently than originally reported, suggesting structural reorganization rather than simple replication. In the ENG group, “Marshaling” does not appear as a standalone factor but merges with “Implementing People.” In contrast, the ENT group shows a combined “Searching–Planning” factor, indicating a more integrated view of opportunity identification and execution. These differences suggest that entrepreneurial self-efficacy is organized in discipline-specific ways rather than following a universally invariant structure.

Both ENG and ENT models exclude ESE3 (*Design a product or service to satisfy customer needs*). In the original McGee et al. (2009) framework, this item is central to the “Searching” dimension. However, within the situated context of ENG and ENT programs, design appears to function primarily as a technical engineering task rather than an entrepreneurial opportunity-recognition activity. Engineering students typically develop design self-efficacy through iterative project-based learning (PBL), design-based learning experiences, and capstone projects [18] that emphasize performance optimization and functional problem-solving, rather than market ideation. As a result, ESE3 does not align with entrepreneurial Searching items such as brainstorming (ESE1) or identifying market needs (ESE2), and therefore fails to load within that factor. At the same time, “Implementing Finance” (ESE17–ESE19) and “Implementing People” (ESE11–ESE15) show strong loadings, particularly for ENT students. This suggests that ENT students demonstrate high efficacy in areas where technical training overlaps with operational execution. Minor variations in loadings also reflect that tasks such as pricing and budgeting are learned within integrated project contexts rather than as separate analytical skills.

Overall, the CFA results suggest that ENT students perceive entrepreneurship primarily through a technical lens rather than an abstract lens of business administration. Whereas the original model conceptualizes “Planning” as a distinct and broad factor, the present findings required removing ESE5 (Pricing), ESE6 (Start-up capital), and ESE7 (Marketing) and repositioning ESE4 (Estimating customer demand) within the “Searching” construct. These adjustments reflect how entrepreneurial tasks are practiced and understood within specific disciplinary learning environments.

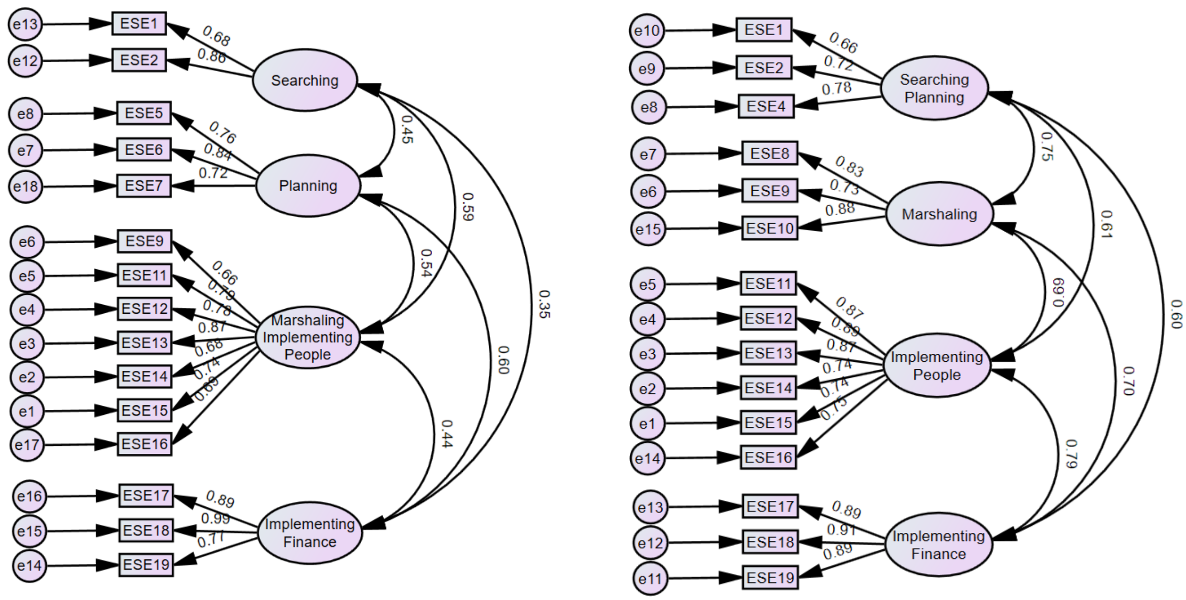

Figure 1. Empirical Comparison of CFA Standardized Loadings for ENG and ENT Students
(Standardized Regression Weights; values ≥ .65 shown)

5. Discussion and Limitations
This study reveals distinct patterns in how engineering (ENG) and engineering technology (ENT) students conceptualize entrepreneurship, despite similar overall self-efficacy levels. Although no statistically significant differences emerged in entrepreneurial self-efficacy scores, ENT students showed consistently higher mean ranks across 16 of 19 items, suggesting a slightly stronger entrepreneurial orientation. From a curricular perspective, this likely reflects ENT programs’ greater emphasis on applied business, management, and quality-control courses compared to ENG programs’ focus on calculus-based engineering science.

The EFA and CFA structural differences do not indicate measurement issues but rather demonstrate how disciplinary context shapes entrepreneurial self-efficacy. Consistent with situated cognition theory, self-efficacy develops through participation in authentic, context-embedded activities, more prevalent in ENT curricula. The stable "Finance" factor across both groups reflects concrete, practice-based financial competencies (budgets, materials, equipment costs), while "Searching" shows lower loadings as a more abstract construct. These factor patterns differ from those of McGee et al.’s (2009) original ESE scale, confirming entrepreneurial self-efficacy’s context dependence. ET students at UW Stout appear to organize entrepreneurial competencies as integrated, practice-oriented skills shaped by their applied learning environments.

The Case of ESE3 - Design as a Distinct Cognitive Domain
ESE3 (*Design a product or service that satisfies customer needs*) failed to load consistently within the “Searching” factor and was excluded from the final CFA model. In McGee et al.’s (2009) framework, product design belongs to opportunity recognition and ideation. However, both ENG and ENT students treated design as separate from entrepreneurial searching. This suggests students cognitively distinguish "technical design" from "entrepreneurial opportunity."

Engineering curricula typically frame design as technical optimization rooted in physics, materials science, and functional performance. Market validation, pricing, and commercialization receive separate treatment, or none at all. Consequently, students experience design as a technical deliverable rather than as an opportunity for entrepreneurial recognition. From a situated cognition perspective, this pattern reveals how self-efficacy beliefs form through task positioning within engineering learning environments. When taught primarily as technical problem-solving rather than market-oriented innovation, design remains distinct from entrepreneurship. This disconnect highlights a curriculum gap: engineering students' design creativity may not naturally connect to business opportunity recognition or customer discovery.

Limitations

This study has several limitations. The sample comes from a single rural institution, potentially limiting generalizability. Self-reported survey data may introduce response bias. The modest sample size constrained statistical power, and nonparametric methods limited exploration of interactions among gender, program type, and entrepreneurship exposure.

Despite these constraints, the findings offer practical implications for curriculum design. Entrepreneurship education should align with disciplinary context: engineering programs could integrate customer discovery and commercialization into design coursework to connect technical creativity with business opportunity; ENT programs might strengthen venture readiness through structured business training. Future analyses will extend this work by using multi-institutional sampling and formal measurement invariance testing to examine how disciplinary learning environments shape the cognitive organization of entrepreneurial self-efficacy.

6. Conclusion

This study demonstrates that although ENG and ENT students report similar levels of entrepreneurial self-efficacy, they organize entrepreneurial tasks differently. ENT students view opportunity search, planning, and implementation as interconnected, practice-grounded processes, while ENG students maintain a clearer separation between ideation and execution. The removal of ESE3 ("Design a product for customer needs") from the Searching factor is particularly revealing for these students: product design functions primarily as a technical engineering task rather than as an opportunity to recognize entrepreneurial opportunities. This pattern suggests engineering programs typically position design creativity as distinct from business and market considerations.

These findings highlight the need to align entrepreneurship education with a disciplinary context. Engineering programs could bridge this cognitive separation by explicitly integrating customer discovery and commercialization into design coursework. ENT programs, where entrepreneurship aligns more naturally with implementation, might enhance venture readiness through structured business-formation training. More broadly, entrepreneurial self-efficacy appears to be shaped by educational context rather than universally structured across disciplines. Rather than assuming measurement invariance, future research should investigate how engineering curricula influence the cognitive organization of entrepreneurial competencies.

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Appendix I

Entrepreneurship Questions

1) Entrepreneurial Self-efficacy (ESE)

A five-point Likert-type scale ranging from 1 = "Not confident at all" to 5= "Very confident."

Searching

ESE1: How much confidence do you have in your ability to ...? - Brainstorm a new idea for a product or service
ESE2: How much confidence do you have in your ability to ...? - Identify the need for a new product or service
ESE3: How much confidence do you have in your ability to ...? - Design a product or service that will satisfy the customer's needs and wants

Planning

ESE4: How much confidence do you have in your ability to ...? - Estimate customer demand for a new product or service
ESE5: How much confidence do you have in your ability to ...? - Determine a competitive price for a new product or service
ESE6: How much confidence do you have in your ability to ...? - Estimate the amount of start-up funds and working capital necessary to start my business
ESE7: How much confidence do you have in your ability to ...? - Design an effective marketing/advertising campaign for a new product or service

Marshaling

ESE8: How much confidence do you have in your ability to ...? - Get others to identify with and believe in my vision and plans for a new business
ESE9: How much confidence do you have in your ability to ...? - Network-i.e., make contact with and exchange information with others
ESE10: How much confidence do you have in your ability to ...? - Clearly and concisely explain verbally/in writing my business idea in everyday terms

Implementing People

ESE11: How much confidence do you have in your ability to ...? - Supervise employees
ESE12: How much confidence do you have in your ability to ...? - Recruit and hire employees
ESE13: How much confidence do you have in your ability to ...? - Delegate tasks and responsibilities to employees in my business
ESE14: How much confidence do you have in your ability to ...? - Deal effectively with day-to-day problems and crises
ESE15: How much confidence do you have in your ability to ...? - Inspire, encourage, and motivate my employees

ESE16: How much confidence do you have in your ability to ...? - Train employees

Implementing Finance

ESE17: How much confidence do you have in your ability to ...? - Organize and maintain the financial records of my business

ESE18: How much confidence do you have in your ability to ...? - Manage the financial assets of my business

ESE19: How much confidence do you have in your ability to ...? - Read and interpret financial statements

2) Creative self-efficacy (CSE)

A six-point Likert-type scale ranging from 1 = “Strongly disagree” to 6 = “Strongly agree.”

Please rate your creative self-efficacy - I will be able to achieve most of the goals I have set for myself in a creative way

CSE1: Please rate your creative self-efficacy - When facing difficult tasks, I am certain that I will accomplish them creatively

CSE2: Please rate your creative self-efficacy - In general, I think that I can obtain outcomes that are important to me in a creative way

CSE3: Please rate your creative self-efficacy - I believe I can succeed at most any creative endeavor to which I set my mind

CSE4: Please rate your creative self-efficacy - I will be able to overcome many challenges creatively

CSE5: Please rate your creative self-efficacy - I am confident that I can perform creatively on many different tasks

CSE6: Please rate your creative self-efficacy - Compared to other people, I can do most tasks very creatively

CSE7: Please rate your creative self-efficacy - Even when things are tough, I can perform quite creatively.

3) Risk Propensity Scale (RSP)

A 9-point scale ranging from 1= “Totally disagree” to 9 = “Totally agree,” except for the last item, which was rated on a scale ranging from 1 = “Risk avoider” to 9 =”Risk seeker.”

RPS1: Please rate your risk propensity. - Safety first

RPS2: Please rate your risk propensity. - I prefer to avoid risks.

RPS3: Please rate your risk propensity. - I take risks regularly

RPS4: Please rate your risk propensity. - I really dislike not knowing what is going to happen

RPS5: Please rate your risk propensity. - I usually view risks as a challenge

RPS6: Please rate your risk propensity. - I view myself as a risk-seeker