2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
Paper ID #51879

From Design Intentions to Student Sensemaking: Entrepreneurial Mindset in an Experiential STEM Learning Environment

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ASEE Conference ID: 51879

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Introduction

Higher education faces growing pressure to prepare students, particularly in Science, Technology, Engineering, and Mathematics (STEM) fields, for professional and societal contexts characterized by rapid technological change, uncertainty, and complex, interdisciplinary challenges (Organization for Economic Co-operation and Development, 2018). Engineers and scientists are increasingly expected not only to apply technical knowledge, but also to identify opportunities, navigate ambiguity, collaborate across disciplinary and organizational boundaries, and generate value in diverse contexts (National Research Council, 2012; Burt et al., 2022). Research has shown that facilitating engagement between engineering education and industry is key to improving the skills and work-readiness of engineering graduates (Valentine et al., 2022). Yet traditional academic curricula have often prioritized disciplinary mastery over the development of these adaptive and integrative capacities, contributing to a persistent gap between formal educational preparation and the demands graduates encounter beyond the university (Bok, 2006; Froyd et al., 2012). Moreover, despite growing recognition of the importance of industry engagement, there is currently limited understanding of how universities and engineering industry partners effectively initiate and establish engagement activities that incorporate direct contact with students (Al-Tabbaa & Ankrah, 2016; Valentine et al., 2022).

In response to this gap, the Experiential STEM Internship Program (ESIP) was developed as a cohort-based, industry-connected experiential learning initiative designed to bridge the divide between formal STEM education and the adaptive, integrative demands of professional practice. By structuring direct, sustained engagement between students, faculty, and industry partners, ESIP sought to cultivate not only technical competency but also the entrepreneurial ways of thinking increasingly required of engineering and science graduates in complex, real-world contexts, including the development of innovation capacities that enable students to generate and apply contextually meaningful solutions (Carroll et al., 2019; McChesney et al., 2025).

Central to this approach is the cultivation of an entrepreneurial mindset, which has gained increasing prominence in STEM education as a means of fostering adaptive, opportunity-driven thinking in uncertain and dynamic environments. Entrepreneurship education, in this regard, has been reframed not as narrowly focused on venture creation, but as a pedagogical approach that develops transferable ways of thinking across professional and societal contexts (Mawson et al., 2022). Within this perspective, the entrepreneurial mindset is understood as a cognitive and behavioral orientation toward recognizing opportunities, acting under uncertainty, and generating value.

Empirical research suggests that entrepreneurship education is associated with improvements in students' entrepreneurial skills, mindset, and career aspirations (Colombelli et

al., 2022). At the same time, scholars have noted that the concept of entrepreneurial mindset remains conceptually ambiguous, often conflated with general competencies such as creativity, problem solving, or initiative (Naumann, 2017). To address this limitation, recent work has introduced the concept of innovation capacities as a more precise and measurable construct that captures the intrapersonal, social, and cognitive competencies through which entrepreneurial thinking is enacted (Selznick & Mayhew, 2018).

While this body of research advances the conceptualization and measurement of entrepreneurial mindset, it has largely focused on defining its attributes or examining the contexts in which it develops. For example, prior studies have linked entrepreneurship education to outcomes such as innovative entrepreneurial intentions (Mayhew et al., 2012) and demonstrated that pedagogical interventions can enhance opportunity recognition and entrepreneurial orientation (Lindberg et al., 2017). However, comparatively little attention has been paid to the processes through which entrepreneurial mindset is formed within educational environments. In particular, existing research provides limited insight into how instructors intentionally design learning environments to foster entrepreneurial thinking, as well as how students interpret, negotiate, and enact these experiences in practice.

Beyond its contributions to student development, this study holds significant implications for industry stakeholders seeking more effective approaches to identifying and cultivating early-career STEM talent. Engineers and scientists are increasingly expected to identify opportunities, navigate ambiguity, and generate value across diverse and uncertain professional contexts, yet traditional hiring mechanisms, including transcripts, resumes, and brief interviews, provide limited insight into how candidates actually perform under these conditions (National Research Council, 2012; Burt et al., 2022). Experiential internship programs offer a structurally different proposition. When industry partners engage with student cohorts over time, they are able to observe how individuals navigate ill-defined challenges, integrate feedback constructively, and sustain productive effort when outcomes are uncertain, behaviors that map directly onto the competencies associated with reduced hiring risk and faster time-to-productivity in technical and innovation-driven organizations (Chen et al., 2017; Ramsgaard & Østergaard, 2018). Importantly, this model of industry engagement need not be high-burden. Rather than assuming supervisory responsibilities, mentors can contribute contextual feedback and professional perspective, creating conditions for meaningful assessment without proportional cost (Carroll et al., 2019). Understanding how the entrepreneurial mindset develops within such environments, therefore, matters not only for educational theory and pedagogy, but for the practitioners and organizations who will ultimately recruit, develop, and rely on the graduates these programs produce (Bok, 2006; Froyd et al., 2012).

This gap is especially salient in experiential STEM education, where entrepreneurial learning is embedded within project-based and industry-connected contexts. In such environments, learning is not only structured through curriculum and pedagogy, but also constructed through students' sensemaking of their experiences. Accordingly, this study adopts a multi-level perspective to examine how the entrepreneurial mindset is both designed and enacted

within an experiential STEM learning environment. Guided by this framing, the study addresses the following research question: *How do program facilitators and students conceptualize and enact the entrepreneurial mindset within an experiential STEM learning environment?*

Literature Review

Conceptualizing Entrepreneurial Mindset in Education

Across the literature, entrepreneurial mindset is variably conceptualized as a cognitive orientation toward opportunity recognition and strategic action under uncertainty (McGrath & MacMillan, 2000), as a multidimensional integration of cognitive, behavioral, and emotional orientations that together enable entrepreneurial action (Kuratko et al., 2021), and as a set of learnable cognitive and emotional competences intentionally cultivated through educational design to support value creation across contexts (Mawson et al., 2022). These studies suggest that an entrepreneurial mindset is not a single trait, but rather a broad and evolving orientation toward opportunity and action.

Within educational settings, an entrepreneurial mindset is often framed as something that can be developed rather than merely possessed (e.g., Linberg, 2017; Mayhew, 2012). Lindberg et al. (2017), for example, found that targeted pedagogical interventions could significantly strengthen students' opportunity recognition and individual entrepreneurial orientation, suggesting that mindset-related capabilities are responsive to curriculum and teaching design.

Some researchers conceptualize the entrepreneurial mindset as a cognitive and opportunity-oriented process. Pidduck and colleagues (2023) conceptualize the entrepreneurial mindset as a belief-based schema that emerges from the interaction between dispositional and opportunity beliefs and functions as a mechanism linking perception to entrepreneurial behavior. This perspective complements prior work by Mayhew et al. (2012), who examined innovative entrepreneurial intentions as an educationally relevant outcome. In their study, innovative entrepreneurship was distinguished from replicative entrepreneurship by its emphasis on new products, services, or methods, and intentions were treated as especially appropriate for undergraduates. Importantly, specific educational experiences, including course-taking, opportunities for argument construction, assessments requiring innovative problem-solving, and meaningful faculty interactions, were positively associated with students' innovative intentions, underscoring the role of educational environments in shaping entrepreneurial development.

Entrepreneurial Mindset in STEM Education

Research in engineering and experiential learning contexts often operationalizes EM through proximate indicators such as initiative, creativity, planning, or tolerance for ambiguity (Colombelli et al., 2022), blurring the distinction between mindset and skill. Similarly, qualitative work with engineering students suggests that EM does not emerge from isolated interventions, but rather through students' sensemaking across multiple curricular, co-curricular, and professional experiences (Jackson et al., 2023). These findings challenge linear or

interventionist models of EM development and point instead to EM as an emergent and interpretive process.

Across STEM education more broadly, EM is frequently embedded within project-based and industry-connected learning designs rather than being explicitly taught or theorized (Yu et al., 2024). While such integration aligns with experiential learning principles, it also contributes to conceptual diffusion, as EM is often inferred post hoc from gains in generic competencies or career readiness (Rodriguez & Lieber, 2020). As a result, entrepreneurial mindset risks becoming indistinguishable from broader 21st-century skills or general goal orientation.

Although there is growing consensus that EM is malleable and shaped by experience, ambiguity remains regarding how it is formed, interpreted, and enacted in educational contexts. Existing research tends to emphasize outcomes and program structures while giving limited attention to the pedagogical conditions and sensemaking processes through which EM is constructed. Addressing this gap requires examining how faculty design entrepreneurial learning environments and how students interpret and enact EM within experiential STEM contexts. In this study, EM is conceptualized as a set of orienting capacities enacted and refined through students' ongoing sensemaking of experiential learning environments.

Empirical research identifies multiple contexts that support EM development, including design-based, problem-centered coursework (Bernal et al., 2017; Jackson et al., 2021), co-curricular and extracurricular experiences (Bonesso et al., 2018; Davis & Amelink, 2016; Chen et al., 2017; Yasuhara et al., 2012), and external professional experiences such as internships and employment (Chen et al., 2017; Ramsgaard & Ostergaard, 2018). Across these settings, students report developing entrepreneurial capacities through less structured, socially embedded, and practice-oriented learning environments. Evidence also suggests that experiences beyond the classroom may be particularly influential. For example, Yasuhara et al. (2012) found that students viewed off-campus work as critical for developing entrepreneurial skills, community, and career-relevant credentials. Similarly, Chen et al. (2017) reported that internships fostered leadership and entrepreneurial capacity more strongly than traditional coursework.

Collectively, this literature indicates that EM-related dispositions, such as curiosity, creativity, teamwork, communication, problem-solving, and confidence, develop over students' educational trajectories rather than through isolated interventions. However, while prior studies identify where EM develops, they provide limited insight into how students integrate experiences across contexts or how pedagogical design and student sensemaking interact to shape EM enactment in experiential STEM environments.

Conceptual Framework

To examine how the entrepreneurial mindset is conceptualized and enacted within experiential STEM learning environments, this study adopts a design-oriented and process-focused conceptual framework. Rather than treating entrepreneurial mindset as a stable individual trait or a discrete set of competencies, the framework conceptualizes entrepreneurial mindset as an orientation enacted through interaction with uncertainty, others, and real-world constraints. From this perspective, entrepreneurial mindset is shaped by how learning

environments are designed and how students interpret and respond to those environments over time. This conceptualization builds on prior scholarship that frames entrepreneurial mindset as a cognitive orientation toward uncertainty, opportunity, and action (McGrath & MacMillan, 2000; McMullen & Kier, 2016), as well as research emphasizing its adaptive and judgment-based nature (Haynie & Shepherd, 2007). Together, these perspectives position entrepreneurial mindset as a dynamic, context-sensitive orientation that shapes how individuals interpret and act within uncertain situations, providing a theoretical foundation for examining entrepreneurial learning as an enacted process rather than an outcome.

In this study, we applied the Kern Entrepreneurial Engineering Network (KEEN, 2006) framework, which echoes these scholarly definitions by emphasizing curiosity, connections, and creating value. Rather than prescribing specific entrepreneurial behaviors or outcomes, the KEEN framework emphasizes how learners approach and engage with complex challenges. The framework serves as an adaptable guide for Entrepreneurially Minded Learning (EML), supporting faculty and instructors in integrating entrepreneurial mindset principles into engineering education (Carroll et al., 2019). Rather than functioning as a prescribed curriculum, the KEEN framework provides conceptual building blocks that instructors can adopt and adapt to design learning experiences that intentionally connect engineering knowledge with entrepreneurial ways of thinking. In this way, the framework articulates a holistic vision of engineering education aimed at preparing engineers who are not only technically capable, but also adaptive, reflective, and oriented toward creating meaningful value in complex, real-world contexts.

Program Context

The study was conducted within the Experiential STEM Internship Program (ESIP), a cohort-based, industry-connected experiential learning initiative situated at a large public research university in partnership with multiple industry collaborators, a regional community college, and a Historically Black Colleges and University (HBCU). ESIP was designed to provide STEM students with immersive research and workforce-oriented experiences in advanced battery manufacturing and clean energy technologies, while also supporting broader learning outcomes related to professional development, interdisciplinary collaboration, and entrepreneurial ways of thinking.

ESIP follows a multi-stage structure consisting of recruitment, training, and project-based experiential learning. Students are selected from associate- and bachelor-level STEM programs and participate as a cohort during a summer research internship. The training phase combines project-based technical instruction with entrepreneurial mindset learning modules, including customer discovery, ecosystem mapping, market analysis, and value proposition development. These modules are integrated alongside laboratory safety training and hands-on instruction in advanced materials synthesis, battery cell fabrication, and manufacturing processes, enabling students to engage with both technical and entrepreneurial dimensions of applied research.

During the project phase, students work on industry-defined research challenges in collaboration with faculty mentors and industry partners. Projects are open-ended and iterative,

requiring students to navigate ambiguity, respond to feedback, and refine both technical approaches and communication strategies over time. Students participate in regular report-outs with mentors, structured feedback sessions, and final presentations to industry stakeholders, creating multiple opportunities for reflection, sensemaking, and enactment of entrepreneurial orientations within authentic professional contexts.

Importantly, while an entrepreneurial mindset is intentionally supported through program design, ESIP does not prescribe specific entrepreneurial outcomes. Instead, the program provides learning conditions, such as interdisciplinary collaboration, real-world constraints, mentoring, and iterative feedback, that invite students to engage with uncertainty, opportunity recognition, and value creation in diverse ways. This design makes ESIP a particularly appropriate context for examining how EM is conceptualized and enacted by both faculty and students within experiential STEM learning environments.

Methodology

This study adopts a qualitative instrumental case study approach grounded in an interpretive, social constructivist research paradigm (Merriam, 2009; Stake, 2005). Qualitative case study research draws on a "palette of methods" that privilege naturalistic inquiry, contextual depth, and attention to meaning-making within real-world settings (Stake, 2005). Case study methodology is particularly well-suited for examining complex educational phenomena as they unfold in practice, as it is inherently particularistic, descriptive, and heuristic (Merriam, 2009). Consistent with Stake's (2005) typology, an instrumental case study is appropriate when a researcher is guided by a research question or puzzlement and seeks a broader understanding of an issue, with the belief that such understanding may be advanced through close examination of a particular case. In this approach, the case itself is of secondary interest; rather, it functions as a vehicle through which insight into a phenomenon of interest can be generated (Creswell & Poth, 2018). Accordingly, this study employs an instrumental case study design to examine how entrepreneurial mindset development is designed and experienced within an experiential STEM learning environment.

Case Description and Boundaries

The bounded case for this study is a 10-week interdisciplinary experiential learning initiative focused on clean technology and battery manufacturing. The case is bounded by time (2025 summer program cycle), place (the program's institutional and industry-affiliated settings), and activity (participation in program-sponsored learning experiences), as described by Creswell and Poth (2018). ESIP was selected instrumentally as a site through which broader processes of entrepreneurial learning in postsecondary STEM education could be examined.

Participants were drawn from three institutional contexts: four from a Midwest R1 university, two from Historically Black Colleges and Universities (HBCUs), and one from a community college.

Data Analysis and Analytic Process

Data sources included four interviews with faculty and staff, seven student interviews (Table 1), and program artifacts documenting instructional intentions and learning goals. Consistent with an interpretive, instrumental case study design, these sources were analyzed collectively to examine how entrepreneurial mindset development is both designed and experienced within the learning environment. Faculty and staff interviews were analyzed as a complementary analytic corpus rather than as parallel evidence of learning outcomes. These interviews were coded to surface design intentions, pedagogical rationales, and assumptions about how an entrepreneurial mindset might be supported within the program. These dimensions represent how educators conceptualize and operationalize the development of the entrepreneurial mindset (EM) within the learning environment. Specifically, design intentions captured the targeted learning conditions that align with core components of EM such as opportunity recognition and adaptive problem solving. Pedagogical rationales reflected instructors' beliefs about how students develop these capacities through particular forms of engagement. Underlying assumptions surfaced implicit theories about learning and student development that shape how EM is expected to emerge. Analytic attention focused on how faculty and staff described the purposes of specific program elements (e.g., entrepreneurial mindset modules, project scoping, feedback structures), the conditions they sought to create for student learning, and the constraints or tensions encountered during implementation. These analyses were used to construct an interpretive account of the program's intended learning architecture, which then served as a comparative lens for examining how students interpreted and enacted the entrepreneurial mindset in practice.

Table 1.

Participants Demographic Information

Pseudonym	*Status*	*Gender Identity*	*Race*	*First-Generation*
Kara	Second Year	Female	African American/Black	No
Jasmine	Second Year	Female	African American/Black	Yes
Jamal	Second Year	Male	Middle Eastern/North African	Yes
Casey	Second Year	Male	White / Caucasian	No
Morgan	Senior Year	Male	White / Caucasian	No
Bruce	Third Year	Male	White / Caucasian	No
Robert	Second Year (M)	Male	White / Caucasian	No
George	Program facilitator	Female	White / Caucasian	No
Jennie	Program facilitator	Female	White / Caucasian	No
Lisa	Program facilitator	Female	White / Caucasian	No
Vanessa	Program facilitator	Female	White / Caucasian	No

Data analysis followed an iterative, multi-phase coding process consistent with qualitative instrumental case study methodology and an interpretive, social constructivist paradigm (Stake, 2005; Merriam, 2009). The purpose of coding was not to produce an exhaustive description of the ESIP, but to use the case as an analytic lens for examining broader

processes of entrepreneurial mindset development within experiential STEM learning environments. Data management and coding were supported by Dedoose qualitative data analysis software, which facilitated the organization of interview transcripts, the application of codes, and comparisons across participants (Salmona et al., 2020). In the first cycle of coding, data were analyzed inductively to privilege participants' perspectives. Interview transcripts were reviewed to identify analytically meaningful excerpts, with faculty and staff data examined for design intentions and instructional framing, and student data examined for sensemaking, interpretation, and enactment of the entrepreneurial mindset. Coding prioritized in vivo codes, which preserved participants' language, and process codes, which captured actions and cognitive movements (e.g., reframing, revising, recognizing, questioning, acting). Rather than coding transcripts line-by-line, excerpts were selected based on their relevance to the phenomenon of interest, allowing analytic focus while maintaining depth. This phase emphasized participants' experiences and how they described making sense of them, without imposing theoretical categories. Analytic memos were written for each participant to document emerging patterns within cases, including how participants described uncertainty, interaction with others, and shifts in how they approached problems over time.

Second-round coding was abductive and theory-informed. At this stage, the KEEN framework's concepts (curiosity, connections, and creating value) were used as interpretive lenses rather than as deductive categories. These concepts guided attention to how participants' experiences reflected entrepreneurial ways of thinking, without requiring participants to name or recognize these constructs explicitly. In this round, we focused on identifying mechanisms (e.g., reframing problems, acting on provisional judgments, learning through interaction) and conditions (e.g., reduced structure, faculty guidance, peer engagement) through which entrepreneurial orientations were enacted in practice. Codes were compared across participants to assess convergence and variation, supporting cross-case analysis.

Trustworthiness

We employed several strategies to strengthen the trustworthiness of this qualitative instrumental case study. First, we drew on multiple sources of evidence, including faculty/staff interviews, student interviews, and program artifacts, which allowed us to examine EM development from both the standpoint of program design and student sensemaking. Second, grounding our claims in participants' accounts and attending closely to the relationship between program context, design intentions, and student meaning-making, we sought to produce a credible and contextually rich interpretation of how EM was enacted within ESIP.

Limitation

Although this study did not explicitly examine differences across student identities, the program's inclusion of participants from different institutional and demographic backgrounds raises important questions about how entrepreneurial learning processes may be experienced differently across social contexts. While our analysis highlights entrepreneurial mindset as a

process of adaptive sensemaking, collective meaning-making, and value-oriented judgment, it does not account for how students' prior experiences, access to resources, or social positioning may shape their ability to engage in these processes. For instance, navigating uncertainty, contributing to group sensemaking, or interacting with industry stakeholders may be experienced unevenly depending on students' confidence, cultural capital, or prior exposure to similar environments.

Additionally, because the study draws on a single program context with a relatively small sample, the findings may not capture the full range of variation in how the EM is enacted across different institutional types or student populations. Future research should examine how identity, background, and institutional context intersect to shape engagement with entrepreneurial learning environments, particularly in relation to power dynamics, access to opportunities, and recognition of students' contributions. Incorporating perspectives from a broader range of participants, including industry stakeholders and alumni, would also strengthen understanding of how EM is differentially developed, recognized, and valued beyond the program setting.

Third, while this study conceptualizes entrepreneurial mindset as a process, it does not directly examine how these processes relate to measurable outcomes or longer-term impacts, leaving open questions about how process-based enactment translates into sustained competencies or professional practice.

Results

Across faculty and staff interviews, the entrepreneurial mindset (EM) was consistently conceptualized as a set of identifiable, teachable mindsets embedded within a structured learning design. Faculty and staff described EM as a way of approaching problems using specific skills and orientations. As one female EM instructor, George explained, *"the idea is that you're looking at challenges and seeing opportunities… part of that is customer discovery, so talking to people in the market and understanding what their needs are, as opposed to just developing things by specification".* This framing positioned EM as a set of skills, such as customer discovery, market analysis, and value creation, that could be explicitly introduced and developed through instruction.

This competency-based approach was further reflected in the program's intentional structure, which scaffolded student learning. Faculty described a deliberate sequencing of activities that introduced entrepreneurial concepts before asking students to apply them in practice. As George explained, the program began with *"four introductory sessions"* focused on key components such as *"curiosity, creativity… making connections and creating value,"* followed by ongoing touchpoints and a final report-out to industry partners. Similarly, a female program facilitator, Jennie, emphasized that the program was designed to provide students with *"hands-on experience with battery technology"* and exposure to real-world industry processes, even when direct access to the facility was delayed. Together, these accounts reflect a shared assumption that an entrepreneurial mindset can be intentionally developed through structured exposure, guided practice, and application within defined project contexts.

Interestingly, student accounts revealed a different understanding of how EM was enacted in practice. Rather than describing EM as a set of predefined competencies, students experienced it as something that emerged through navigating ambiguity, working with others, and making decisions in situations where expectations and solutions were not clearly defined. The findings below illustrate how EM was enacted through three interrelated processes:

Acting Under Uncertainty Through Adaptive Sensemaking

Students experienced this uncertainty acutely, particularly when projects lacked clear boundaries or when anticipated resources were unavailable. Bruce, a third-year computer engineering student, described a marked contrast between classroom problem-solving and the work he encountered in the program:

> *"When we're getting a homework assignment in class, you know exactly what you're looking for. There's a number you have to get at the end. But with the ESIP, they're very open ended. You could take it a lot of different ways as long as you could justify your steps."*

Jasmine, a second-year female student, similarly described moments of frustration when market research failed to yield clear pathways. Rather than persisting along an unproductive trajectory, she recounted deliberately stepping back to reassess the problem: *"I had to really take a step back. I erased everything and kind of started from scratch. I realized it wasn't about just having the answers. I had a whole team that I needed to rely on."* This process of *"starting from scratch"* illustrates adaptive sensemaking: recognizing when existing frames no longer fit the situation and actively reconstructing the problem in response to changing conditions.

Another second-year female student, Kara, further highlighted how uncertainty prompted students to act without complete data. Tasked with creating an energy dashboard for a facility that was not yet operational, she described working entirely with projections and assumptions. She explained, *"None of the numbers were finalized. We didn't have solid data to build of."* Rather than waiting for definitive inputs, Kara proceeded by identifying what could be reasonably inferred, treating uncertainty as a condition to be managed rather than avoided.

Casey, as a second-year student, also offered a particularly detailed account of adaptive sensemaking in technically complex work. During an energy-use analysis project, he described struggling to locate relevant literature and reconcile competing demands from mentors. *"There was basically one paper that helped us. That was it. And we were being asked for numbers that we just couldn't know yet. So we had to figure out how to make the best estimate possible with the information we had, knowing it might not be perfect."* Casey's account underscores that adaptive sensemaking involved judgment, not certainty, making defensible decisions under conditions of limited evidence.

Across these accounts, adaptive sensemaking operated as a central mechanism through which the entrepreneurial mindset was enacted. Importantly, students did not simply tolerate uncertainty, they actively reconstructed the meaning of the problem as conditions changed, shifting from seeking correct answers to determining what constituted a reasonable path forward.

This suggests that the entrepreneurial mindset, in practice, is not primarily about solving well-defined problems, but about working in contexts where the problem itself is unstable or incomplete. Rather than applying predefined skills, students engaged in an ongoing process of interpretation in which understanding and action developed simultaneously.

These findings extend common conceptualizations of entrepreneurial mindset by highlighting that acting under uncertainty requires more than persistence or creativity; it involves epistemic flexibility, the ability to revise assumptions, redefine goals, and justify decisions without complete information. In this sense, entrepreneurial mindset emerges as a way of navigating ambiguity through continuous sensemaking, rather than resolving it in advance.

Making Meaning Collectively Across Differences

Entrepreneurial mindset was enacted not as an individual cognitive shift, but through collective sensemaking across differences in background, expertise, and perspective. Students consistently described learning what a problem meant and how to proceed through interaction with peers, mentors, and collaborators who approached the work differently. Meaning was not established individually in advance, but negotiated through dialogue, comparison, and shared judgment.

Several students emphasized that working across differences required them to reconsider assumptions and expand interpretive frames. A third-year mechanical engineering student, Morgan, described how engaging with peers and mentors who thought differently prompted her to rethink his own approach to problems: *"They kind of switch your mind around and think of a different way to see it. I get locked in on an idea and try to make it perfect, and they [my teammates] help me see when I need to pivot."* For Morgan, collective interaction disrupted habitual ways of thinking and opened space for alternative interpretations, making collaboration a catalyst for reframing rather than simple coordination. Several students described collective sensemaking as essential for determining standards of adequacy when information was incomplete. A second-year male student, Casey, explained that progress depended on negotiating, rather than discovering, what constituted an acceptable approach:*"We had to decide what was acceptable with the information we had. It wasn't about being exact, it was about agreeing on what made sense given the constraints."* This shared determination of *"what made sense"* illustrates an entrepreneurial mindset as a relational process, where judgment was co-constructed rather than individually asserted.

A mechanical engineering student, Robert, similarly emphasized that meaning-making involved learning to interpret relevance through interaction. He described how, over time, communicating with others helped him distinguish between essential and non-essential work: *"Over time, you learn how to sort out what's fluff and what people actually care about… and that comes from communicating with people who are really good at doing those things."* For Robert, entrepreneurial thinking emerged through exposure to others' interpretive frameworks, rather than through predefined criteria. When the project structure diminished, collective sensemaking became even more salient. Robert described how the cohort relied on conversation

to regain direction and momentum: *"When things got less structured, talking about it within the cohort was the biggest thing, starting conversations, sparking new ideas, finding a different path we hadn't thought about before."* Here, interaction functioned as a mechanism for reframing problems and generating alternative pathways forward.

Our second-year students echoed the importance of learning through others' approaches. Jamal described the cohort as a distributed source of insight, where individuals brought back different strategies and information that reshaped collective understanding: *"The cohort was kind of like a big knowledge tank. Not everyone reached out to the same people, so when we came back together, we were bringing different information and perspectives."* Rather than treating knowledge as individually held, Jamal framed entrepreneurial learning as emerging from the pooling and synthesis of diverse experiences. Kara likewise highlighted how disciplinary differences shaped collective interpretation. As the only computer science major on her team, she described relying on discussion to integrate perspectives and determine how to proceed: *"I was the only computer science major, so we had to work together because everybody couldn't do the same thing. Asking questions and talking things through was how we figured it [the problem] out."*

Notably, collective sensemaking functioned not merely as a support mechanism but as a core process through which the entrepreneurial mindset was enacted. Rather than individuals independently recognizing opportunities or generating solutions, students engaged in a socially distributed process of interpretation, where meaning, direction, and standards of adequacy were co-constructed through interaction. This challenges dominant conceptualizations of entrepreneurial mindset as an individual cognitive orientation, suggesting instead that entrepreneurial thinking is inherently relational and dialogic, particularly in interdisciplinary contexts where no single perspective is sufficient to define the problem or solution. In this sense, collaboration does not simply enhance individual thinking, it constitutes the process of entrepreneurial cognition itself.

Exercising Value-Oriented Judgment Through Iteration

Based on responses, this result focuses on how students acted on those shared interpretations through prioritization, iteration, and judgment. Students described learning to decide what mattered, how to prioritize effort, and when to revise direction under constraints of time, information, and resources. Rather than optimizing for correctness or completeness, the entrepreneurial mindset took shape as the capacity to make defensible trade-offs and move work forward in ways responsive to context and audience.

Several students emphasized that judgment emerged through iteration and feedback, particularly when projects required them to sift through large amounts of information and determine relevance. A mechanical engineering student, Robert, described how market research and industry-facing tasks forced him to move beyond exhaustive analysis toward selective focus: *"A lot of the challenge was sorting through a massive amount of information to pick out what you really want and need. Over time, you learn what actually matters and what people really care about."* For Robert, entrepreneurial judgment involved filtering rather than accumulating

information, a shift that required letting go of completeness in favor of usefulness. Another mechanical engineering student, Casey, similarly described learning to revise approaches based on emerging constraints and feedback. Reflecting on design work that required multiple iterations, he noted: *"It didn't work great at first, so we showed our designs, combined ideas, and kept redesigning until it worked. The process was more important than the answer at the end of the day."* Here, value was created not through initial success, but through sustained engagement with iteration and refinement. Other students described judgment as deciding when to pivot and when to persist. Jamal, a second-year student, explained that entrepreneurial learning involved recognizing diminishing returns and redirecting effort accordingly: *"You realize at some point that thinking about it more isn't helping. You just have to try something, see what happens, and adjust from there."* This orientation reflects a shift from deliberation toward action, where progress depended on provisional decisions rather than certainty.

Students also highlighted the role of audience awareness in shaping value-oriented judgment. A second-year student, Jasmine described how presenting work to industry partners required them to reassess not only content, but framing: *"When we presented to industry, it felt different. You had to think about what actually mattered to them and how to explain it without wasting their time."* In this context, entrepreneurial mindset was enacted through tailoring communication to stakeholder priorities, reinforcing that value is relational and context-dependent.

Senior student, Morgan, further emphasized that value-oriented judgment was learned through comparative evaluation. Describing a project where multiple design options were explored, he explained: *"We all came up with different ideas, and then we had to decide which ones actually made sense to move forward with. It wasn't about whose idea was best, it was about what worked given everything else."* This process of weighing alternatives underscores that entrepreneurial mindset involved collective judgment grounded in feasibility and impact rather than individual preference.

Thus, value-oriented judgment emerged not as a matter of selecting optimal solutions, but as a process of making contextually appropriate decisions under constraint. Students were not attempting to arrive at objectively correct answers; instead, they evaluated ideas based on feasibility, relevance, and responsiveness to stakeholder needs. This reframes entrepreneurial mindset as a form of situated judgment, where decisions are guided by shifting criteria rather than fixed standards of correctness. In contrast to traditional academic problem-solving, which prioritizes completeness and accuracy, students learned to act on provisional and good enough solutions that could be tested, revised, and improved over time. Importantly, value was not inherent in any single idea, but emerged through interaction with audience expectations, resource constraints, and iterative feedback. This positions entrepreneurial mindset as the capacity to align action with context-dependent definitions of value, rather than to optimize for universally defined quality.

Discussion

This study reveals a critical disconnect between how the entrepreneurial mindset (EM) is conceptualized in educational design and how it is enacted in practice. Consistent with prior research, faculty and program structures frame EM as a set of teachable mindsets, such as opportunity recognition, market awareness, and value creation, that can be intentionally cultivated through structured pedagogical design (Mawson et al., 2022; Lindberg et al., 2017). At the same time, our findings extend this literature by demonstrating that students do not experience EM solely as a set of discrete skills. Rather, EM is enacted as a dynamic, socially mediated process of sensemaking that unfolds through engagement with uncertainty, collaboration, and real-world constraints. Importantly, this distinction suggests that EM is not simply acquired through instruction but emerges through participation in environments that require students to interpret, digest, negotiate and act under conditions of ambiguity.

Curiosity as Adaptive Sensemaking Under Uncertainty

Rather than "developing curiosity" as an internal disposition, students enacted curiosity as an orientation toward entering and working through uncertainty, aligning with, but also extending, KEEN's emphasis on questioning and exploration (KEEN, 2006). Prior literature often conceptualizes curiosity as an antecedent to opportunity recognition or innovation (Kuratko et al., 2021; Mawson et al., 2022), yet our findings suggest that curiosity operates as a mechanism of adaptive sensemaking (Haynie & Shepherd, 2009), enabling students to reframe problems, act on incomplete information, and revise their understanding over time.

This process-based view helps reconcile competing conceptualizations of EM in the literature. While EM has been described as a cognitive orientation (McGrath & MacMillan, 2000), a set of competencies (Mawson et al., 2022), or a belief-based schema linking perception to behavior (Pidduck et al., 2023), our findings suggest that curiosity functions as the mechanism through which these orientations are enacted in practice. In this sense, curiosity is not merely an attribute students develop, but a way of engaging uncertainty that enables action despite incomplete information. In this sense, curiosity is not merely an attribute students develop, but a form of epistemic engagement that enables action despite incomplete or evolving information.

Moreover, this finding clarifies how experiential pedagogies contribute to entrepreneurial development. Prior research highlights the importance of design-based, problem-centered learning environments (Bernal et al., 2017; Jackson et al., 2021), yet provides limited insight into how such environments function. Our results indicate that pedagogical conditions such as open-ended projects, delayed instruction, and iterative feedback create structured uncertainty that compels students to engage in adaptive sensemaking. Uncertainty, therefore, should be understood not as a byproduct of experiential learning but as a deliberately structured condition through which the entrepreneurial mindset is enacted and refined.

Connections as Collective Sensemaking Across Differences

While KEEN and related literature often frame connections in terms of collaboration, interdisciplinarity, or professional networking, our findings demonstrate that connections

function more fundamentally as a mechanism of collective sensemaking (KEEN, 2006; Jackson et al., 2023). In this study, connections were not simply a means of coordinating work, but a process through which students negotiated meaning, determined what constituted adequate solutions, and co-constructed direction under conditions of ambiguity.

This finding extends prior research that emphasizes social interaction in experiential learning (Jackson et al., 2023) by showing that entrepreneurial mindset is not merely supported by collaboration, but constituted through it. Students did not independently arrive at solutions and then share them; rather, they developed interpretations, priorities, and judgments through dialogue, comparison, and shared reasoning. In this way, entrepreneurial thinking emerged as a relational and interpretive process.

This process-based understanding challenges dominant approaches that operationalize EM through individual-level indicators such as initiative, creativity, or tolerance for ambiguity (Colombelli et al., 2022). While such indicators capture important dimensions of entrepreneurial development, they risk obscuring the collective processes through which these capacities are enacted. Our findings suggest that previously observed gains in entrepreneurial skills (Chen et al., 2017; Davis & Amelink, 2016; Yasuhara et al., 2012) may be better understood as outcomes of collective sensemaking processes rather than solely individual acquisition.

Furthermore, this perspective highlights the importance of difference as a resource in entrepreneurial learning. Variation in disciplinary background, experience, and perspective was not a barrier to be managed, but a condition that enabled richer interpretation and more robust decision-making. Entrepreneurial mindset, therefore, emerges not only through individual cognition, but through interaction across diverse ways of knowing. In this way, collective sensemaking serves as the mechanism through which individual interpretations are expanded, challenged, and transformed into shared directions for action.

Creating Values as Judgment Under Constraint

Findings from this study complicate this outcome-oriented framing by showing that value creation was enacted as a process of judgment under constraint, rather than as a final product or measurable impact. Students described learning to prioritize, filter information, and tailor decisions to the audience and context, often before knowing whether their choices would succeed. This aligns with calls in the literature to move beyond product-based definitions of value and toward process-oriented understandings of entrepreneurial action (Neck et al., 2014), while providing empirical evidence of what such process-oriented enactment actually looks like in practice.

This finding extends McGrath and MacMillan's (2000) conceptualization of entrepreneurial mindset as a cognitive orientation toward opportunity and action by showing how such orientation is enacted through specific practices of prioritization, iteration, and tradeoff-making. When Jasmine described reassessing "what actually mattered to them [industry partners] and how to explain it without wasting their time," or when Morgan explained evaluating design

options based on "what worked given everything else," they demonstrated that value-oriented judgment is fundamentally context-dependent and audience-aware.

Moreover, this finding addresses a critical gap in understanding how off-campus work experiences and industry-connected learning, consistently identified as influential in shaping entrepreneurial development (Chen et al., 2017; Yasuhara et al., 2012), actually cultivate entrepreneurial mindsets. Our results suggest that the value of external professional experiences lies not simply in exposure to real-world contexts, but in the opportunities, they provide for students to exercise judgment under authentic constraints, receive stakeholder feedback, and refine their capacity to determine what constitutes meaningful value in specific situations.

Significance and Implications

Through grounding KEEN's conceptual framework in students' experiences and sensemaking processes, this study contributes a process-oriented, socially mediated form of engagement, rather than a set of discrete, teachable competencies. While prior research and educational frameworks, including KEEN, emphasize curiosity, connections, and creating value as key components of entrepreneurial mindset, this study demonstrates how these orientations are enacted in practice through interconnected processes of adaptive sensemaking, collective meaning-making, and value-oriented judgment.

By grounding these constructs in students' experiences, the findings clarify how the entrepreneurial mindset develops not through the transmission of skills but through participation in learning environments that require students to interpret uncertainty, negotiate meaning with others, and make contextually grounded decisions under constraint. In doing so, this study advances a process-based understanding of the entrepreneurial mindset that helps bridge the gap between conceptual frameworks and the way entrepreneurial learning actually unfolds in experiential STEM contexts.

Importantly, this study does not suggest that the entrepreneurial mindset is unteachable. Rather, it shows that entrepreneurial mindset develops through engagement in designed experiences that require students to work on open-ended problems, collaborate across disciplinary differences, and make decisions with incomplete information, prompting them to act, reflect, and adapt in real time. This distinction shifts the focus from teaching entrepreneurial mindset as content to cultivating it through pedagogical design.

Implications

Our findings provide important implications for pedagogy and future research. First, this study underscores the importance of deliberately designing structured uncertainty as a productive condition for learning, rather than treating it as an incidental feature of experiential contexts. Faculty and program designers should consider how specific design elements, such as open-ended project scopes, delayed or partial instruction, and iterative feedback cycles, require students to define problems, justify decisions, and adapt their approaches over time. These conditions create opportunities for students to engage in adaptive sensemaking rather than simply applying predefined solutions.

Second, our findings emphasize the importance of collective sensemaking as a core mechanism of entrepreneurial learning. Rather than treating collaboration as an ancillary support for individual learning, this study highlights how meaning-making, judgment, and direction-setting emerged through interaction across differences in disciplinary background, experience, and perspective. This suggests that experiential STEM programs seeking to support an entrepreneurial mindset should intentionally structure opportunities for students to compare interpretations, challenge assumptions, and co-develop solutions, positioning difference as a cognitive resource rather than a challenge to be managed.

Third, our study's process-oriented account of value creation has implications for assessment and evaluation practices in entrepreneurship-oriented STEM education. Because students enacted entrepreneurial mindset through prioritization, tradeoffs, and audience-aware judgment, often before outcomes were known, traditional assessments focused on final products or performance metrics may overlook critical dimensions of entrepreneurial learning. Educators and program designers may therefore need to consider assessment approaches that capture how students make decisions, respond to feedback, and refine their thinking over time, rather than relying solely on deliverables or measurable products.

This study points to several productive directions for future research. First, longitudinal research is needed to examine how the EM enacted within time-bound experiential programs like ESIP persist, evolve, or attenuate as students move across educational and professional contexts. Second, comparative scholarship, examining how EM is enacted across different types of experiential learning environments, would help clarify which pedagogical conditions are necessary versus sufficient for entrepreneurial development. Third, research can examine how student characteristics including disciplinary background, prior educational experiences, and social identities, shape engagement with entrepreneurial learning opportunities. While this study centered on student sensemaking, we did not explore variations in how students from different backgrounds experienced or engaged EM. Finally, our study focused exclusively on students and faculty within a single program context. Research expanding additional stakeholders perspective such as industry partners and institutional leaders could provide insight on how EM is recognized, valued, and leveraged beyond educational settings, helping to bridge persistent gaps between educational preparation and professional demands (Bok, 2006; Froyd et al., 2012).

Conclusion

This study positions ESIP as a powerful model for preparing STEM students to meet the demands of contemporary industry. By embedding students in sustained, industry-connected, and open-ended learning environments, the program cultivates an entrepreneurial mindset through the development of innovation capacities, enabling students to navigate ambiguity, respond to feedback, and generate contextually meaningful solutions. These are precisely the capabilities that traditional curricula and hiring metrics often fail to capture.

For industry partners, ESIP offers more than engagement. It provides a low-burden, high-value mechanism to observe talent over time. As Jay emphasized, this kind of longitudinal

exposure produces stronger signals of workforce readiness, reducing hiring uncertainty and accelerating time-to-productivity. At the same time, consistent with Matt's insight, these environments not only develop students' capacities but may also accentuate differences in how individuals engage with uncertainty and opportunity.

Taken together, ESIP demonstrates that well-designed experiential programs can simultaneously advance student learning and meet industry needs. Investing in such models is not simply an educational priority, it is a strategic approach to developing the next generation of innovative STEM professionals.

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