Leveraging the Collective Wisdom of a Network to Identify Behaviors Linked to Entrepreneurial Mindset

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As a lifelong resident of Milwaukee County, Leitzke is dedicated to serving the community. She is a board member of SHARP Literacy Inc., program quality committee member of the Boys & Girls Clubs of Greater Milwaukee, and committee member of the Wisconsin Servant-Leader Group. Leitzke looks forward to nurturing and growing the CAECM department's mutually beneficial relationships with industry and community partners to provide all students with the opportunity to learn from real-world experiences that help them develop the skillset and mindset they need to solve the complex challenges of today and tomorrow.

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Kurt Paterson enjoys re-imagining higher education with others, then making it happen.

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Introduction

This paper reports on the results of a four-year project to identify a set of observable behaviors associated with entrepreneurial mindset (EM) development. Design content is commonplace in engineering education, from developing requirements to analyzing solutions to creating models or prototypes. However, simply going forth with a design process without pursuing an exploration for opportunity and without opening an eye for impact may not create the best value for users and society. Accordingly, engineering programs can prepare their students for a more successful career by embracing the practical orientations of EM – opportunity, design, and impact. By adding opportunity and impact to their design skills, students can apply creative thinking to ambiguous problems, convey engineering solutions in terms of value, evaluate technical feasibility, and understand the motivations and perspectives of team members and stakeholders. However, mindsets of any kind are challenging to assess. We hypothesize that behaviors provide an opportunity to observe the translation of mindsets into actions and that observing these behaviors, in turn, allows for assessing EM development.

Background and Prior Work

In 1959, Robert D. and Patricia E. Kern founded what became Generac Power Systems, one of the world's largest manufacturers of complete engine-driven power generator systems. After selling a division of Generac in 1998, the Kerns established the Kern Family Foundation [1]. The Foundation's mission is to focus on efforts that have long-term, systemic impact, thereby empowering the rising generation of Americans to build flourishing lives anchored in strong character, inspired by quality education, driven by an entrepreneurial mindset, and guided by the desire to create value for others [2]. One such effort launched in 2005 is the Kern Entrepreneurial Engineering Network (KEEN), which aims "to reach all undergraduate engineering students with an entrepreneurial mindset (EM) so they can create personal, economic, and societal value through a lifetime of meaningful work [3]." Faculty at nearly 70 institutions across the United States emphasize the "3Cs" of an entrepreneurial mindset as defined by KEEN: empowering students with an insatiable *curiosity* to investigate a rapidly changing world, fostering *connections* to integrate the pursuit of knowledge as a means for revealing innovative solutions, and championing *creating value* in diverse contexts to positively impact others [4]. Using a shared language and framework, KEEN fosters collaboration among administrators, faculty, and institutions to implement entrepreneurially-minded learning in various contexts. This enables students to recognize and identify opportunities, focus their impact, and create value in any context.

Through its Engineering Unleashed subsidiary, an online community of more than 6,000 engineering faculty, staff, and administrators, KEEN provides numerous tools and resources to make adopting EM-promoting materials easy and impactful. These tools and resources are organized as "Cards," an online information repository for members to publish their materials. To date, nearly 2,700 cards spanning various topics have been published. But how does one measure the effectiveness of any of these materials? Understanding the value of the entrepreneurial mindset to engineering education is central to the adoption, growth, and influence of EM in engineering academics and the profession. It was recognized early on that assessment "is one of the most challenging tasks confronting" the network of KEEN member institutions (Network) and the Foundation [5]. Assessment is important, as the Network benefits from baseline measures of EM development across KEEN-affiliated institutions, longitudinal insights of EM development, and identification of strong impact EM activities. Similarly, institutions benefit as assessment provides benchmarking data for future EM implementations, serves as another source of accreditation materials, leverages existing work in the Network, and provides scaffolding for institutional-specific EM implementations [6]. Consequently, there have been prior attempts to assess entrepreneurial mindset within the Network. One concerted effort started in 2009 when an assessment committee was formed between Network faculty, Foundation staff, and representatives from TTI Performance Systems, a firm specializing in developing assessment frameworks [7]. They identified seven learning outcomes and 23 personal and professional competencies, which were assessed using a website-hosted survey taken by student participants. However, while pilot studies were conducted [8] and some initiatives were undertaken [9] [10], this methodology failed to be adopted within the Network. And, while others have published their use of KEEN-based models for EM assessment (a compilation of which is beyond the scope of this paper), a 2019 study concluded that many of these papers are missing "the theoretical and conceptual frameworks to support the actions taken and connections to existing research [11]."

To understand which academic efforts work best for developing EM in engineering students, the Network needs to clearly identify and articulate a set of observable student behaviors that can be used to comprehensively and comparatively assess EM development throughout the Network. By collectively agreeing upon a set of behaviors, both the Foundation and the Network can better understand what types of EM-based educational initiatives within the Network are more successful, thus permitting much-needed comparative return-on-investment analyses to help identify the most effective approaches to EM education, thereby enabling the promotion of such practices across the Network and beyond. A key premise in this effort is that the KEEN Framework [12] emphasizes opportunity, design, and impact as the essential elements for successful innovation. An accredited engineering curriculum is already grounded in design content. Thus, EM-based educational activities need to focus on opportunity and impact, and how faculty might recognize this development of their students. In short, which observable behaviors are exhibited by engineering students with an entrepreneurial mindset that differ from those of traditionally prepared engineering students?

Methodology

The following sections chronologically document this research's six data collection rounds. As the research involved human subjects, the protocol was reviewed under the Department of Health and Human Services Regulations for Protection of Human Subjects (45 CFR 46.101) by the Institutional Research Board (IRB) at the Milwaukee School of Engineering. The protocol was subsequently approved (Study #I-2021-011-MSOE) by the IRB through the expedited review procedure, as the proposed research involved no more than minimal risk to human subjects. Appropriate informed consent notifications were made to the participants for all modes of interaction, who were free to end the interaction at any time. Save for the last round, no data involving personal identity was recorded. Unless otherwise noted, the authors evaluated the results after the end of each round and processed them into appropriate inputs for the next round.

Round 1: Fall 2021 Focus Groups and 2022 KEEN National Conference Presentation

An initial solicitation was distributed to the Engineering Unleashed community requesting volunteers to serve as focus group participants regarding their needs, wants, and pains associated with EM assessment. Two focus group meetings consisting of a total of 12 faculty members, each representing a different institution, were conducted in Fall 2021 based on the responses received. Each focus group started with a framing exercise based on the question, “When I think of assessment, I think of…” The participants were then asked to compare and contrast the comments others made in the group. Similarly, a framing exercise was based on the question, “When I think of EM, I think of…” Participants were then asked to identify what was confirmed and what was missed. Participants were then asked to make lists of both positive and negative aspects of EM and how to assess EM at both the course and program levels effectively. Input was also received from a “Why Assess EM?” discussion held during the 2022 KEEN National Conference. The key takeaway from these meetings was that a standard set of criteria for assessing EM was needed. Consequently, the value proposition for this research was adjusted to reflect this need, with the goals being to:

- Identify a set of key behavioral indicators,
- Recommend actions to address EM assessment needs, and
- Facilitate workshops to support assessment and development.

Round 2: Interviews - 2022 ASEE Annual Conference ENT Social

The ASEE Entrepreneurship & Engineering Innovation (ENT) Division is considered the division with the greatest affinity toward EM-related research, so much so that Engineering Unleashed has sponsored their Tuesday evening social event at the Annual Conference for several years. While open to all conference attendees, those at the Social are generally familiar with the concept of EM. As this was a social event, data collection was kept short and unobtrusive, with the authors wearing bright yellow t-shirts featuring the question being asked of attendees: *How do students with EM behave differently than students without EM?*

Responses were taken using a handheld audio recorder to minimize the intrusiveness of each interaction while also allowing for accurate transcription of the responses to be compiled later. To gauge the extent of institutions covered, each interviewee was asked to identify their institution, but names were not requested to protect the participant's anonymity. Once a participant answered the question, an “It’s About Mindset” sticker was provided so the authors would know that those attendees wearing that sticker had already been interviewed. Out of approximately 150 attendees, 60 responses representing 31 colleges and universities were obtained and transcribed.

Round 3: Thematic Analysis - Summer 2022

Before this round, one author conducted a literature review on entrepreneurial mindset using a coded approach, examining the 23 books listed in Table 1. These books, aimed at the business community, delve into themes related to the entrepreneurial mindset, such as fostering creativity, curiosity, decision-making, diverse thinking, innovation, and personal growth.

TABLE 1. BOOKS USED FOR EM-FOCUSED LITERATURE REVIEW DURING ROUND 3.

▪ Catmull, Ed., Wallace, Amy. Creativity, Inc.: Overcoming the Unseen Forces That Stand in the Way of True Inspiration. United States: Random House Publishing Group, 2014. ▪ Garman, Kyle. The Entrepreneurial Mindset. n.p.: New Degree Press, 2020. ▪ Gelb, Michael J., How to Think Like Leonardo da Vinci: Seven Steps to Genius Every Day. United Kingdom: Random House Publishing Group, 2009. ▪ Grant, Adam. Originals: How Non-Conformists Move the World. United Kingdom: Penguin Publishing Group, 2017. ▪ Hamilton, Diane. Cracking the Curiosity Code: The Key to Unlocking Human Potential. United States: Gatekeeper Press, 2019. ▪ Harrdas, Miliind. Ideas on Demand: A Crash Course on Creativity: Bust Creativity Blocks, 10x Your Ideas, Become an Ideas Machine. United States: n.p., 2021. ▪ Heath, Chip., Heath, Dan. Decisive: How to Make Better Choices in Life and Work. United States: Random House of Canada, 2013. ▪ Hooydonk, Stefaan van. The Workplace Curiosity Manifesto: How Curiosity Helps Individuals and Organizations Thrive in Transformational Times. United States: New Degree Press, 2022. ▪ Kahneman, Daniel. Thinking, Fast and Slow. United States: Farrar, Straus and Giroux, 2011. ▪ Kaufman, Scott Barry., Gregoire, Carolyn. Wired to Create: Unraveling the Mysteries of the Creative Mind. United States: Penguin Publishing Group, 2016. ▪ Klein, Gary A. Streetlights and Shadows: Searching for the Keys to Adaptive Decision Making. United Kingdom: MIT Press, 2011.	▪ Latham, Ann. The Power of Clarity: Unleash the True Potential of Workplace Productivity, Confidence, and Empowerment. United Kingdom: Bloomsbury Publishing, 2021. ▪ Leslie, Ian. Curious: The Desire to Know and Why Your Future Depends on It. United States: Basic Books, 2014. ▪ Martin, James. The Jesuit Guide to (Almost) Everything: A Spirituality for Real Life. United States: HarperCollins, 2010. ▪ Morgan, Adam., Barden, Mark. A Beautiful Constraint: How to Transform Your Limitations Into Advantages, and Why It's Everyone's Business. Germany: Wiley, 2015. ▪ Mumford, George. The Mindful Athlete: Secrets to Pure Performance. United States: Parallax Press, 2015. ▪ Page, Scott E. The Diversity Bonus: How Great Teams Pay Off in the Knowledge Economy. United Kingdom: Princeton University Press, 2019. ▪ Suzuki, Shunryū. Zen Mind, Beginner's Mind. United States: Weatherhill, 2005. ▪ Syed, Matthew. Rebel Ideas: The Power of Diverse Thinking. United States: Flatiron Books, 2022. ▪ Thaler, Richard H., Sunstein, Cass R.. Nudge: Improving Decisions About Health, Wealth, and Happiness. Ukraine: Penguin Publishing Group, 2009. ▪ Thinknetic. Cognitive Biases In A Nutshell: How To Spot And Stop The Hiccups In Our Thinking Process. United States: M & M Limitless Online Inc., 2022. ▪ Wedell-Wedellsborg, Thomas. What's Your Problem? To Solve Your Toughest Problems, Change the Problems You Solve. United States: Harvard Business Review Press, (n.d.). ▪ Widmer, Andreas. The Art of Principled Entrepreneurship: Creating Enduring Value. United Kingdom: BenBella Books, 2022.

Each Round 2 response was ranked on a 5-point scale based on how much that response correlated, in the opinion of the reviewing author, with one or more of the coded book excerpts, with 5 being "very strong" and 1 being "not at all." Responses scoring either 1 or 2 were subsequently removed from further consideration. From there, references to notes culled from the readings, along with initial reflective comments, were added to each response to provide additional fodder for analysis and commentary. These activities allowed the formulation of the following set of observable behaviors for further consideration:

1. *Engages in psychological safety practices that allow for informed risk-taking.*
2. *Employs sets of empathetically-based and cognitively-diverse problem framings for better recognizing innovative opportunities.*
3. *Demonstrates a propensity to suspend judgement and mitigate bias while seeking and gathering information through propelling, clarifying questions.*
4. *Synthesizes information into breakthrough ideas through mental incubation practices.*
5. *Differentiates between standard and ambiguous problems requiring either standard or innovative solutions.*

Round 4: Survey - 2023 KEEN National Conference

Behavioral indicators are only useful if they can be widely adopted and regularly used; in this case, to enhance EM-related learning and for comprehensive and comparative EM assessment. Initially, an interactive workshop session was proposed for the 2023 KEEN National Conference to provide a dedicated forum for interested parties to help determine whether a specific behavior belongs for further consideration and if any behaviors are missing. However, the conference organizers believed that presenting this activity in a way that could engage the maximum number of attendees would be more effective. Accordingly, five minutes were provided during one of the plenary sessions for a brief presentation, followed by the projection of a QR code providing access to a survey soliciting quantitative and qualitative feedback regarding the behaviors. Attendees were asked to scan the QR code with their cell phones to access and complete the survey. 207 respondents were presented with the following eight draft behaviors listed in Table 2. In preparation for this conference session, these eight candidate behaviors were developed iteratively over the fall of 2022 via discussions amongst the authors to simplify the previous set of behaviors while aligning them to one or more of KEEN's 3Cs Framework.

TABLE 2. LIST OF OBSERVABLE BEHAVIORS USED DURING ROUND 4.

1. Ask discerning, open-ended questions before offering solutions.
2. Show excitement for learning.
3. Initiate their own exploration.
4. Contribute to a safe environment for idea sharing.
5. Articulate positive and negative consequences of ideas.
6. Seek diverse perspectives.
7. Iterate to maximize opportunity.
8. Integrate value statements when offering solutions.

Respondents were asked to score each behavior based on one of three perceived levels of importance: important, somewhat important, or not important. The results were strongly positive, with the rating of "Important" ranging from 87% (behavior #1) to 79% (behavior #8). The survey also included a qualitative question soliciting additional behaviors not listed. This qualitative question was valuable in eliciting 36 behavioral-related comments, which were then fed into the discussions to modify the draft behaviors.

Round 5: Campus Visit Round Tables - Spring through Fall 2023

One of the strengths of the methodology described here was the concerted effort to listen to all voices within the Network. At this point, the authors were at a critical juncture and wanted to ensure they continued listening to the Network regarding its needs. Specifically, faculty are vital partners in the teaching and learning process, with their classroom experiences potentially providing insight into the current list of behaviors and helping with both its validation and possible expansion in incorporating additional behaviors not previously captured. Accordingly, those identified as institutional representatives at the 2022 KEEN Leader Meeting were approached regarding having one of the authors engage a group of faculty who promote EM-based learning at their institution. Out of 56 KEEN institutions contacted, 41 agreed to participate, resulting in 30 in-person and 11 virtual visits. As part of these meetings, each faculty participant used an electronic device to respond to two randomly assigned draft EM behaviors out of the eight listed in Table 2 by describing this behavior in their own words, allowing the authors to understand better how others thought about these behaviors. This resulted in having anywhere from 49 to 58 descriptions, with an average of 53, for each behavior. All participants were presented with the same third and final question, asking them to list any additional behaviors they believe help engineering educators observe EM behavior in the classroom and beyond. This question served to both reinforce the presence of behaviors in the list that were not shown to that respondent and to capture suggestions for behaviors that were either not listed or were variations on those already listed. Following this round, the authors carefully reviewed the responses and, with an eye toward the next round, developed an expanded set of 27 possible behaviors listed in Table 3 based on suggestions received in both this and the previous round.

Round 6: Delphi Method - Winter 2023-2024

The final round of collecting input from the Network used the Delphi Method, an iteratively structured decision-making process where a panel of experts independently answer a set of statements. Participants were asked to rate the EM importance of each of the 27 provided draft behaviors in Table 3 on a 7-point Likert scale, with 7 being "strongly agree." After each round, a quantitative analysis was performed. The results were then shared with the panelists, encouraging them to consider these aggregate responses as inputs to their responses in the next iteration. This process continued until the panelists collectively converged upon an agreed subset of the originally presented behaviors, using *a priori* convergence criteria. Similarly, those

TABLE 3. SET OF OBSERVABLE BEHAVIORS FOLLOWING ROUND 5.

1. Embraces failure as a learning opportunity. 2. Asks discerning, open-ended questions before offering solutions. 3. Initiates their own exploration. 4. Identifies impact for various stakeholders. 5. Recognizes various types (e.g., social, economic, environmental, etc.) of consequences of an idea. 6. Manages risks associated with working out of one's comfort zone. 7. Iterates continuously to improve solutions. 8. Adapts to changing conditions. 9. Recognizes the need to communicate value propositions appropriately to different stakeholders. 10. Integrates information from many sources. 11. Persists through failure. 12. Identifies opportunities to create value. 13. Questions accepted solutions. 14. Goes above and beyond what is expected.	15. Recognizes how design choices impact stakeholders. 16. Seeks diverse perspectives before offering solutions. 17. Manages risks to maximize impact. 18. Employs reflective practices when problem solving. 19. Learns from failure. 20. Mitigates biases when problem solving. 21. Approaches problem solving holistically. 22. Recognizes personal biases. 23. Observes surroundings to recognize opportunity. 24. Gathers data to support and refute ideas. 25. Integrates different kinds of knowledge. 26. Demonstrates how the elements of a system are connected. 27. Values diversity of expertise when working with others.

behaviors that failed to obtain adequate support in an iteration were delisted, resulting in a smaller set of behaviors to evaluate in subsequent iterations. The authors received a strong response from the call for volunteers made during Round 5, with 110 individuals answering the call. A discernment process was used to select one representative per institution, resulting in 42 panelist invitations being sent out, 39 of which were accepted. To compensate these individuals for their time, performed asynchronously over a two-week window for approximately 30 minutes each round, a $500 stipend was provided to each of the 38 who subsequently participated in the Delphi surveys. Because of the need to track responses for the compensation process and allow participants to see their earlier responses in subsequent Delphi iterations, a short pre-survey was administered to collect contact information and generate anonymous IDs. Only the project administrator had access to this information, thus providing appropriate response anonymity for the three principal research investigators. After two iterations, the set of behaviors shown in Table 3 was winnowed to the 13 shown in Table 4. Sufficient consensus was achieved after the third iteration, where a rating ≥ 6.0 on a 7-point scale and/or agreement $\geq 75\%$ was formed around nine of the initial 27 presented behaviors.

Although the first nine behaviors listed (and shaded in Table 4) met the consensus standard after the third iteration, two of them - "embraces failure as a learning opportunity" and "learns from failure" - were very similar. Multiple discussions were held about whether they should be combined into one behavioral entry; it was concluded that having two very similar observable behaviors would cause more confusion than it would be worth, so they were combined. However, trying to discern the subtle distinctions between the two and thus better understand what might differ between the behaviors is worthy of further research, with the possibility of going back to the two separate failure behaviors if warranted by the results. Similarly, the

TABLE 4. SET OF OBSERVABLE BEHAVIORS EVALUATED OVER ALL THREE DELPHI ITERATIONS.

Observable Behavior	Round 1		Round 2		Round 3	
	$\bar{x}$	%	$\bar{x}$	%	$\bar{x}$	%
1. Asks discerning, open-ended questions before offering solutions	6.2	82	6.3	92	6.5	94
2. Embraces failure as a learning opportunity	6.2	85	6.5	92	6.6	88
3. Learns from failure	6.4	91	6.4	84	6.4	85
4. Gathers data to support and refute ideas	6.1	81	6.2	84	6.1	84
5. Identifies impact for various stakeholders	5.9	61	5.9	73	6.0	79
6. Adapts to changing conditions	6.0	76	5.9	68	5.9	79
7. Recognizes the need to communicate value propositions appropriately to different stakeholders	5.7	73	5.9	67	5.9	74
8. Identifies opportunities to create value	6.1	79	6.2	81	6.2	76
9. Integrates information from many sources	5.9	70	6.0	70	6.0	74
10. Values diversity of expertise when working with others	5.9	82	6.1	78	5.8	71
11. Initiates their own exploration	5.7	63	5.9	70	5.8	68
12. Persists through failure	6.2	76	5.8	73	5.6	65
13. Iterates continuously to improve solutions	5.8	76	5.2	59	5.2	50

"values diversity" behavior satisfied the acceptance criteria in the first two iterations but fell outside of the specifications in the third. Although it might have bounced back into making the cut were the authors to engage in a fourth Delphi iteration, it was felt that its downward trend in support over the three iterations, coupled with the ask for additional time from the participants, could not be justified, so this was left out of the final set of behaviors, shown in Table 5.

TABLE 5. FINAL SET OF OBSERVABLE BEHAVIORS.

1. Asks discerning, open-ended questions before offering solutions.
2. Learns from failure by embracing it as a learning opportunity.
3. Gathers data to support and refute ideas.
4. Identifies impact for various stakeholders.
5. Adapts to changing conditions.
6. Recognizes the need to communicate value propositions appropriately to different stakeholders.
7. Identifies opportunities to create value.
8. Integrates information from many sources.

Findings and Discussion

Through the six-round process detailed above, a Network-sourced opinion emerged regarding observable behaviors important as key indicators for developing the entrepreneurial mindset in undergraduate engineering students. These results align well with the 17 behaviors associated with the "Final Framework" articulated by London *et al.* in 2018, relating the 3Cs to sets of both mindset and behavioral outcomes [13]. Their list of behaviors was collected through three rounds of iteratively reviewing and synthesizing academic journal and conference publications (in contrast, the literature review in Round 2 focused on business and management books) related to

measuring EM. To compare and contrast these results, the list below first provides the list of eight observable behaviors discerned through this research, with the sub-list under each behavior listing one or more associated Final Framework behaviors, with the leading letter indicating the ordinal indicator from the Framework's behavioral list entry [13]:

1. Asks discerning, open-ended questions before offering solutions.
    d. Suspends initial judgement on new ideas.
2. Learns from failure by embracing it as a learning opportunity.
3. Gathers data to support and refute ideas.
    c. Gathers data to support and refute ideas.
4. Identifies impact for various stakeholders.
    f. Collects feedback and data from many customers and customer segments.
5. Integrates information from many sources.
    q. Integrates/synthesizes different kinds of knowledge.
6. Recognizes the need to communicate value propositions appropriately to different stakeholders.
    m. Articulates the idea to diverse audiences.
    n. Persuades why a discovery adds value from multiple perspectives.
7. Adapts to changing conditions.
    h. Modifies an idea/product based on feedback.
8. Identifies opportunities to create value.
    a. Critically observes surroundings to recognize opportunity.

The Final Framework behaviors that do not have a close association with this work are:

b. Explores multiple solution paths.
e. Observes trends about the changing world with a future-focused perspective.
g. Applied technical skills/knowledge to the development of a technology/product.
i. Focuses on understanding the value proposition of a discovery.
j. Describes how a discovery could be scaled and/or sustained, using elements such as revenue streams, key partners, costs, and key resources.
k. Defines a market and market opportunities.
l. Engages in actions with the understanding that they have the potential to lead to both gains or losses.
o. Understands how elements of an ecosystem are connected.
p. Identifies and works with individuals with complementary skill sets, expertise, etc.

Recall that this research explicitly examined what *observable* behaviors differentiate students using EM from just being a good student. While there is considerable alignment between the two lists, the research conducted here includes learning from failure by looking at it as an opportunity. This builds upon two intersecting concepts. The first is how to fail intelligently, which, as posited by Edmondson [14], involves factors such as breaking new ground, having a credible opportunity to advance toward a desired goal, being informed by present knowledge, and minimizing the risks associated with failure should it occur. Part of this risk management involves pursuing psychological safety within teams, as the fear of failure, or the response received for said failure, can easily inhibit a person. Techniques such as radical candor [15] can

help develop a working environment where taking calculated risks is encouraged because of the potential knowledge gain. Additionally, in looking at the list of Final Framework "leftovers," many of the behaviors fall more within the realm of being a good engineering or business student and/or are not readily observable, such as one's "understanding" of an ecosystem.

Limitations

As the results of this research are meant for use within the KEEN ecosystem, each of the six rounds of engagement for developing the list of eight observable EM behaviors presented in Table 5 involved participants from KEEN-affiliated institutions. Given that 588 institutions in the United States have ABET-accredited engineering programs [16], the 67 institutions currently within the Network only comprise 11% of this total. Consequently, while these results are meant for the Network and thus arguably do not exhibit selection bias, they may not scale to all engineering programs nationwide. There is a level of confirmation bias, given that this research involved KEEN-affiliated institutions sharing the 3Cs EM framework of curiosity, connections, and creating value. Other organizations promote different EM models, such as the eight domains of the NFTE Operation Mindset [17]. Given that most of those contributing to this research operate under the 3Cs model, some observable EM behaviors that fit well with NFTE's model (or other models) may have been missed. The face-to-face interactions conducted in Rounds 1, 2, and 5 might have been influenced by a response bias, where those being interviewed might have provided answers that they believed the interviewer wanted to hear. However, the authors believe that the asynchronous and private nature of the responses given in Rounds 4 and 6 helped mitigate this bias. Finally, relying on volunteers at various process stages might have induced a sampling bias. However, the discernment process used in Round 6 to winnow 110 volunteers down to 42 invited participants included attempts to balance representation across engineering disciplines and years of teaching experience; this is an example of attempting to mitigate this type of bias.

Next Steps

Now that a set of observable behaviors has been identified by and for the Network, the immediate task is to share these behaviors with the Network. The first step was taken via a presentation on this work at the 2025 KEEN National Conference held in Austin, Texas. During the session, attendees were asked to watch a short video featuring students involved in an urban planning design activity and evaluate the ability of the students to "ask discerning, open-ended questions before offering solutions," which was the top-listed behavior. After a round of table-based discussions, a draft rubric (provided in Figure 1) listing examples of this behavior categorized into three developmental levels was distributed, and the video was shown again. Attendees subsequently discussed strategies for evaluating student behavior using videos. They noted that applying the rubric to one student at a time significantly improved clarity and emphasized the value of repeated viewings to capture subtle dynamics, especially among shy

Entrepreneurial Mindset Observable Behaviors Field Guide

Behavior #1: ***Asks discerning, open-ended questions before offering solutions***

A. Rubric: The detailed rubric below focuses on observable behaviors associated with ***Asks discerning, open-ended questions before offering solutions*** across three developmental levels beyond Not Present (0). The rubric is designed to help evaluators:

1. Assess both the quality and quantity of questions students ask
2. Track the sequence of questioning versus solution-offering
3. Evaluate how students build upon received information
4. Consider the breadth and depth of student questioning strategies

Emerging (1)	Effective (3)	Proficient (5)
The student demonstrates early development of questioning skills but may rush to solutions: 1. Questions tend to be closed-ended (yes/no) or focused solely on technical specifications 2. Often jumps to proposing solutions after asking only 1-2 basic questions 3. Questions primarily seek confirmation of their own assumptions rather than exploring the problem space 4. Rarely asks follow-up questions based on received answers 5. Questions focus mainly on surface-level aspects without probing deeper contexts or constraints 6. Shows limited awareness of stakeholder perspectives beyond the immediate technical problem	The student consistently demonstrates effective questioning behavior: 1. Regularly asks open-ended questions that explore multiple aspects of the problem (technical, economic, social) 2. Systematically gathers information through 3-5 well-structured questions before proposing solutions 3. Questions challenge assumptions and explore underlying causes of problems 4. Builds follow-up questions based on previous responses to develop deeper understanding 5. Demonstrates awareness of different stakeholder perspectives through targeted questions 6. Questions address both immediate technical needs and broader contextual factors 7. Shows patience in developing understanding before moving to solution phase	The student demonstrates sophisticated questioning strategies that enhance problem understanding: 1. Consistently asks probing questions that reveal hidden complexities and interconnections within problems 2. Develops comprehensive questioning frameworks that systematically explore technical, social, economic, and environmental dimensions 3. Questions actively challenge both their own and others' assumptions while maintaining professional rapport 4. Synthesizes information from multiple answers to formulate increasingly insightful questions 5. Demonstrates exceptional awareness of diverse stakeholder perspectives through questions that anticipate potential conflicts or opportunities 6. Questions reveal consideration of long-term implications and systemic impacts 7. Creates an environment where others feel comfortable providing detailed, honest answers 8. Effectively documents key insights from questioning process to inform solution development

FIGURE 1. DRAFT RUBRIC FOR THE OBSERVABLE BEHAVIOR PRESENTED AT KNC2025.

students. This rubric is part of a planned EM Behavior Field Guide currently under development that includes behaviors and performance levels, identifies evidence sources, and tags existing Engineering Unleashed activities that may help develop the behaviors. Once a draft of the Field Guide is completed, the authors will partner during the 2025-2026 academic year with faculty at Network institutions selected through an application process to beta-test the materials in educational settings and, in the process, identify sample classroom activities for each behavior. It is expected that the release version of the Field Guide will be available by the fall of 2026.

Another step involves coordinating with others in the Network who have worked on developing and/or identifying EM-related assessment tools. Of particular interest are the current efforts underway by the KEEN COMPASS group to create a navigational tool to help interested researchers determine the best type of assessment tool to use with a particular EM project [18].

Resources

A card has been created for this paper on the Engineering Unleashed website [19]. This card contains the latest draft (and eventually final release) version of the Field Guide. Anyone can freely download, review, adopt, and, if desired, modify the Field Guide for use in their courses under the Creative Commons CC BY-NC license [20].

Conclusion

This research was based on the premise that tapping into the collective wisdom of the KEEN Network would be the best way to identify and build consensus around a set of observable entrepreneurial mindset behaviors. Having a shared set of behaviors will better facilitate the development of assessment tools that, in turn, will allow for the evaluation and comparison of EM-related classroom resources. Ideally, widespread adoption of these efforts will allow Network members to share validated EM learning materials within and outside the Network, thereby promoting entrepreneurially minded learning amongst engineering students, ultimately fostering future generations of engineering professionals equipped to deliver value to society. Lastly, this work shows how to elicit collective insight across large, diverse groups.

References

[1] The Kern Family Foundation, LinkedIn, [Online]. Available: https://www.linkedin.com/company/kern-family-foundation-inc/about/. [Accessed 7 January 2025].

[2] The Kern Family Foundation, [Online]. Available: https://www.kffdn.org/. [Accessed 7 January 2025].

[3] Engineering Unleashed, "KEEN: The Kern Entrepreneurial Engineering Network," [Online]. Available: https://engineeringunleashed.com/what-is-keen. [Accessed 7 January 2025].

[4] Engineering Unleashed, [Online]. Available: https://engineeringunleashed.com/mindset. [Accessed 7 January 2025].

[5] J. Blessing, K. Mekemson and D. Pistrui, "Building an entrepreneurial engineering ecosystem for future generations: The Kern Entrepreneurship Education Network.," in *2008 ASEE Annual Conference & Exposition*, Pittsburgh, PA, USA, 2008.

[6] Engineering Unleashed, "Assessment in Entrepreneurial Mindset," [Online]. Available: https://engineeringunleashed.com/assessment. [Accessed 7 January 2025].

[7] C. C. Fry and D. Pistrui, "Assessing the Entrepreneurial Mindset within Engineering Programs," in *2011 ASEE Annual Conference & Exposition*, Vancouver, BC, Canada.

[8] D. Pistrui, R. Bonnstetter, B. J. Bonnstetter and C. C. Fry, "Creating, educating and assessing a new class of entrepreneurial minded engineers," *The Journal of Engineering Entrepreneurship,* vol. 2, no. 2, pp. 1-14, 2011.

[9] O. G. Petersen, W. M. Jordan and R. Radharamanan, "Proposed KEEN Initiative Framework for Entrepreneurial Mindedness in Engineering Education," in *2012 ASEE Annual Conference & Exposition*, San Antonio, TX, USA, 2012.

[10] C. C. Fry, W. M. Jordan, E. J. Dougherty, N. E. Rayess, P. Singh and K. F. Bloemer, "The Helping Hands Dense Network: A Collaboration Across Multiple Universities," in *2012 ASEE Annual Conference & Exposition*, San Antonio, TX, USA, 2012.

[11] A. Huang-Saad, C. Bodnar and A. Carberry, "Examining current practice in engineering entrepreneurship education," *Entrepreneurship Education and Pedagogy,* vol. 3, no. 1, pp. 4-13, 2020.

[12] Engineering Unleashed, "The KEEN Framework," [Online]. Available: https://engineeringunleashed.com/framework. [Accessed 7 January 2025].

[13] J. S. London, J. M. Bekki, S. R. Brunhaver, A. R. Carberry and A. F. McKenna, "A Framework for Entrepreneurial Mindsets and Behaviors in Undergraduate Engineering Students: Operationalizing the Kern Family Foundation's" 3Cs"," *Advances in Engineering Education,* vol. 7, no. 1, pp. 1-12, 2018.

[14] A. C. Edmondson, "Failing Well: How Your 'Intelligent Failure' Unlocks Your Full Potential," Harvard Business School, 5 September 2023. [Online]. Available: https://www.library.hbs.edu/working-knowledge/failing-well-1-when-failure-is-intelligent. [Accessed 7 January 2025].

[15] K. Scott, Radical candor: fully revised & updated edition: be a kick-ass boss without losing your humanity, New York: St. Martin's Press, 2019.

[16] ABET, "Accredited Programs," [Online]. Available: https://amspub.abet.org/aps/category-search?commissions=3&countries=US. [Accessed 7 January 2025].

[17] Network for Teaching Entrepreneurship, "The Entrepreneurial Mindset," [Online]. Available: https://nfte.com/entrepreneurial-mindset/. [Accessed 7 January 2025].

[18] H. Dillon, N. Ralston, V. Sathy, B. Hutson, M. Rust and D. Grzybowski, "COMPASS for EM Assessment," Engineering Unleashed, 17 November 2023. [Online]. Available: https://engineeringunleashed.com/card/3912. [Accessed 7 January 2025].

[19] J. K. Estell, D. Leitzke and K. Paterson, "A Field Guide to Observable EM Behaviors," Engineering Unleashed, [Online]. Available: https://engineeringunleashed.com/card/4721. [Accessed 10 February 2025].

[20] Creative Commons, "Attribution-NonCommercial 4.0 International," [Online]. Available: https://creativecommons.org/licenses/by-nc/4.0/. [Accessed 10 February 2025].