Exploratory Factor Analysis of Students' Entrepreneurial Self-Efficacy: Implications for Survey Validation

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INTRODUCTION

Human skills can take on a variety of forms as they evolve. These various functional domains require unique knowledge and abilities. Given no one can embody *all* knowledge and abilities, one's perceptions of their efficacy in various activity domains vary one's efficacy belief system is viewed by social cognition theory as a discrete collection of self-beliefs connected to multiple functional domains rather than as an all-encompassing characteristic. Comparative research demonstrates that motivation and action are well predicted by domain-linked assessments of perceived efficacy [1]. An individual's awareness to apply these abilities when faced with a task or situation is described as self-efficacy. This perception, whether precise or not, portrays one's capability to coordinate their cognitive, physical, and emotional abilities to achieve the goals of the task [2]. According to research, entrepreneurial self-efficacy (ESE) is a significant predictor of entrepreneurial interest [3] – [5]. As such, ESE provides critical insight into how individuals may demonstrate entrepreneurial attributes in the future and may engage in venture-specific entrepreneurial activities.

Furthermore, external factors can play a significant factor in molding the ESE of an individual as they embark on their journey to initiate a business or as they demonstrate any entrepreneurial behaviors in non-venture-creation settings. Particularly, external elements like the experiences gained throughout one's life and more importantly entrepreneurship education programs can also influence the perceptions of an individual regarding their ESE [6]. Thus, it is important to examine ESE to understand to what extent external elements, such as entrepreneurship education programs, can positively impact students. Entrepreneurship education refers to any educational effort targeted at enhancing students' intellectual capability, skills, attitudes, and unique characteristics associated with entrepreneurship [7]. Ginanjar characterizes this education as a university course that concentrates on the theoretical and applied components of entrepreneurship [8].

ESE has been typically examined and studied in business fields, particularly among business students and professionals. While there has been an abundance of research on ESE and ESE instruments in business and management contexts, literature suggests ESE remains unexplored in the context of engineering [9]. Researchers have called for a deep and refined understanding of ESE and its various dimensions [10], [11]. For the continuous improvement of entrepreneurship education programs in engineering education, *assessment and evaluation are necessary*, which involve collecting data and analyzing the gathered data to derive context-specific, research-based conclusions on program effectiveness, respectively [12].

This study aims to address the needs described in literature by finding evidence of validity of an ESE instrument in engineering education contexts. To the best of our research, no one has validated an ESE instrument in the context of engineering education, revealing a gap in how we teach engineers entrepreneurship. By validating a multi-dimensional ESE instrument among students enrolled in engineering entrepreneurship programs (EEP), we gain the ability to better understand ESE in engineering contexts. Furthermore, this work focuses on understanding the how latent factor structures change after students have been exposed to EEP experiences by performing factor

analysis on both pre- and post-course data from students enrolled in an entrepreneurship course. In doing so, the study examines the following research questions: 1) What is the latent factor structure of an Entrepreneurial Self-Efficacy instrument for students enrolled in engineering entrepreneurship programs? and 2) What are the differences (if any) in the factor structure before and after taking an entrepreneurship course?

BACKGROUND LITERATURE

Many researchers have contributed to the literature on ESE by developing instruments to measure various aspects of the ESE [13], [14]. These instruments have been used to study how ESE predicts entrepreneurial intentions among various group of students and business professionals. Using these instruments, ESE has been explored across undergraduate and graduate levels of education, among business professionals at various stages their business ventures [15]–[17], and between entrepreneurs from non-entrepreneurs [9], [13], [14]. Overall, researchers have identified ESE as a domain specific construct in relation to the belief or confidence one holds in performing different entrepreneurial tasks. Researchers assert that ESE is multi-dimensional which consists of broad dimensions related to entrepreneurship such as identifying opportunities, management, planning, decision making, and marketing [9].

Researchers have generally developed ESE instruments by either leveraging existing research to use the items from existing studies or develop their own instruments. The validation of these developed instruments has been performed by factor analysis by either extracting factors through principal component analysis [9], [14] or principal axis factoring [18]. Table 1 provides a summary of articles which focus on the development of an ESE instrument. The table presents the steps performed in validation process used by the researchers (e.g., numbers of factors extracted after factor analysis, sample and sample size, number of questions retained, and extraction methods).

Table 1. Summary of the Instrument Development and Validation**.**

Study Description	**Factors**	**Sample (Sample size)**	**Extraction & Rotation Method**	**Number of Items - Initial/Final**
Comparison of the ESE in students from different courses (entrepreneurship, psychology, and organizational development) [13]	5 (Marketing, Innovation, Management, Risk-Taking and Financial Control)	Students of management, psychology, and organization (140)	PCA & Varimax	30
Developed and validated an instrument for the measurement of ESE. [19]	6 (Developing new product or market opportunities, building and innovative environment, initiating investor relationships, defining core purpose, coping with unexpected challenges, developing critical human resources)	Undergraduate Students Sample randomly divided in two for the analysis (272) And additional 87 MBA students	PCA & Varimax	29/22

Measurement of ESE and effect of risk on it [4].	4 (Opportunity Identification, Relationship, Managing, Tolerance)	Graduate and undergraduate entrepreneurial students of Russia, Norway, and Finland (528)	PAF & Oblimin	18
The study aims to refine and standardize the measurement of ESE [9].	5 (Searching, Planning, Marshalling, Implementing People and Implementing Finance)	Students and the nascent entrepreneurs (303)	PCA & Varimax	50/26
Measured different factors of entrepreneurial self-efficacy (ESE) [20]	9 (Innovation, Financial Value, Attitude to risk, Teamwork, Product development, Startup Processes, Leadership, Creativity, Attitude)	Post graduate Students (1086)	PAF & Oblimin	--

This research summary indicates that to develop a better understanding of the entrepreneurial self-efficacy in engineering EEPs, the validity of the instrument needs to be established among Engineering Entrepreneurial Program students, who often come from non-business fields. We address this gap by scoping our work to validate the instrument developed by McGee et al. [9] among EEP students. The instrument was selected because the subconstructs map to the different stages of the entrepreneurial process which students are exposed to in their courses.

METHODS

Data collection: Data was collected from a 400-level entrepreneurship course offered at a large college of engineering at one university located in the United States. The study was conducted in two phases with the aim of understanding the changes in factor structure in students' ESE instrument before and after completing the course. During Phase 1 we collected 252 student responses at the beginning of semester; for Phase 2, we collected 230 student responses at the end of the entrepreneurship course. Demographic factors examined including gender and ethnicity are reported in Table 2. Responses were recorded using an instrument validated by McGee et al. [9] among business students and entrepreneurs; this instrument assesses ESE on a 5-point scale across 19-items. In this instrument, respondents would rate their self-confidence by responding (1) “very little” to (5) “very much” to the prompt “how much confidence do you have in your ability to…” Researchers developed the instrument items to measure the confidence for the 4 stages of the entrepreneurial process, defined in the literature as searching, planning, marshaling, and implementation. The initial stage involved pinpointing distinct tasks linked to each stage of the four-phase process of creating a new venture (namely, searching, planning, marshaling, and implementing). To enhance clarity, tasks related to the implementing phase were categorized into two groups, distinguishing between tasks related to managing people and those related to managing finances in a small startup business [9].

Table 2. Sample Demographics for Phase 1 and Phase 2.

		Phase 1 (n=252)	Phase 2 (n=230)
Gender	Male	152 (60.2%)	147 (63.9%)
	Female	92 (36.5%)	78 (33.9%)
	Missing Values	8 (3.3%)	5 (2.2%)
Race/Ethnicity	Asian/Asian American	51 (20.2%)	44 (19.1%)
	Black/African/African American	3 (1.2%)	4 (1.7%)
	Latino(a)/Hispanic	6 (2.4%)	7 (3.0%)
	Native Hawaiian/Pacific Islander	1 (0.4%)	1 (0.4%)
	White/Caucasian	167 (66.3%)	153 (66.5%)
	Other	5 (2.0%)	5 (2.2%)
	Multiracial	8 (3.1%)	11 (4.8%)
	Missing Values	11 (4.4%)	5 (2.2%)

Analysis: We conducted an Exploratory Factor Analysis (EFA) in SPSS (version 28) using principal axis factoring to identify the underlying five-factor structure and validate that the survey items effectively measure their intended latent factors. We tested requisite assumptions by ensuring 1) normality by evaluating skewness and kurtosis; 2) sampling adequacy by conducting the Kaiser Meyer Olkin test; and 3) sufficient correlation among factors through Bartlett's Sphericity Test. Following recommended practices [22], we used a combination of methods to identify the ideal number of factors to retain after EFA including scree plots, Kaiser criterion, and minimum average partials (MAP) test. Additionally, we evaluated instrument reliability using Cronbach's alpha, aiming for a value exceeding 0.70 for each construct. We removed items that did not satisfy the factor loading criteria of 0.40 or higher for the factor loading value, high communality (greater than 0.40), and/or cross-loaded on multiple factors (i.e., factor loading more than 0.40 on multiple factors), as these traits would indicate poor validity [23]. The analysis was conducted on both Phase 1 and Phase 2 data. The results of the assumption tests and factor analysis are presented in the following section.

RESULTS

Phases 1 and 2 data were suitable to perform the EFA as all the assumptions were met. Particularly, we found the data to be normally distributed (using skewness and kurtosis) and sufficiently reliable (Table 3). We found that Phase 1 was suitable for factor analysis showing adequate sampling (KMO = 0.91) and sufficient factor correlations ($\chi^2_{171} = 2562.3$, $p < 0.001$). Phase 2 also showed suitable results (KMO = 0.92) and ($\chi^2_{171} = 2690.6$, $p < 0.05$).

Table 3. Cronbach Alpha's Value for Both Study Phases.

	Phase 1	Phase 2
	Cronbach's alpha	**Cronbach's alpha**
Searching (S)	0.78	0.80
Planning (P)	0.73	0.77
Managing (M)	0.77	0.82

Implementing People (IP)	0.88	0.90
Implementing Finances (IF)	0.91	0.92

Table 4. Descriptive Statistics for Responses to both Study Phases.

Questions	Phase 1				Phase 2			
	Mean	**Std Dev**	**Skewness**	**Kurtosis**	**Mean**	**Std. Dev**	**Skewness**	**Kurtos**
S1- Brainstorm (come up with) a new idea for a product or service	3.74	0.93	-0.61	0.21	4.19	0.76	-0.82	0.61
S2- Identify the need for a new product or service	3.61	0.92	-0.37	-0.11	4.11	0.71	-0.45	0.00
S3- Design a product or service that will satisfy customer needs and wants	3.39	3.39	-0.21	-0.23	3.99	0.81	-0.57	-0.05
P1-Estimate customer demand for a new product or service	3.38	0.90	-0.52	-0.02	4.00	0.76	-0.42	-0.10
P2-Determine a competitive price for a new product or service	3.04	1.00	-0.06	-0.42	3.72	0.95	-0.61	0.12
P3-Estimate the amount of start-up funds and working capital necessary to start my business	2.66	1.13	0.17	-0.92	3.40	1.11	-0.27	-0.71
P4-Design and effective marketing/advertising campaign for new product or service	3.42	1.07	-0.48	-0.44	3.95	0.92	-0.66	-0.14
M1-Get others to identify with and believe in my vision and plans for a new business	3.66	0.88	-0.43	0.01	4.12	0.78	-0.83	1.30
M2-Network -- i.e. make contact with and exchange information with others	3.84	0.99	-0.72	0.13	4.15	0.88	-0.84	0.17
M3-Clearly and concisely explain verbally/in writing my business idea in everyday terms	3.68	0.87	-0.46	0.11	4.17	0.76	-0.72	0.29
IP1-Supervise employees	3.68	0.94	-0.60	0.10	3.77	1.00	-0.68	-0.03
IP2-Recruit and hire employees	3.42	1.11	-0.40	-0.57	3.53	1.03	-0.40	-0.34
IP3-Delegate tasks and responsibilities to employees in my business	3.89	0.87	-0.91	1.23	3.99	0.87	-0.94	1.25
IP4-Deal effectively with day-to-day problems and crises	3.77	0.82	-0.63	0.48	4.01	0.87	-1.03	1.49
IP5-Inspire, encourage, and motivate my employees	3.91	0.89	-0.69	0.22	4.08	0.90	-0.88	0.59
IP6-Train employees	3.56	0.97	-0.67	0.17	3.72	0.97	-0.64	0.33
IF1-Organize and maintain the financial records of my business	3.18	1.11	-0.19	-0.75	3.65	1.05	-0.62	-0.18
IF2-Manage the financial assets of my business	3.02	1.17	-0.10	-0.83	3.45	1.08	-0.49	-0.33

IF3-Read and interpret financial statements	2.81	1.21	0.08	-1.03	3.33	1.12	-0.45	-0.42

Responses in the Phase 1 data showed a low communality (0.263) for the fourth Planning item (P4), "Design and Effective Marketing/Advertising Campaign for New Product or Service." A low communality represents that an item may not be well represented by the extracted factors in the EFA, which would indicate limited item validity in the survey. Communality explains the shared variance of one item with the other items [24]. As such, we removed P4 from the instrument. In the next analysis iteration, we observed that the third Planning item (P3), "Estimate the amount of start-up funds and working capital necessary to start my business," cross loaded on two factors (-0.40 on Factor 2 and -0.47 on Factor 4), so this item was also removed. In the next analysis iteration, we found the remaining items yielded a coherent five factor structure where each item loaded on a single factor with a loading of 0.40 or greater (Table 5 - Phase 1). The resultant 5-factor solution cumulatively explained 72.7 % of the variance in the data.

Table 5. Pattern Matrix for Five-factor Solutions.

	Factor Pattern Matrix (Phase 1)					**Factor Pattern Matrix (Phase 2)**				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
S1- Brainstorm (come up with) a new idea for a product or service			0.74						0.74	
S2- Identify the need for a new product or service			0.62						0.55	
S3- Design a product or service that will satisfy customer needs and wants			0.61						0.75	
P1- Estimate customer demand for a new product or service				-0.68				0.58		
P2- Determine a competitive price for a new product or service				-0.79						-0.43
M1- Get others to identify with and believe in my vision and plans for a new business					-0.68			0.67		
M2- Network -- i.e. make contact with and exchange information with others					-0.54			0.80		
M3- Clearly and concisely explain verbally/in writing my business idea in everyday terms					-0.50			0.58		
IP1- Supervise employees	0.56					0.81				
IP2- Recruit and hire employees	0.64					0.84				

IP3- Delegate tasks and responsibilities to employees in my business	0.72	0.71
IP4- Deal effectively with day-to-day problems and crises	0.58	0.54
IP5- Inspire, encourage, and motivate my employees	0.63	0.63
IP6- Train employees	0.80	0.66
IF1- Organize and maintain the financial records of my business	0.78	0.90
IF2- Manage the financial assets of my business	1.01	0.93
IF3- Read and interpret financial statements	0.77	0.86

We found similar findings for Phase 2 as we found in Phase 1. In Phase 2, P4 again had a low communality value (0.44) falling short of the communality requirements. Upon suppressing poor loadings (below 0.4), we observed thatP3 did not load on any factor. As a result, these two items were eliminated from the analysis in Phase 2. As a result, each item loaded on a single factor with a loading of 0.40 or greater (Table 5 - Phase 2). A 5-factor analysis that showed 73.57% of the total variance in the data.

In contrast with Phase 1 results, we observed Phase 2 EFA results revealed that the remaining Planning items (P1- "Estimate customer demand for a new product or service" and P2 – "Determine a competitive price for a new product or service") loaded on different factors. P1 loaded on Factor 3 (0.58) along with the Marshaling items, and P2 loaded by itself on Factor 5 (-0.43). The remaining items in the planning subfactors (P1and P2) were eliminated to fully assess the behavior of the planning element as in the final iterations of EFA. By removing this factor, we pursued another EFA for both phases seeking a four-factor solution. Table 5 provides a pattern matrix for the four-factor solutions.

Table 6. Pattern Matrix for Four-factor Solutions.

	Factor (Pattern Matrix (Phase 1)				**Factor (Pattern Matrix (Phase 2)**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
S1- Brainstorm (come up with) a new idea for a product or service			0.76					0.68
S2- Identify the need for a new product or service			0.65					0.60
S3- Design a product or service that will satisfy customer needs and wants			0.64					0.81
M1- Get others to identify with and believe in my vision and plans for a new business				-0.70			0.63	

M2- Network -- i.e. make contact with and exchange information with others		-0.52	0.78
M3- Clearly and concisely explain verbally/in writing my business idea in everyday terms		-0.50	0.48
IP1- Supervise employees	0.60		0.84
IP2- Recruit and hire employees	0.66		0.80
IP3- Delegate tasks and responsibilities to employees in my business	0.75		0.77
IP4- Deal effectively with day-to-day problems and crises	0.61		0.60
IP5- Inspire, encourage, and motivate my employees	0.65		070
IP6- Train employees	0.80		0.70
IF1- Organize and maintain the financial records of my business		0.82	0.86
IF2- Manage the financial assets of my business		0.99	0.92
IF3- Read and interpret financial statements		0.80	0.87

DISCUSSION

We conducted two exploratory factor analyses (EFA) at the beginning and end of an engineering entrepreneurship course to comprehensively understand the underlying factors influencing students' entrepreneurial self-efficacy (ESE). We found evidence of discriminant validity in the ESE instrument through repeatedly “good” factor loadings [23]. In answering Research Question 1, we obtained a very reliable four-factor model for phases 1 and 2, which excludes the Planning task. Future studies should deeply evaluate why the Planning items performed poorly, such as by revising how these items are written by consulting field experts for guidance or students for their interpretation of the items.

Moreover, we encourage others to continue to evaluate validity and reliability evidence among more diverse groups to ensure generalizability. Our sample was composed of primarily white/Caucasian (66-67%) male (60-64%) students, which may have some impact on results obtained with this ESE instrument. With this sample, we report on limited differences by race and ethnicity in other work [25], yet larger and more diverse samples may be needed to ensure validity among all groups, which may lead to more equitable learning outcomes in ESE.

In answering Research Question 2, we found relatively similar results between the two study phases, indicating the instrument likely will provide reliable and valid results among engineering

students before and after engaging with EEPs. As such, we encourage its use in exploring how engineering students express and develop their ESE, citing the sufficient evidence of validity and reliability that we found. Refining the instrument to measure Entrepreneurial self-efficacy is important to accurately measure it among students enrolled in an engineering college's entrepreneurship program [9]. Programs may utilize this survey to identify methods of adjusting their teaching methods and curricula to improve students' entrepreneurial self-efficacy. As such, students from these programs may be better empowered to engage in entrepreneurial activities in the future [3] – [5]. We share this validated tool as a reliable means of assessment that is easily accessible for instructors.

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