From faculty values to student outcomes: ”modeling entrepreneurial ways of thinking in engineering education”

Mr. Emmanuel Tetteh Teye, Montana State University

Emmanuel Teye is a doctoral student in adult and higher education program at Montana State University. He is interested in exploring the connection between entrepreneurship and engineering, STEM Education research, Students motivation, Belonging, Identity and Career choices in Higher education

Prof. Carrie B Myers

Dr. Carrie B. Myers is a professor in Adult and Higher Education graduate program at Montana State University in Bozeman, Montana. Her research areas include (1) socialization experiences of undergraduate and graduate students in STEM, with a special inte

Dr. Bryce E. Hughes, Montana State University - Bozeman

Bryce E. Hughes is an Associate Professor in Adult and Higher Education at Montana State University. His research interests encompass diversity and equity in engineering education, with a focus on LGBTQ students. He was recently awarded an NSF CAREER grant to study the experiences of LGBTQ undergraduates in STEM fields. He holds a Ph.D. in education from the University of California, Los Angeles, an M.A. in student development administration from Seattle University, and a B.S. in general engineering from Gonzaga University.

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Abstract

With the intensifying demand for cultivating entrepreneurial mindsets (EM) across engineering and the broader STEM disciplines, national policy initiatives and practice-based efforts such as the CHIPS and Science Act of 2022, the NSF Innovation Corps program, and the proactive programming of The Kern Entrepreneurial Engineering Network (KEEN) have sought to emphasize the entrepreneurial potential of technically trained students. KEEN’s taxonomy of curiosity, connections, and creating value has become an influential organizing framework as well as their support for curricular resources, faculty development, and funding to advance EM integration. But we should be curious about how faculty belief systems, identities and experiences about entrepreneurism shape pedagogy. This study examined engineering faculty perceptions of what it means to “be entrepreneurial,” the EM attributes they most value, and the pedagogical strategies they employ to cultivate EM among students. Drawing on effectuation theory and KEEN’s five EM habits, we employed a mixed-methods design utilizing closed- and open-ended survey items and reflective responses from a faculty learning workshop at a U.S. land-grant university. Deductive thematic analysis, guided by the five principles of effectuation (bird-in-hand, affordable loss, lemonade, crazy quilt, pilot-in-the-plane), alongside inductive coding, revealed both overlapping and divergent interpretations of entrepreneurship, entrepreneurial mindset, and engineering mindset; accentuating the need for clearer conceptual perspective and integration of these terms in engineering education. Additionally, Faculty participants prioritized EM traits such as persistence, inquisitiveness, initiative, resilience, curiosity, continuous learning, adaptability, accountability, and resourcefulness. This shows that

faculty placed particular emphasis on “action orientation agency,” suggesting that entrepreneurial mindsets are nurtured through experiential and iterative learning processes. Teaching strategies such as open-ended design projects, think pair share, reflective writing, peer review, concept map, presentations and team-based learning were adopted by faculty and are shown to align with experiential, student-centered, and constructivist pedagogical goals in engineering. Our findings make two primary contributions. First, they highlight how faculty perceptions, values, and identities function as both enablers and filters of EM cultivation, shaping how entrepreneurism is positioned within engineering education. Second, they suggest that EM outcomes observed in students often mirror the orientations and practices of faculty themselves, rendering faculty development a critical site for EM cultivation. The study then advocates for educators and policy makers to gravitate the teaching of entrepreneurship in more intentional and reflective ways recognizing faculty as both interpreters and co-constructors of entrepreneurial learning environments within the engineering discipline

Background

Beyond technical proficiency, 21st century engineering educators expect graduating students to think creatively, work collaboratively, generate socio-economic value, adopt knowledge sharing and ambidextrous behavior. This expectation has resulted in the cultivation of an innovation and entrepreneurial mindset (EM); the motives, attitudes, and behaviors associated with entrepreneurial actions.[1], [2], [3], [4], [5]. A big driving force behind efforts to promote and nurture EM within engineering education in the United States is the Kern Entrepreneurial Engineering Network (KEEN), a group of over 70 institutions united in this mission. Recent initiatives such as the United States National Science Foundation Innovation Corps program, CHIPS and Science Act of 2022 and the European Union via its Skills Agenda have also highlighted the need for workforce development by promoting EM and hands-on training within STEM and innovation-oriented educational programs. Within engineering entrepreneurship education, EM is increasingly viewed as a set of transferable skills relevant to all students, regardless of whether they intend to pursue startup ventures[6], [7], [8]. It has also been viewed as foundational to leadership, innovation, and sustainable development in both public and private institutions[9], [10], [11]. As a result, employers and institutions are prioritizing EM in their hiring practices and leadership development initiatives to prepare individuals for future-ready roles [12]. Typically, business schools have had a strong tradition for teaching entrepreneurial skills to their students and although EM has grown in engineering, the research has not kept pace. Successful EM integration in engineering can be as much about faculty identity, professional development, and pedagogical belief systems as it is about curricular content. This means EM cannot be tacked on to engineering curricula but must be internalized by educators to shape transformative learning experiences. Therefore, without our understanding of faculty perspectives, we risk lacking key insights into how EM are prioritized and nurtured within engineering curricula. Faculty teaching practices are informed by their philosophy to their discipline, which often includes their experiences, expertise, values, and beliefs. Thus, we can assume that faculty who value entrepreneurial skills and mindsets would be more likely to teach with these skills in mind. Yet, the extent to which engineering faculty conceptualize and value EM is not well understood. Some empirical studies suggest that engineering faculty generally recognizes the value of entrepreneurship education for students' professional preparation and success [13] [14] and that faculty also believe entrepreneurship courses should emphasize both skills and attitudes, with many expressing confidences in their ability to teach both [15]. However, faculty perceptions of entrepreneurship education vary, potentially shaping their teaching practices [16]. For example, these authors reported that both capstone design and engineering entrepreneurship instructors use similar teaching techniques such as student-led presentations, mentoring and coaching students, use of personal experiences, and guest speakers. But when these two groups of instructors were asked whether EM can be innate or taught, engineering instructors were more likely to believe that the necessary habits or characteristics to be entrepreneurial are mostly taught while capstone design instructors were more likely to feel these habits were innate.

Given the attention that EM has received in engineering education and the mixed results of previous efforts to refine engineering education, we should also be curious whether it is necessary for faculty to possess an EM to effectively teach it. To date, there is little to no evidence illuminates our understanding of the mechanisms and contexts through which faculty express an EM themselves and how this translates into their classroom practices. To this end, this study explored the EM that engineering faculty value most, the teaching activities they use to develop these mindsets in their students and how they conceptualize one as being entrepreneurial in the discipline. The following research questions guided the study:

RQ1: What does faculty perceive to be entrepreneurial in general?

RQ2: What EM's do engineering faculty most value?

RQ3: What teaching activities do engineering faculty use to develop EM in their students?

Entrepreneurial Mindset in Engineering Education

EM has become an essential component of engineering education, with studies showing its positive impact on students' attitudes, intentions, and skills [17], [18] . EM is a set of attitudes, dispositions, habits, and behaviors that shape a unique approach to problem-solving, innovation, and value creation. *"But why engineering skills and EM together?"*. When an engineer possesses an EM, it amplifies the technical skills they already have. Thus, by combining EM with technical skills, engineering professionals and the workforce are equipped to recognize and identify opportunities, focus their impact, and create value in any context which in in turn can help cultivate the ability to solve societal problems and create an environment for human flourishing. Engineers with an EM go beyond technical problem-solving to consider market viability, user needs, and societal impact.[19]. In sum, developing EM is not only important for engineers and other STEM people but helps individuals including students see how to make connections between their technical knowledge and real-world problems, exercise creativity in how they approach solving problems with knowledge and skills, and comprehend how their solutions create value for others, whether that be a company they work for, a community they are serving, or their own personal endeavor.

Research suggests that integrating entrepreneurial thinking into engineering education enhances creativity, adaptability, and leadership, preparing the workforce for diverse career paths [20]. Some effective strategies for embedding EM include adopting a 21st-century engineer orientation, using a structured EM framework, and providing faculty support [17], [21]. Multidisciplinary programs and experiential learning have also been particularly effective in enhancing students' entrepreneurial abilities [20]. Integrating EM into capstone design courses has also shown promise, though challenges related to tradition, faculty experience, and institutional support persist.

KEEN advocacy for EM implementation in engineering programs

KEEN has played a central and sustained role in advancing the implementation of EM across engineering education through coordinated, multi-institutional strategies. KEEN's implementation strategy operates across multiple levels, including curriculum redesign, faculty professional development, course-embedded EM modules, and cross-disciplinary integration. Studies have documented how EM principles are embedded into engineering curricula through scaffolded course redesigns and program-level initiatives [22], as well as how faculty learning communities and workshops support instructors in adopting EM-aligned pedagogies [23]. Course-specific modules further operationalize EM through project-based learning, reflective activities, and open-ended design challenges [24]. A growing body of empirical research also demonstrates the scholarly uptake and pedagogical impact of the KEEN 3Cs framework. For example, London et al. [18] articulated a detailed mapping of twelve entrepreneurial attitudes and seventeen observable behaviors aligned with the 3Cs, providing a foundation for instructional design and assessment. Gorlewicz et al. [25] illustrated how the framework informs curriculum development across engineering courses, while [26] traced how students' understanding of EM concepts evolves and persists. Additional studies have examined entrepreneurial predispositions, identity development, and learning outcomes associated with 3C-based instruction [2], [27], [28]. These bodies of evidence position KEEN not merely as an advocacy network, but as a theoretically grounded and empirically supported movement shaping how EM is conceptualized, taught, and studied within engineering education.

Theoretical Framework

The theoretical framework guiding this study merges the KEEN EM habits (an extension of the 3Cs) with the effectuation theory of entrepreneurship to explore faculty perception on entrepreneurial activities and how they nurture them in their students. The 25 EM habits are specified under five main mindsets. This includes: *Curiosity* – seeking information about our changing world and exploring contrarian views of accepted solutions. *Connection* – integrating varied sources and perspectives to gain insight, *Creating Value* – placing engineering work in the context of societal needs and working through failure to see those needs met, *Action agency*- habits that drive initiative, persistence and proactive problem solving and *EM- enhancing*- habits that are enriched through ethical thinking, self-awareness and continuous improvement.

Though EM has been measured in various ways, this study adopts KEEN's conceptualization because in their review of STEM entrepreneurship literature, Zappe et.al [2] highlighted KEEN as a central driver in the field. They noted that over 50% of the studies reviewed were either funded by KEEN or structured around its 3Cs framework. This widespread adoption across institutions reinforces KEEN's credibility and demonstrates the effectiveness of its framework in shaping and defining EM within engineering education [29]. The five EM habits suit this study as it provides faculty with a proven list of habits of mind that helps them relate with aspects of EM they might prioritize and value most. Effectuation theory [30] is a decision-making framework used by expert entrepreneurs that contrasts with traditional causal reasoning. Instead of setting a goal and then acquiring the necessary resources, effectuation emphasizes leveraging existing means to create new opportunities. Effectuation is based on five principles: *Bird-in-Hand Principle* – Start with what you have (skills, resources, networks), *Affordable Loss Principle* – Focus on minimizing risk rather than maximizing returns, *Lemonade Principle* – Embrace and leverage unexpected opportunities, *Crazy Quilt Principle* – Build partnerships to co-create new ventures, *Pilot-in-the-Plane Principle* – Focus on actions that shape the future rather than predicting it. These principles provide a useful lens for examining how faculty translate EM into their classroom pedagogy. It helps contextualize pedagogical strategies that faculty may employ. For example, Faculty may encourage students to use available resources (Bird-in-Hand), navigate uncertainty (Lemonade), and collaborate across disciplines (Crazy Quilt), reinforcing their EM through classroom experiences. Together, the 5

EM habits help to highlight the mindsets faculty value most, while effectuation principles help explain faculty perceptions on entrepreneurship and teaching activities that might facilitate these EM in practice.

Methods and Data Source

We employ the qualitative approach with a post-positivist lens within descriptive phenomenology. This perspective is relevant as the analysis incorporates descriptive statistics to examine faculty perceptions of EM. The study took place within the faculty learning meetings of the engineering department at a U.S Land-grant University. These are one-hour lunch meetings where faculty members gather to discuss, network, and explore strategies for enhancing teaching, learning outcomes, and professional development. Seven faculty members from various engineering disciplines, with different faculty statuses, who regularly attend these meetings responded to the instrument (Table 1a) and three of them took part in a follow-up informal discussion with the research team to provide additional qualitative insights. A key topic of discussion at these meetings has been equipping faculty with the tools to foster an EM in students, particularly focusing on the KEEN framework.

Table 1a descriptions of participants discipline and status

Engineering discipline	**No.**	**Faculty status**	**No.**
Product design	1	Instructor	4
Civil and environmental	1	Assistant professor	0
Electrical Engineering	2	Associate professor	0
Manufacturing	1	Professor	3
Chemical engineering	1		
Multi-d engineering design	1		

Data collection, Variables and Instrument design

We developed a theme-specific mindset assessment instrument [31] to evaluate how faculty members value and integrate EM within engineering education. Faculty were asked to rank entrepreneurial habits based on their perceived importance and describe how they cultivate these habits through their teaching methods. This shed indirect insight into assessing whether teaching activities and perceptions on EM might give a cue to effectively developing entrepreneurial competencies and outcomes in students. Though the instrument was an indirect tool for measuring students' outcomes it did also reveal if faculty themselves possess an EM in some sense in addition to the insights they shared in the follow-up informal discussion. Data was collected prior and during the final faculty learning meeting of the Spring 2025 semester. The first author delivered a presentation on the study topic at the meeting, and prior to that, the survey instruments were distributed to all faculty members. Feedback and notes taken from the meeting and responses received from the survey were prepared, transcribed and coded for analysis. The data collection instrument is presented in Table 4. It specifically asks faculty; to what extent selected EM habits are important to them as they deem relevant for engineering students in general. Responses range from: (5 absolutely essential to 1 not important at all.). It included twenty-five specific habits that measure EM. The one-sentence-summary was used to ask open-ended questions about faculty perceptions and teaching activities on EM. In the follow-up discussion, faculty were asked whether they should embody EM traits to effectively teach it and why? and what barriers or supports influence their ability to teach EM? Demographic data were also collected.

Data analysis

Data analyses were conducted in two phases: descriptive analysis and thematic analysis. First, descriptive statistics were used to analyze responses from the survey. This helped to rank entrepreneurial habits based on perceived importance and frequency of integration into courses. Measures such as mean, standard deviation, and distribution patterns were used to identify broad trends in faculty valuation of EM. Second, thematic analysis were used to analyze the qualitative responses and identify emerging patterns in how faculty conceptualize entrepreneurship, teach EM, their perception on embodying EM and the challenges or supports for the ability to teach EM. This process involved coding faculty responses using a combination of both deductive and inductive approaches and interpreted themes that emerge naturally from the data. The analysis was guided by the five principles of effectuation theory. This ensured alignment with established models of entrepreneurial education. To enhance rigor, triangulation was done by comparing survey results with discussions from the faculty learning meeting.

Results

The purpose of this work explored the entrepreneurial mindsets that engineering faculty value most and the teaching techniques they use to develop these mindsets in their students. These results are based on both closed- and open-ended survey data, as well as notes taken from faculty reflections during a faculty learning meeting. From the total of seven engineering faculty members responses received, majority of the respondents held instructor-level positions, and the teaching disciplines varied across departments. (see Table 1a).

Research question 2 What entrepreneurial mindsets do engineering faculty most value?

In examining the entrepreneurial mindset (EM) constructs (Table 1b), mean scores were used to identify which mindsets and habits faculty members valued most. Overall, all EM habits were rated above average. *Resilience and persistence* received the highest rating (M = 4.8), followed by *continuous learning* and *inquisitiveness (M=4.71)*, and then *accountability* and *adaptability* (each with M = 4.5). Among the five main EM constructs; *curiosity*, *creating value*, *connection*, *action agency*, and *foundational traits that enhance EM*; *action agency* was rated the highest (M = 4.48), followed by *curiosity* (M = 4.0). The remaining constructs also had mean scores above average. These results suggest that faculty place significant importance on specific EM habits such as *resilience*, *persistence*, *continuous learning*, *inquisitiveness*, *accountability*, and *adaptability*. The high score for the *action agency* construct indicates that the habits associated with it—*initiative*, *resilience*, *continuous learning*, *adaptability*, and *resourcefulness* align closely with the entrepreneurial mindsets faculty consider most essential.

Table 1b Descriptive Statistics of faculty ranking on EM habits

Mindsets/habits	Min	Max	M	SD	
inquisitiveness	4	5	4.71	0.48	
contrarian thinking	3	5	3.42	0.78	
opportunity seeking	3	4	3.71	0.48	
experimentation	2	5	4.14	1.06	
embracing ambiguity	3	5	4.14	0.69	
creativity	3	5	4.28	0.75	
systems thinking	2	5	3.28	0.75	
implications thinking	4	5	4.14	0.37	
strategic thinking	2	5	3.57	1.13	
assess and manage risk	3	5	3.85	0.89	
value awareness	3	4	3.85	0.37	
customer centered	3	5	4	0.81	
scale	2	5	3.14	0.89	
persistence	4	5	4.85	0.37	
socially minded	3	5	3.85	0.69	
initiative	4	5	4.14	0.37	
resilience	4	5	4.85	0.37	
continuous improvement/ learning	4	5	4.71	0.48	
adaptability	4	5	4.57	0.53	
resourcefulness	4	5	4.14	0.37	
character	3	5	4.28	0.75	
growth mindset	3	5	4.28	0.95	
intellectual humility	2	5	3.57	1.13	
accountability	4	5	4.57	0.53	
metacognition	2	4	3.14	0.89	
N= 7					
Categories of habits of EM	**Min**	**Max**	**M**	**SD**	**Ranking**
Action agency	4.2	4.6	**4.48**	0.15	Highest
curiosity	3.2	4.4	4.02	0.42	
Enhancing	3.4	4.4	3.97	0.33	
Creating value	3.8	4.2	3.94	0.15	
Connections	3.2	4.6	**3.82**	0.42	lowest
N= 7					

Research questions 1 and 3: What does faculty perceive to be entrepreneurial? What teaching techniques do engineering faculty use to develop entrepreneurial mindsets in their students?

Reflections and feedback from the faculty learning meeting raised important questions and issues that warrant further investigation. Faculty views varied regarding the term's *entrepreneurship*, *entrepreneurial mindset*, and *engineering mindset*; particularly in how these concepts intersect, overlap, or remain distinct. One faculty member suggested more direct methods for assessing how students learn or demonstrate EM through faculty instruction. Some of the methods include classroom observations, reviewing student feedback, analyzing assignments, exams, and projects to identify which mindsets are being embedded or reinforced.

To better understand how faculty generally perceive someone to be entrepreneurial, and the activities they use to develop entrepreneurial mindsets and habits in their classrooms, a combination of deductive and inductive thematic analyses was conducted. The open-ended responses were first examined using the five principles of effectuation theory as a deductive lens. Then, emerging themes were identified through inductive interpretation. Table 2 presents the five effectuation principles, summaries of the teaching activities described by faculty, and insights into how each principle aligns with related activities.

Table 2: EM teaching through effectuation

Effectuation principle	**EM teaching activities**	**Insights**
Bird-in-Hand Principle (Start with what you have)	Open-ended design projects, concept maps	Faculty structure assignments that allow students to start with their existing knowledge, promoting student ownership over the learning journey rather than passively receiving information.
Affordable Loss Principle (Minimize risk)	Draft submissions, resubmissions, peer reviews	Iterative assignments encourage students to take small risks, learn from mistakes, and build confidence through manageable failures. It mirrors real-world entrepreneurial experimentation.

Lemonade Principle (Embrace surprises)	Reflection activities on frustration and improvement	Faculty cultivate a mindset where students are expected to adapt and reframe obstacles, reinforcing resilience and opportunity-seeking behavior in uncertain environments.
Crazy Quilt Principle (Build partnerships)	Team-based peer reviews, group projects	Faculty create ecosystems of collaboration where students depend on diverse peer feedback, mirroring entrepreneurial ecosystems built on partnerships and collective problem-solving.
Pilot-in-the-Plane Principle (Shape the future through action)	Creativity-forcing assignments, student-driven projects	Faculty teaching prioritizes active learning where students are the drivers of their own innovation and learning trajectories, reinforcing a proactive rather than predictive approach.

Table 3 below also matches faculty perception and definition of being entrepreneurial with EM teaching activities and then provides some students outcomes.

Table 3: Faculty definition of EM along effectuation and students' outcomes

Faculty perception of being Entrepreneurial	**EM teaching activities**	**Effectuation outcomes on students**
Solution seeking and resilience	Open-ended design projects; Think-Pair-Share exercises	Bird-in-Hand: Students start by using their existing skills and ideas in open-ended projects. Pilot-in-the-Plane: Students drive the project outcomes themselves through problem-solving and persistence, rather than following a strict blueprint. Example: Students are challenged to define project problems themselves, using what they know.
Self-motivation to move organizations forward	Concept maps, Video reflections; Presentations	Crazy Quilt: Students are encouraged to connect diverse societal perspectives into their solutions. Example: Students present how engineering decisions impact society, requiring integration of technical and ethical thinking.

Motivation, persistence, working through setbacks and adapting and motivated engineering mindset	Research assignments; Drafts and resubmissions for continuous improvement	Affordable Loss: Students are given low-stakes opportunities to experiment creatively without fear of high penalties. Lemonade: Mistakes and setbacks are framed as valuable learning opportunities. Example: In creative assignments, students may fail initial attempts but are taught to adapt and persist.
Creativity, inquisitiveness, multi-perspective thinking and collaboration	Team projects focused on systems thinking, strategic collaboration	Crazy Quilt: Students co-create knowledge and solutions by collaborating across diverse backgrounds. Bird-in-Hand: Students bring their unique skills and viewpoints into the team.
Continuous learning to improve and create value	Tracking activities; Reflection on frustrations; Peer review and redesign	Lemonade: Students learn to view failures and frustrations as opportunities for improvement. Crazy Quilt: Peer review processes mimic real-world partnerships where feedback and joint problem-solving are critical. Students are also embedded in iterative feedback loops where collective critique strengthens innovation

Significance of the study

This study explored the entrepreneurial mindsets engineering faculty's most value and some teaching strategies they use to develop such mindsets in their classroom. Along these lines faculty also expressed their perceptions of how they see someone as being entrepreneurial. Using both deductive analyses grounded in effectuation, inductive thematic elaborations, and the KEEN EM habits, the findings offer valuable insights into how faculty indirectly nurture EM in engineering education. A key finding from the study is that faculty definition of someone being entrepreneurial was not in terms of business creation, but as an engineering mindset centered mostly action agency. The most important habits associated with their perception on EM are persistence, adaptability, creativity, continuous learning, accountability, initiative, resilience and inquisitiveness. These habits align closely with the principles of effectuation, particularly *Affordable Loss*, *Pilot-in-the-Plane*, and *Lemonade*, which emphasize acting with available resources, embracing uncertainty, and viewing failure as an opportunity for growth. Some important teaching activities described by faculty include open-ended design projects, team-based collaboration, iterative assignments, peer review and redesign align well engineering practice. These activities promote student agency, resilience, and value creation, confirming that entrepreneurial mindsets can be cultivated through intentional, experiential learning and decision making. Moreover, faculty feedback from the learning meeting revealed terms that warrants further understanding. There remains ambiguity around the distinctions and overlaps between the term's entrepreneurship, entrepreneurial mindset, and engineering mindset. This opens a need for shared language and frameworks in faculty development for a better understanding of these terms. Some faculty members recommend more robust and direct methods to assess how EM is taught and demonstrated suggesting opportunities for further research into instructional observation, curriculum mapping, and student learning evidence (exam, assignment and project materials) to identify how EM is embedded. Some limitations of the study are that the reliance on self-reported data may introduce social desirability or recall bias [32]. Faculty reflections may not fully capture actual classroom practices or how students experience them. Also, though both qualitative and quantitative elements are used it does not triangulate with direct classroom observations or student performance data, which could add valuable depth and reliability. Future study might examine potential differences in EM interpretation based on discipline, teaching experience, or rank, which may influence faculty approaches and priorities as this study did not examine.

Implications for practice

Engineering educators and practitioners could use the following takeaways when modeling EM to inform how they design their classes and experiences with students. First, because students' entrepreneurial orientations often reflect the values, perspectives and practices of their instructors, faculty should intentionally model entrepreneurial ways of thinking such as curiosity, experimentation, persistence, inquisitiveness, initiative, resilience, continuous learning, adaptability, accountability, and resourcefulness through their teaching and professional examples. Second, educators can reflect on the 25 EM habits to select which of the habits they value for specific subjects or topics and then use them to guide course design by structuring learning experiences that encourage and intentionally reflect their EM specific values. Finally, educators can incorporate thinking through effectuation as an iterative process when designing EM focused lessons. Ultimately, cultivating EM begins with the orientations and practices of faculty themselves. Educators should then create the space for shifts in their pedagogies by seeing themselves as whole mediators in students EM learning and as such intentionally model learning opportunities into their courses and classroom environments where students can develop the curiosity, agency, and resilience necessary to innovate and address complex societal challenges.

Conclusion

This study contributes to ongoing efforts to understand how entrepreneurial mindsets are fostered within engineering education. The alignment between faculty-valued EM traits (e.g., resilience, initiative, continuous learning) and the principles of effectuation [30] suggests that

EM can be embedded in engineering curricula through open-ended problem solving, iterative design, and reflective practice[33]. Integrating EM systematically into project-based and experiential learning can better prepare students for innovation-driven careers[20] . Despite varied definitions of entrepreneurship among faculty, their pedagogical practices, such as iterative projects, team-based learning, structured reflection and peer learning, implicitly support entrepreneurial identity development in students. This aligns with research showing that mindset development can occur through both intentional curriculum design and informal learning contexts. [34]. Given faculty uncertainty around distinctions between entrepreneurship, EM, and engineering mindset, there is a clear opportunity for faculty development initiatives that clarify these frameworks.

Appendix

Table 4: Survey questions

To what extent are these entrepreneurial habits important to you as you deem relevant for engineering students to develop?					
Mindset	Absolutely essential	Very important	Of average importance	Of little importance	Not important at all
	5	4	3	2	1
inquisitiveness					
controrrion thinking					
opportunity seeking					
experimentation					
embracing ambiguity					
creativity					
systemes thinking					
implications thinking					
strategic thinking					
assess and manage risk					
value awareness					
customer centered					
scale					
persistence					
socially minded					
initiative					
resilience					
coninous learning					
adaptability					
resourcefulness					
character					
growth mindset					
intellectual humility					
accountability					
metacognition					

Qualitative/ open-ended questions

Question1: could you please list one to three activities you do in class related to the habits above? that is what are the activities that you do in class to help students develop these habits., please bear in mind the most important habits you prioritized in the list above.

Question2: Please provide a one sentence summary of how you perceive someone to be entrepreneurial in the general sense

Question3: please what is your teaching discipline or your engineering specialty

Reflecting through the 25 habits of EM

- **Curiosity- habits that fuel exploration, challenge assumptions and reveal opportunities**
    - Inquisitiveness- leans into work with curiosity about our changing world
    - contrarian thinking- explores alternatives perspectives views of current or accepted solutions
    - opportunity seeking – actively identifies new themes, trends and unmet needs to uncover new opportunities or solutions
    - experimentation- constantly experiment, try out and iterate to refine methods and solutions
    - embracing ambiguity- develops comfort with uncertainty, to make decisions when information is limited
- **Connections- habits that build relationships, integrate different perspectives, ideas and systems to drive innovation and impact**
    - creativity – build new things from existing or multiple sources, integrates from disparate sources to spark new ideas
    - systems thinking- recognizes interdependence in systems and identifies leverage points
    - implications thinking- anticipates the long-term impacts and consequences of actions
    - strategic thinking- develop long term strategies with clear milestones
    - assess and manage risk – proactively incorporate risk management into decision making
- **Creating value- habits that focuses on delivering meaningful outcomes that benefit others at a scale**
    - value awareness- focuses on solutions where extraordinary value can be created
    - customer centric thinking- Framing efforts in terms of the users or customers' actual needs

    - scaling- leverages systems and networks to expand reach and maximize outcomes
    - persistence- maintains sustained efforts to achieve goals despite obstacles or delays
    - socially mindful- prioritizes creating meaningful and positive societal impacts, prioritizes positive change in others
- **Action agency- habits that drive initiative, persistence and proactive problem solving**
    - initiative- drives progress by initiating solutions and creating forward looking momentum
    - resilience- bounces back from setbacks and recovers from failures
    - continuous improvement- continuously refines methods to enhance outcomes
    - adaptable- adopts strategies and pivots to respond effectively to changing conditions
    - resourcefulness- solving problems creatively with available or limited resources
- **Enhancements- habits that enrich work through ethical thinking, continuous learning and self-awareness**
    - character- considers ethical implications of decisions
    - growth mindset- embraces learning and feedback for development
    - intellectual humility- acknowledges limitations and seeks diverse perspectives and avoids overattachment to one's own ideas
    - accountability- takes responsibility for actions, decisions and their consequences
    - metacognition- reflects on thoughts processes to improve self-awareness.

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