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Work in Progress: From Curriculum to Competence: Exploring Pedagogical Practices in Engineering Entrepreneurship and Human Capital Formation

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Key words: entrepreneurship education, innovation, assessment, emotion, human capital, venture capital, culture

Introduction

The growth of entrepreneurship education in recent decades has been fueled by interests in innovation, venture creation, and contributed to employment opportunities and economic and development [1]. Universities have played a critical role in the advancement of entrepreneurship as a unique discipline and field, especially in engineering. This Work-In-Progress paper aims to examine how the pedagogical practices of entrepreneurship education can inform new applications and frameworks for how entrepreneurship and innovation are taught in engineering with a focus on venture design and capital formation.

A fundamental component of entrepreneurship education is experiential learning [2] which has also been a foundational pedagogy in engineering education [3]. Following Kolb's learning cycle [4], understanding how entrepreneurs learn is often directly related to an educator's teaching philosophy.

Entrepreneurship education can be operationalized and described in four modes [2, 5, 6]:

- Teaching **'about'** entrepreneurship takes the traditional format of lectures and seminars.
- Teaching **'for'** entrepreneurship focuses on skill development and acquisition in practicums and projects.
- Teaching **'through'** entrepreneurship explores experiences that involve application of knowledge and skills that may take place via clubs and organizations, internships, projects, etc.
- Increasingly, teaching **'in'** entrepreneurship highlights opportunities to embed entrepreneurial principles and concepts into other disciplines or subjects such as incorporating entrepreneurial scenario-based learning in an introductory solid mechanics course [7]. Teaching "in" entrepreneurship also highlights the learning that comes from peers in a facilitated community of practice.

Learning skills and mindsets 'for' entrepreneurship moves beyond research and traditional business and management-related content to encompass durable skills [8] as problem-solving, creativity, the ability to navigate ambiguity, and critical thinking. Experiential learning as a pedagogy in entrepreneurship education is also well-suited to prepare students to consider their own character and intentions [9, 10].

This focus on character opens the door to examine how personal values, qualities, and attitudes are connected to professional growth and entrepreneurial aspirations. This emphasis is especially critical for those who wish to successfully navigate the "Valley of Death" (VoD) which typically refers to a funding gap that contributes to failed businesses, especially startups and in technology-related industries. In a review of the VoD literature and Research and Development management literature, Gbadegeshin, et al. [11] identify several causes of VoD beyond simply lack of funding, namely, entrepreneurial and leadership skills, competences, insufficient human resources and infrastructure, and identifying and engaging stakeholders in the early pre-commercialization stages.

Capital Formation and Entrepreneurship Education

The model of capital formation describes the process of harnessing human potential, individually or collectively. This could be investing in and developing the knowledge, skills, and abilities of individuals to improve their economic value and productivity; or it could be doing the same things but with the goal of meeting new societal and environmental challenges. In the context of a new venture, "capital" encompasses not only financial but also human resources (i.e., talent, network), intellectual resources (i.e., patents, practices), process resources (i.e., hiring, scaling), and cultural resources (i.e. values, mission) (Figure 1) [12].

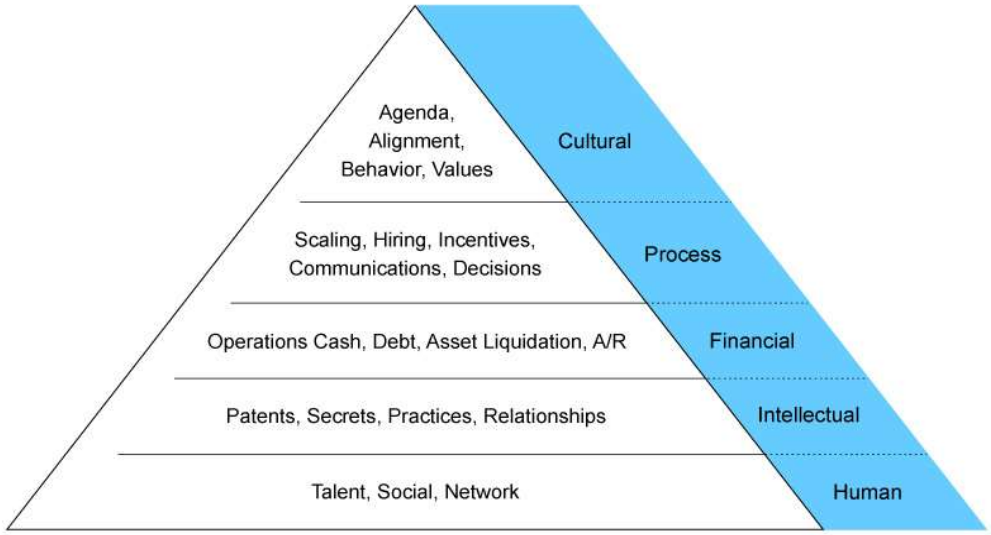

Figure 1. The Startup Capital Hierarchy of Needs: (At Least) Five Types of Capital for Success. (Figure reproduced from Wickham (2015) with permission)

ENGR 306: Capital Formation Design Theory in Practice

Over the last seven years, an elective engineering course taught at [13] Stanford University has introduced human capital formation in the context of entrepreneurship and venture design education to undergraduate and graduate engineering students. The course is taught by a venture capitalist and design researcher, both with mechanical engineering backgrounds. [13]

Approximately one-third of venture capitalists graduated with an undergraduate major in a STEM field [14]. However, what is not often explored outside of traditional business schools and programs is how venture capitalists can also serve as mentors and guides for young entrepreneurs and inventors. This role and function are important to address and understand since entrepreneurial pathways are often characterized by uncertainty. Learning how to navigate ambiguity while working on a team and interacting with the world outside of academia and engineering can become emotional events that lead to entrepreneurial competencies related to self-efficacy, an entrepreneurial identity, and greater self-insights [15]. This recognition of the emotional trajectory follows a corresponding though nascent effort to understand the importance of emotions in engineering education [16].

The emphasis on *human* capital has the potential to address the level of entrepreneurial or venture readiness for a prospective founder. In Figure 2, Aly et al. [9] map the emotional challenges that may accompany each stage of the venture journey. One of the learning goals of the Capital Formation Design Theory course is to demonstrate to students how an understanding of oneself can provide a strategic and defensive function while confronting and surviving the challenges of navigating often multiple or successive VoDs.

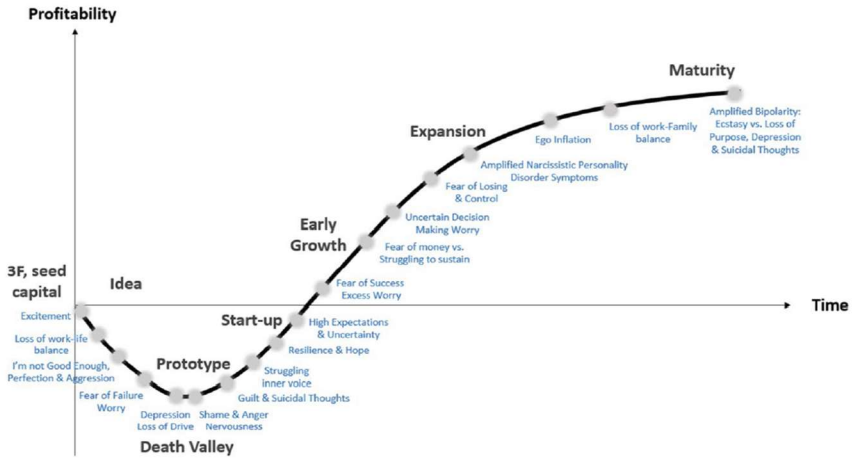

Figure 2. A clinical perspective of the J-Curve model of the Entrepreneurial Life Cycle by Love [17] adapted by Aly et al. [9]. Reprinted from Aly et al., 2021, *The Journal of Technology Transfer, 46(*5), p. 1615. [9] Licensed under a Creative Commons Attribution 4.0 International License).

To accomplish this learning goal, we describe the course according to the four modes of entrepreneurship education described earlier in this paper (*About*, *For*, *Through and In*) and summarized in Table 1.

The Capital Formation Design Theory in Practice course is uniquely embedded **'in'** engineering, drawing both undergraduate and graduate (masters, doctoral) students in engineering departments and majors from across the university (e.g., economics, history, management, earth systems, undeclared). Over the last three years, there has been increased interest from undergraduate students who have discovered the class through word of mouth and targeted outreach. Some students and faculty have wondered "why engineering?" and asked whether this course would be a more appropriate offering in the business, psychology, or education schools and programs. Similar questions were raised with the growing interest in curriculum related to ethics and entrepreneurship and innovation in engineering education. Our metaphor for capital formation is the power cycle and leveraging engineering principles to create a design that maximizes their energy on a path towards self-actualization.

Students learn **'about'** capital formation, venture design, and entrepreneurship in weekly lectures, guest speakers, readings, and case studies that address topics ranging from conscious leadership, venture capital "product" strategies, globalization of innovation, mapping local vs. global ecosystems, and impact entrepreneurship. Students are assessed through reflective assignments.

In the first two weeks of the course, students complete several self-assessments, such as the Enneagram (personal characteristics) [18], Working Genius (what you are good at) [19], and the SCARF Model (social motivation) [20] which serve as the foundation for subsequent discussions in the class about emotional competence and behavioral fitness. Students' understanding of these assessments is summarized in an Energy Matrix that addresses how they view themselves and their behaviors, under positive and negative conditions and identifying what gives and takes energy from them. In Figure 3, the Enneagram results are illustrated by identifying how your basic type transitions under stress (contractive energy/disintegration) and under healthy conditions (expansive energy/growth). Students are prompted to write down the main characteristics and behaviors associated with both types and what triggers healthy and unhealthy behaviors.

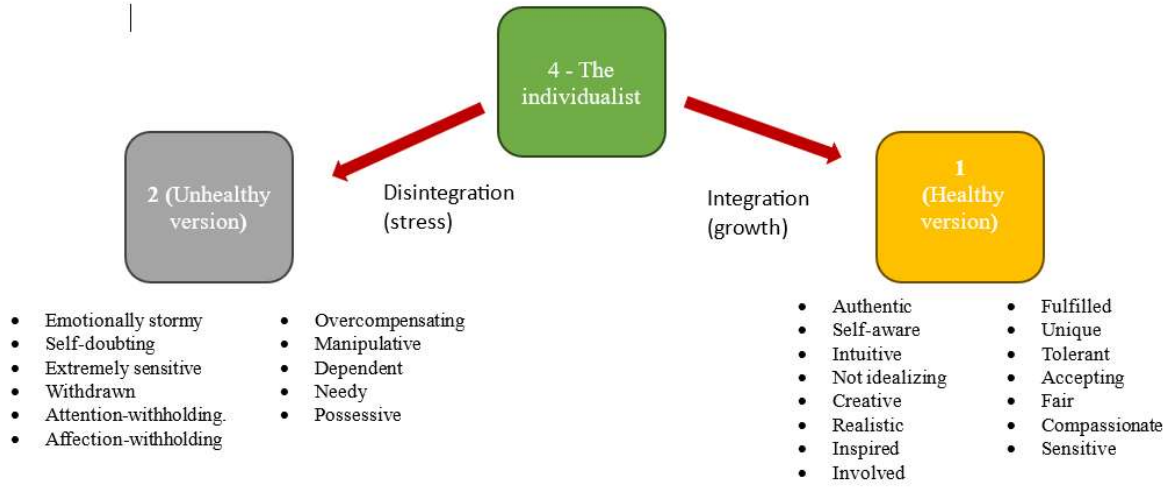

Figure 3. Example of How the Enneagram Results are Represented in the Energy Matrix.

Skill development **'for'** entrepreneurship and capital formation are practiced and developed in the course in multiple ways. For each guest speaker, students are asked to conduct "due diligence" on each speaker. In this situation, "due diligence" involves more than just doing a quick Google search and looking at the first page of results. For each speaker, students are prompted to approach this task as if they were helping a friend who is preparing to pitch to this person/organization and is asking what is known about them. What interesting facts can be discovered about this person via social media, press articles or interviews, talks on YouTube, etc.? Who are they connected to on LinkedIn and could they talk to someone who might know them (hint: the ENGR 306 instructors)? Students are prepared to be called on to introduce the speaker and pose thoughtful and sometimes challenging questions for the class discussion.

Another opportunity for practicing and honing relevant capital formation skills in relation to engineering challenges and environments (teaching "in" entrepreneurship) takes place during weekly Studio sections. Students share project narratives for feedback and coaching from peers and the teaching team. The method of feedback takes a specific format of successive quick rounds of targeted questions culminating in suggestions that are delivered through statements that begin with "If I were you…" highlighting the need for the recipient to recognize the bias and motivations of the source and to independently evaluate the usefulness of the recommendations for themselves.

We acknowledge that the opportunities to apply the insights gained **'through'** capital formation require additional exploration. The evolution of the project narrative is iteratively revisited throughout the course and informs the final presentation at the end of the term. Final reflection exercises include a journey mapping exercise that prompts the students to identify which

speakers, exercises, interactions and experiences were most meaningful and impactful to them in the course (see examples in [13]). While the ten-week quarter currently represents a design constraint, the teaching team is exploring other ways of providing experiences for students to engage directly in the capital formation learning process.

Table 1. Forms of entrepreneurship education in the Capital Formation Design Theory in Practice course (adapted from [21])

	About	**For**	**Through**	**In**
Objectives	- To understand the role of "capital" in nourishing organizations - To demonstrate how organizations can and should be designed	- To design and prototype for performance - To practice capital design formation skills	- To apply and effectively leverage insights about one's energy over time - To foster a capital formation approach to a current or future venture	- To recognize how the framework of human capital formation can contribute to and strengthen the design, challenges, and solutions addressed in engineering ventures and by entrepreneurial engineers
Main focus	Knowledge	Skills	Attitudes	Application of Knowledge, Skills, and Abilities in the engineering domain
Learning	Passive	Active/Reflective	Active/Reflective	Active/Reflective
Teaching Tools, Activities	Lectures; invited speakers; weekly readings and case studies;	Peer Coaching; Case studies; Q&A and advice giving	Iterative refinement of the design of Entrepreneurial Vision, Calling or Cause and Coaching Philosophy	Self-assessments (Enneagram, Working Genius, Purpose, Upper Limit)
Assessment	Reflective assignments on readings; Energy Matrix	Venture project narrative, peer coaching, engagement with teaching team for feedback	Journey mapping at the end of the course; Final presentations;	Additional development needed to assess post-course impact over time and in the engineering context especially on identity and belonging
Learning impact	Knowledge exploration via exposure to guest speakers' journeys and experiences	Knowledge application, personally and with peers	Knowledge transformation, generalizing insights into other situations and contexts	Integration of Knowledge, Skills, and Abilities into the engineering entrepreneurial mindset
Applications	Individual/Team	Individual/Team/ Venture project	Individual	Individual/Team/ Venture project

	About	For	Through	In
Settings	Formal course setting	Formal and informal settings	Formal and informal settings	*Additional development needed*

Implications and Future Work

In this work-in-progress paper, we have focused on advancing our efforts in developing a curriculum on capital formation design theory by contextualizing this work in relation to entrepreneurship education and experiential learning. The focus on individual development via self-reflection and understanding reiterates the recommendations of [15] who noted the role of emotions and non-cognitive competencies as an important avenue for future investigation in entrepreneurship education. A parallel call by [1] for the expansion of authentic assessment practices opens up the door for interdisciplinary collaboration, especially with colleagues in design and education. The findings and insights from this preliminary work have served two purposes: first, to expand and strengthen the theoretical and pedagogical foundation for capital formation and venture design; and second, directly inform iterative improvements to the curriculum and prototypes of new activities, assessments, and exercises in the ENGR 306 course.

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