

Does an Intolerance of Ambiguity Influence Undergraduate Engineering Students to Choose Entrepreneurial Coursework?

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Work In Progress: Does an Intolerance of Ambiguity Influence Undergraduate Engineering Students to Choose Entrepreneurial Coursework?

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Abstract

Engineering programs increasingly encourage entrepreneurial thinking, yet little is known about how engineering students decide to enroll in entrepreneurial courses or minors. Prior research shows that course-choice decisions are shaped by both structural constraints and motivational factors, while Self-Determination Theory (SDT) suggests that students are more likely to engage in learning experiences that support autonomy, competence, and relatedness. This Work-in-Progress study explores whether engineering students' intolerance of ambiguity is associated with their decisions to enroll in entrepreneurial coursework and how their stated motivators for course selection align with SDT-based constructs. Data were collected from four student affiliation groups representing entrepreneurial and non-entrepreneurial pathways: an Entrepreneurship Minor, a Management Minor, an entrepreneurial capstone section, and a traditional capstone section. Students completed Budner's 16-item Intolerance of Ambiguity Scale and selected motivating factors for enrolling in their course or minor, including requirement status, workload, relevance, interest, advice, and variety.

Results show significant differences in ambiguity intolerance across affiliation groups, with Entrepreneurship Minor students reporting the lowest intolerance (highest tolerance) and Traditional Capstone students reporting the highest intolerance. Contrary to the initial hypothesis, Entrepreneurial Capstone students more closely resembled Traditional Capstone students than Entrepreneurship Minor students, suggesting that self-selection into optional entrepreneurial pathways may be more strongly associated with ambiguity tolerance than enrollment in required entrepreneurial coursework. Motivational patterns also differed by affiliation group. As expected, both capstone groups overwhelmingly selected "required" as their primary motivator, while minor students rarely did so. Entrepreneurship Minor students reported the highest levels of interest and relevance, consistent with SDT's emphasis on intrinsic motivation and identity alignment. These findings suggest that ambiguity intolerance may influence students' willingness to pursue optional entrepreneurial pathways, while required entrepreneurial coursework may attract a broader range of students with diverse motivational profiles.

Introduction

Entrepreneurship manifests in engineering course programming in several ways. Huang-Saad et al. (2020) provide a field-level overview of how entrepreneurial education has become embedded across engineering through courses, minors, national programs, and institution-wide initiatives [1]. Looking at course selection through the lens of Self-Determination Theory (a theory that explains motivation in terms of autonomy, competence, and relatedness) engineers are most likely to enroll when the course feels intrinsically interesting, supports their sense of engineering competence, and fits their emerging professional identity [2]. Against this backdrop of expanding and differentiated choices, a central question emerges: when faced with this myriad of choices, what factors drive students to enroll in an entrepreneurial class or minor?

At the University of Colorado Boulder, all engineering students can pursue an Entrepreneurship Minor (through the Engineering Management program), and some may select an entrepreneurial section of their required capstone course in their major, while still meeting degree requirements and without extending time to graduate. (Appendix A for Course Descriptions)

In this work, we examine how students' motivations related to entrepreneurship influence their course-selection decisions and whether intolerance of ambiguity plays a role in those choices. We also aim to develop a clearer framework for describing entrepreneurship within engineering, with the goal of helping undergraduate students better understand the relevance of entrepreneurial thinking across diverse engineering career paths.

Study Design

Factors that motivate students' course selection are well-studied [3,4,5]. Not only do these findings suggest that key influencing factors cut across cultural and geographic lines, but they also define three primary decision-making categories. One category is if the course is required. The other two categories of influencing factors can be separated into two segments. On one level, students look at section-specific factors such as scheduling (i.e., time of day or day of week), instructor reputation, or class size/location. On another level, they focus on course-specific factors, including course workload (ability to succeed), relevance to future career, level of interest in the topic, advice received (friends, advisors), and the variety the course may add to their courseload. This research focuses on course-specific factors most closely aligned with the intrinsic motivation of the student, as section specific factors vary from term to term and cannot be reliably projected into hypothetical or future looking scenarios. Six motivating factors derived from the literature review were coded as the following "motivators":

- Required (whether the course is mandatory)
- Load (appropriateness of course workload)
- Relevant (alignment with future career goals)
- Interest (personal interest in the course topic)
- Advice (recommendations from trusted sources)
- Variety (diversity added to the student's schedule)

Additionally, an intolerance of ambiguity is cited as highly correlated to entrepreneurial ventures and an ability to adapt to changing situations [6]. Stanley Budner as part of a PhD dissertation at Colombia University in 1960, developed a test to determine an individual's *intolerance* of ambiguity. Budner's Intolerance of Ambiguity Scale is a 16-item self-report questionnaire that measures an individual's propensity to perceive ambiguous situations as threatening (intolerance) or desirable (tolerance) [7]. It uses a 7-point Likert scale to assess responses to novel, complex, or insoluble situations. The survey measures "intolerance", thus, lower scores indicate a high tolerance for ambiguity while higher scores indicate a lower tolerance for ambiguity. The survey requests the student to indicate their major and minor(s) and then to answer the 16-question ambiguity test (See Appendix B), as well as to select the motivating factor(s) for enrolling in the particular course or minor they were in.

Four groups of enrolled students were studied, representing two categories: entrepreneurial and non-entrepreneurial students. In the entrepreneurial category were students from the Engineering Management - Entrepreneurship Minor and an entrepreneurial section of a required capstone course. In the non-entrepreneurial category, the students were from the Engineering Management - Management Minor and the traditional section of a required capstone course. These distinct groups will be referred to in this paper as "affiliation groups".

The hypothesis is that students enrolled in entrepreneurial courses will report a lower intolerance for ambiguity than those who have not chosen to participate in entrepreneurial courses. Because students choose to enroll in entrepreneurial courses, they are likely to display traits typically associated with entrepreneurship such as a high comfort-level with ambiguity. The expectation is that students with high intolerance of ambiguity will prefer traditional coursework with clear rubrics and will avoid opportunities that require independent navigation of ambiguity. As predicted by Self-Determination Theory, it is also hypothesized that students enrolled in entrepreneurial courses will identify interest and relevance as their highest motivating factors, based on self-identification as entrepreneurs.

Preliminary Data Collection

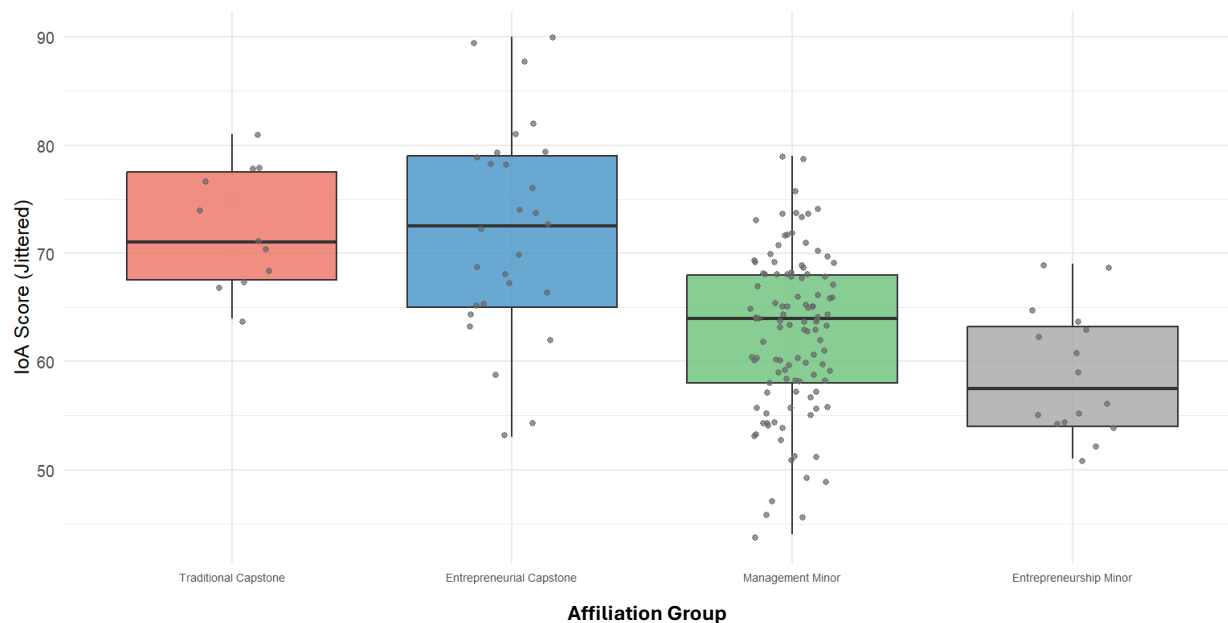
Figure 1 displays the data collection for each affiliation group. The table shows a separation between capstone students and minor students in their intolerance of ambiguity scores. Both the Traditional Capstone ($M = 72.3$) and Entrepreneurial Capstone ($M = 72.0$) groups report similarly high scores. In contrast, the Management Minor ($M = 62.6$) and especially the Entrepreneurship Minor ($M = 58.9$) show substantially lower scores. While the population size of each affiliation group varies, the response rates from the groups are comparable.

Figure 1- Population Data

	Mean	SD	n	Response Rate
Traditional Capstone	72.3	5.6	11	38%
Entrepreneurial Capstone	72.0	9.8	28	52%
Engineering Mgt- Management	62.6	7.3	111	21%
Engineering Mgt – Entrepreneurship	58.9	5.9	16	34%

The data is visually represented in Figure 2. As typical with a boxplot, each thick horizontal line represents the group median within the boxes whose range shows the 25th to 75th percentiles. The vertical whisker lines show the full range of data with individual data points jittered for visibility. The Traditional Capstone students exhibit the highest level of ambiguity intolerance, with the narrowest data range (Figure 2, far left box). Observable in the boxplot is that the Entrepreneurial Capstone students show a wide spread of intolerance of ambiguity scores. Their median score is almost equal to that of the Traditional Capstone students, but their score distribution is wider. Management Minor students show moderate intolerance of ambiguity, with scores lower than those of either capstone group but higher than those of the Entrepreneurship Minor students.

Figure 2- Intolerance of Ambiguity by Affiliation Group (Boxplots)



Welch's ANOVA and Games-Howell post hoc test confirm significant differences among these groups. (See Appendix C)

Next, we look to observe any patterns within the reasons listed for taking the course (Table 1).

Table 1- Percentage of Motivator Selection by Affiliation Group

	Traditional		Entrepreneurial	
	Traditional Capstone n=11	Management Minor n=11	Entrepreneurial Capstone n=28	Entrepreneurship Minor n=16
It is a required course	100%	4%	79%	6%
It will be relevant to my future career	73%	78%	50%	75%
I am interested in the topic	27%	59%	64%	81%
Provides variety (technical and non-technical) in my schedule	0%	38%	29%	50%
I received trusted advice to enroll	0%	19%	11%	31%
I think it will be easier than my other courses	0%	13%	4%	6%

As shown in Table 1, the data supported the expectation that both capstone groups would identify their course as required, and that minor students would identify their minor as not required. Basic observations of the four affiliation groups include:

- Traditional Capstone students' responses indicated that 100% were motivated to take the course because it was required. This group shows the narrowest distribution of motivational profiles, suggesting that they are in the course because they must be.
- Entrepreneurial Capstone students overwhelmingly selected the course because it was a required course (79%), a pattern consistent with other capstone groups and distinct from the minors. Their interest (64%) and desire for variety (29%) are higher than in the Traditional Capstone. Career relevance is notably low (50%) compared to all other groups, suggesting that although the course is required and may be of interest, these students are not necessarily aligned with an entrepreneurial pathway.
- Management Minor respondents perceived the course as required in only 4% of cases, consistent with expectations for a self-selected elective population. They show moderate levels in all other motivators. Management Minor students appear to perceive that the content is directly beneficial to their future careers whether or not they are interested in all of the content.
- Six percent of Entrepreneurship Minor students responded that a course was required, similarly confirming that this is a self-selected elective population. However, the Interest motivator was selected (81%) by far the most out of all groups. Relevance was also highly selected (75%), and while variety (50%) and advice (31%) were at moderate levels, they were the highest reporting of all groups.

Outcomes to Date

This initial data collection shows that counter to the hypothesis, the mean intolerance of ambiguity score for the Entrepreneurial Capstone more closely resembles the Traditional Capstone than the Entrepreneurship Minor. This might suggest that an intolerance of ambiguity may not function as a strict predictor of entrepreneurial engagement. Instead, it might be more closely associated with students' decisions to pursue a self-selected, optional pathway such as a minor.

Additionally, across all groups, many students selected multiple motivators influencing enrollment, but the distribution of these motivators differed by affiliation type. As expected, both capstone groups overwhelmingly identified "required" as a reason for enrollment, reflecting the structural nature of capstone coursework. In contrast, students in both minors rarely selected "required" and instead reported higher levels of interest and relevance as Self-Determination Theory would predict.

Limitations

The initial data collection prevents broad conclusions. The Traditional Capstone data was from the Electrical Engineering department, while the Entrepreneurial Capstone data was from the Mechanical Engineering department. Additionally, while the differences in population sizes of each affiliation group could be accounted for, the small population size of certain affiliation groups makes it difficult to make definitive conclusions.

Conclusion

This research set out to determine undergraduate engineering students' motivation to enroll in entrepreneurship programs and whether an intolerance to ambiguity was a factor. Across the four affiliation groups examined (Traditional Capstone, Entrepreneurial Capstone, Management Minor, and Entrepreneurship Minor), a clear structural divide emerged between required capstone courses and self-selected minors. Capstone students, in either the traditional or entrepreneurial sections, were motivated primarily by the required nature of the course and reported a higher intolerance of ambiguity. In contrast, students who optionally enrolled in either the Management or Entrepreneurship Minor, demonstrated more intrinsically driven motivations, particularly interest and career relevance, and reported lower ambiguity intolerance.

These patterns indicate that intolerance of ambiguity and intrinsic motivation are associated not with exposure to entrepreneurial course content, as the hypothesis posited, but rather with students' decisions to pursue optional, self-selected pathways. An intolerance of ambiguity is linked to creative risk-taking and divergent thinking, how individuals adapt to unfamiliar cultural norms, and decision-making under uncertainty [8]. This orientation can shape students' willingness to participate in open-ended, innovation-focused learning experiences. By identifying the factors that influenced students' choices, unintended barriers can be identified and removed for those students who may be inclined to participate but are not participating.

Appendix A: Course Descriptions

The Mechanical Engineering - Engineering for Social Innovation section is an opportunity for students to explore innovation and entrepreneurship as they progress a design from ideation to manufacturing, with projects in this section focused on societal impact. Students were encouraged to pursue opportunities in design that address issues in developing countries, underprivileged domestic populations, sustainability, and the environment. Funding is provided to each team in the same amount as the industry-funded section of the course. Student teams will be held to the same standards across all sections and are expected to have the same general course outcomes. Projects in this section will end at the same level of completion, although the innovation and entrepreneurship section will start earlier in the design process. (University of Colorado Boulder, Department of Mechanical Engineering, n.d., Senior Design).

The Electrical Engineering Capstone is described as comprising a two-semester senior design lab, in which students form teams that use an industrial-type process to propose, design, build, and document their projects. They make formal presentations at a preliminary design review in the first semester and a critical design review in the second semester, before presenting their finished project at the college's Engineering Projects Expo (University of Colorado Boulder, Department of Electrical, Computer & Energy Engineering, n.d., Senior design).

Engineering Management Minor

The Engineering Management minor is designed to help advance abilities in leadership for application to industry. This minor is designed for students who wish to advance their business skills and knowledge within industry. Students will learn the skills necessary to integrate engineering management systems into the engineering and technology environment. A minor in engineering management will broaden your knowledge and skills in project management, leadership, marketing, economics, accounting and finance.

Details:

Total Credits Required: 12

- **Required Courses (6 credits, 2 courses)**
 - EMEN 4100: Engineering Economics
 - EMEN 4030: Project Management Systems
- **Elective Courses (6 credits, 2 courses)**
 - EMEN 3100: Introduction to Engineering Management
 - EMEN 4050: Leadership & Professional Skills
 - EMEN 4110: Supply Chain Management
 - EMEN 4120: Managing Business Processes
 - EMEN 4400: Quality Management
 - EMEN 4405: Fundamentals of Systems Engineering

Engineering Entrepreneurship Minor

The Engineering Entrepreneurship minor equips students with the knowledge, understanding and skills to effectively contribute to an entrepreneurial venture as a start-up or with a larger enterprise. The minor provides the opportunity to develop leadership skills while introducing students to innovation management, creative development and the overall entrepreneurial process.

Details:

Total Credits Required: 12

- **Required Courses (6 credits)**
 - EMEN 4800: Technology Ventures and Marketing
 - EMEN 4820: Entrepreneurial Product Development
- **Elective Courses (6 credits)**
 - EMEN 4200: Engineering Entrepreneurship for the Developing World
 - EMEN 4825: New Venture Creation
 - EMEN 4830: Intro to Entrepreneurship (one credit)
 - New EMEN 4830: Strategic Management in Biomedical Product Development
 - **New EMEN 4830-one credit 5 week courses**
 - Innovation Communication
 - Innovation Finance and Legal
 - Innovation Discovery
 - >>>If you would like to apply any of the EMEN 4830 classes to your minor, please email kendra.thibeault@colorado.edu.

Note: <https://www.colorado.edu/emp/undergraduate-programs>

Appendix B: Data Collection

Survey 1

Please respond to the following statements by indicating the extent to which you agree or disagree with them.

[illegible]

Often the most interesting and stimulating people are those who don't mind being different and original.

○ ○ ○ ○ ○ ○ ○

What we are used to is always preferable to what is unfamiliar.

○ ○ ○ ○ ○ ○ ○

People who insist upon a yes or no answer just don't know how complicated things really are.

○ ○ ○ ○ ○ ○ ○

A person who leads an even, regular life in which few surprises or unexpected happenings arise really has a lot to be grateful for.

○ ○ ○ ○ ○ ○ ○

Many of our most important decisions are based upon insufficient information.

○ ○ ○ ○ ○ ○ ○

I like parties where I know most of the people more than ones where all or most of the people are complete strangers.

○ ○ ○ ○ ○ ○ ○

Teachers or supervisors who hand out vague assignments give people a chance to show initiative and originality.

○ ○ ○ ○ ○ ○ ○

The sooner we all
acquire similar
values and ideals
the better.

○ ○ ○ ○ ○ ○ ○

A good teacher is
one who makes
you wonder about
your way of looking
at things.

○ ○ ○ ○ ○ ○ ○

What factors influenced your decision to take this section of this course? (Select ALL that apply.)

- ☐ It is a required course
- ☐ I think it will be easier than my other courses
- ☐ I think it will be relevant to my future career
- ☐ I am interested in the topic
- ☐ I received trusted advice to enroll
- ☐ It provides a variety (technical and non-technical) in my schedule

Appendix C: Statistical Analysis

Welch's ANOVA for Differences in Intolerance of Ambiguity by Affiliation Group

Source	df	F	p value
Between groups	3	18.84	<.001
Within groups	31.33		

Welch's one-way ANOVA confirmed a statistically significant difference ($p < .05$) amongst the intolerance of ambiguity scores of the four Affiliation groups. Games-Howell confirms no difference between Capstone groups, a trend towards a difference between the Minor groups, and differences in all other cases.

Games-Howell Post Hoc Test Comparing Ambiguity Scores Across Affiliation groups

Group 1	Group 2	Mean Diff	CI lower	CI upper	p adj
Traditional Capstone	Entrepreneurial Capstone	-0.24	-7.04	6.56	1
Traditional Capstone	Management Minor	-9.72	-15.4	-4.13	<.001
Traditional Capstone	Entrepreneurship Minor	-13.3	-19.6	-7.11	<.001
Entrepreneurial Capstone	Management Minor	-9.49	-14.8	-4.18	<.001
Entrepreneurial Capstone	Entrepreneurship Minor	-13.1	-19.4	-6.76	<.001
Management Minor	Entrepreneurship Minor	-3.61	-8.12	0.9	0.148

Note. Mean differences reflect Group 1 minus Group 2. Confidence intervals are 95%. Games-Howell post hoc procedure was used following a significant Welch's ANOVA.

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