Civil Engineering and the Entrepreneurial Mindset – Cultivating Teaching Practices that Enhance Entrepreneurial Minded Learning

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Abstract:
The entrepreneurial mindset (EM) is a set of attitudes and behaviors providing a unique and powerful approach to problem-solving, innovation, and value creation. Engineering programs across the country spanning many disciplines have increasingly incorporated EM principles into undergraduate curricula – entrepreneurial minded learning (EML) – demonstrating success in cultivating these attitudes and behaviors. However, adoption of EML into civil engineering curricula has lagged. Civil engineering students and faculty alike struggle to see the immediate applications of an entrepreneurial mindset. While other engineering disciplines develop prototypes and complete physical tests on products and "inventions," civil engineers can not do that in most cases, given the larger scale of their constructions. Rather, within the civil engineering community, the common interpretation of EML is that the skills and attitudes are only applicable to those starting a design firm or construction company. To the contrary, EML promotes and encourages students to approach complex civil engineering problems with curiosity in pursuit of innovative solutions, draw connections between design challenges and the community that each project serves, and develop solutions that create value across all domains of sustainability.

A new faculty development workshop has been created to demonstrate how the entrepreneurial mindset can be incorporated into common courses across a civil engineering curriculum, specifically structural engineering. The workshop includes EML activities relevant to statics, mechanics of materials, dynamics, structural analysis, steel design, reinforced concrete design, and structural dynamics. This paper summarizes the details of two iterations of the workshop and each of the associated modules. The paper also includes a summary of pre and post assessments of the faculty participants from both workshop cohorts. The assessments include evaluation of each participants' active learning practices and their incorporation and understanding of EM principles.

Introduction
An ABET accredited undergraduate engineering program in civil engineering requires the inclusion of a variety of topics. In the Civil Engineering Program Criteria (CEPC) the list of topics includes sustainability, risk, resilience, diversity, equity, inclusion, an engineering code of ethics ethical dilemma along with engineering mechanics, materials science, and numerical methods [1]. These topics are included because engineers do not work in a vacuum and must ultimately meet the needs of their clients and society. One of the overarching themes that connects much of this content is entrepreneurial minded learning (EML). Entrepreneurial minded learning has gained in popularity because it helps connect abstract concepts to real-world problems and benefits the economics of the students and, ultimately, the companies they work

for and pursuits they may take upon graduation. One way this is described is that an engineer needs to have the mindset of an inventor who can see and solve the problem and the mindset of an entrepreneur who can bring the solution to life [2]. Civil engineering is no exception.

The following project describes a week-long training program run through the Kern Entrepreneurial Engineering Network's (KEEN) Engineering Unleashed faculty development program focused on implementing an entrepreneurial mindset (EM) into the structures and mechanics courses of a civil engineering curriculum. The first two cohorts of participants have successfully completed the workshop and begun to implement EML concepts into their courses. These participants were surveyed and the results demonstrate the gains made in their knowledge and ability to teach EML topics. Included are a series of examples and lessons learned from this project.

Background

Much has been written about EM and its value to the economy, a country's competitiveness, and business growth. While EM learning is traditionally a business topic, engineers are product designers who provide the technical knowledge and contributions to business organizations. Ultimately, they end up in many leadership roles in companies [3]. Many professors in the engineering profession have made this realization and begun to use EML in engineering education, especially in the 21st Century [4], [5], [6], [7]. Providing EML within an engineering curriculum is an opportunity that can help the next generation of students expand their skillset and provide value to the profession [8].

Along with any change, there are caveats for successful implementation. The content must be clearly identified and then the method of implementation can be planned. Neither of these are trivial tasks and they come with challenges [9], [10]. Many engineers, particularly civil engineers, do not have a clear understanding of what EML entails nor how to teach the concepts. While many would include venture development, product creation, and product development, there is overlap in this definition. One viewpoint is teaching attitudes and awareness is as important as teaching a clear set of skills [5]. Others point to the importance of focusing on two phases of entrepreneurial instruction: intention and competencies. Students must first become aware of the need and then become acquainted with the techniques to become more entrepreneurial minded. Both parts work together and are important [11]. Equally important is the acknowledgement that many ventures result in failure. Learning through failure is an extremely important part of entrepreneurial education and a lesson that can help students throughout their career. Learning from what works and does not work in startup companies and technology transfer can be a key part of the process [12], [13]. Many of these topics and techniques are already embedded in civil engineering courses such as learning through failure, looking at design options, and considering social and economic impacts of designs.

There are numerous methods of incorporating new topics into curriculum including adding material to individual classes, creating new programs and certificates, and developing new majors [14]. With a topic like EML, adding it to an existing engineering course makes sense because it accentuates and adds to existing content. Within engineering education there is a growing awareness of the importance and value of teaching students the EM characteristics of the topics they are learning and the research they are performing. Many promote integrating lessons or units within existing classes or research in order to emphasize the importance of making the connections between the solutions engineers develop and the end users [3], [14].

Some researchers have reported designing their courses in a variety of engineering disciplines with EML. One group worked to implement a challenge based learning approach to teach project managers how engineering and entrepreneurs are similar. Their results showed that the two topics enhance specific knowledge gains in both areas and help their personal and professional growth [9]. Others have attempted to put EML in an engineering dynamics class [15]. A separate university incorporated EML into a senior level applied fluid mechanics course in a Mechanical Engineering Technology program. They were also able to connect all of their Student Learning Outcomes for ABET accreditation with this class [16]. A similar project in space medicine confirms the importance of entrepreneurial education [17]. Entrepreneurial education has been used in a broad spectrum of engineering fields including Mechanical Engineering, Materials Science, Computer Science, and Chemical Engineering [18], [19], [20], [21].

KEEN has developed a framework that helps professors build EML into their curriculum. These values help students think about the solutions they develop and consider the value they can provide. The framework revolves around three key concepts: promoting curiosity, making connections, and creating value [22]. Rather than provide a specific set of topics to teach, the KEEN methodology is to develop a mindset that helps students see the entrepreneurial ideas in everything they learn. Studies on this method have shown that faculty resonate with these three core concepts, although creating value has been emphasized as the most significant by one research study [7]. Another study showed the importance of the KEEN network both in emphasizing the importance of EML and providing resources for faculty. Engineering professors are not overly confident in teaching EML and appreciate this network of resources [10].

EML is well connected to many of the active learning techniques that have been used effectively in engineering education [23]. Studies have shown the connection between entrepreneurial learning, active learning and design thinking [4], [14]. Students are generally receptive to the entrepreneur concepts and find they overlap with many of the activities and learning styles they prefer like competition based learning and service learning [5], [24]. The use of different experiential learning approaches has been suggested to effectively show students how to be more imaginative, creative, take risks, and develop entrepreneurial skills [25]. Others have used case studies to help students develop a solution and implementation plan. This helps the students tackle both the design and EML way of thinking about a problem [2].

In one example, an engineering dynamics professor used hands-on labs with professional writing as a means to include more active learning within EML. These modules helped increase student engagement and conceptualize the concepts. In addition, the lab reports from the activities helped the students brainstorm ideas and see opportunities while they searched for solutions to their problems [15]. Another study used Project Based Learning (PBL) techniques coupled with EML concepts to incorporate economic and societal impacts into their assignments. The assessment and survey results of the course indicated students became more aware of the impacts of their projects and became prepared for the workforce [16]. A research study in an electrical and computer engineering program indicated that the entrepreneurial intention of a student can be influenced by linking entrepreneurship to activities and research in education programs [8]. Another study researched students' perceived entrepreneurial self efficacy for a group of biomedical engineering students in a senior design course. They found an increase in students' abilities to accomplish entrepreneurial tasks after exposing students to EML [14]. A different group, teaching material science classes, incorporated self directed, group learning module experiments and teaching [19]. Another study looked into the effectiveness of using scaffolding learning and hands-on activities to help improve students' EM. The students' confidence and success significantly increased by the end of the class [21]. Lastly, a research group developed modules with active learning techniques in a software engineering class for computer science students that resulted in improved performance and an improved EM [20]. Many different fields of engineering have successfully incorporated active learning with EML.

The timing of EML may also benefit students in their program of study. A group of educators implemented an open ended, team based design challenge with EML into an introduction to engineering, first-year course. The results indicated that students were significantly more aware of making connections and creating value. They also indicated they were better prepared to work on interdisciplinary teams and valued seeing the sociotechnical learning aspects of the project [26]. Others have reported the importance of including EML and suggested using techniques such as the customer viewpoint and approach. This can be compared to the experience of students as customers throughout their education program [27].

The literature demonstrates that EML techniques are being implemented in a variety of engineering programs. Many view it as an essential part of modern engineering education [6]. Various active learning techniques that have proven effective in the past have also been used successfully to teach EML. However, there is a limited amount of literature focused on civil engineering topics, particularly related to statics, solid mechanics, and structural engineering.

The following study focuses on implementing EML topics in civil engineering programs using the KEEN framework, a model for defining EML, as a guide. This paper reports on a week-long faculty development workshop that provided professors with resources to teach civil engineering students EML techniques.

The Kern Entrepreneurial Engineering Network (KEEN) Framework

KEEN currently includes 67 partner institutions that are dedicated to embedding the Entrepreneurial Mindset within their undergraduate engineering programs. KEEN developed a framework for the Entrepreneurial Mindset that revolves around the 3 C's: Curiosity, Connections, and Creating Value which serve as a supplement to the technical skills students already learn in their courses. Curiosity is the ability to "demonstrate constant curiosity about our changing world and to explore a contrarian view of accepted solutions;" Connections is the ability to "integrate information from many sources to gain insight and to assess and manage risk;" and Creating Value is the ability to "identify unexpected opportunities to create extraordinary value and to persist through and learn from failure" [28].

Faculty from across the nation have developed a myriad of interventions based on this framework. Their work is shared via a network platform called *Engineering Unleashed* [28]. The primary mechanism for sharing course content is a "card." Cards are "dynamic and adaptable publications that serve as a repository for sharing innovative teaching practices, classroom activities, and educational resources" [28]. Cards are open to any faculty member who signs up via the platform regardless of whether they are from a member institute.

Faculty Development Workshop

Civil engineering faculty struggle at times to incorporate EML into their classrooms. The goal of the EMCE workshop is to illustrate the presence of curiosity, connections, and creating value within the context of several civil engineering courses and create an opportunity to embed EML into a series of civil engineering courses ranging from the first year (freshmen) all the way to the senior level.

The inaugural Embedding EM in Civil Engineering: Structures and Mechanics (EMCE) workshop was held in the summer of 2023 in St. Louis, Missouri, over a span of four days. It consisted of an evening ice-breaker and dinner, followed by two full days of demonstrations and hands-on exercises, and concluded on day four with a morning work time session and participant presentations of developed ideas. A total of 18 faculty members from 17 different universities across the nation attended the workshop. Participants were introduced to the best practices of using research-based pedagogical methods and experienced a variety of vetted activities using EML approaches. Upon completion of the workshop, participants were expected to be able to develop a "card" on *Engineering Unleashed* [28], assess the classroom activity to determine impact on student learning, and make proposed modifications to the activity to be implemented in future offerings. Of the 18 active participants, only five of them had successfully published cards within one year of the workshop.

The second annual EMCE workshop was held in the summer of 2024 in Milwaukee, Wisconsin and saw an increase in participation to 28 faculty members across 26 different universities. While the basic format of the workshop remained the same, slight modifications to the daily agenda were implemented in an effort to increase the success rate of card publication from the participants. These modifications included time and content adjustments to the daily activities, an increase in the amount of cohort work time for the participants, as well as guided card development and assistance in navigating the *Engineering Unleashed* website [28]. Table 1 shows the schedule and listing of the workshop modules for each of the four days. The following section provides a more detailed description of the activities and details of the civil engineering focused EML modules.

Table 1: EMCE Workshop Modules

Day 1	**Icebreaker**
	Intro to Civil Eng. - Introduction to Entrepreneurial Minded Learning
	Structural Analysis - K'Nex Tower Design Challenge
Day 2	**Statics -** Flying Forces: Adding Lift to Statics
	Mechanics - Styrofoam Beam Design
	Steel Design - Intro to Steel Design Projects
	Reinforced Concrete (RC) - Intro to RC Projects, Design and Casting 24-hour RC Beam Design
Day 3	**Dynamics -** Challenge-based Instruction Module for Dynamics: Pulley Panic
	Structural Dynamics - Phone-Based Measurements
	Structural Analysis - Deflection of Beams: Part I and Part II
	Reinforced Concrete (RC) - 24-hour RC Beams
Day 4	**Assessment of EML Activities**

EML Module Descriptions

The EMCE workshop modules are hands-on physical demonstrations and activities that engage participants in a highly active learning environment to encourage collaborative solutions in mechanics and structures subjects. The modules range from concepts in statics, solid mechanics, structural theory and behavior, reinforced concrete and steel design, and structural dynamics. Each module provides a space to consider how the 3 C's can be infused in otherwise traditional topics.

Introduction to Entrepreneurial Minded Learning

The objective of this activity is to ensure a foundational understanding of KEEN's 3Cs (curiosity, connection, and creating value) for all workshop participants as well as facilitate a discussion on the applicability of the 3Cs in the context of civil/structural engineering [29]. The module begins with a short video about the Eads Bridge in St. Louis, MO followed by a think-pair-share activity where participants write down how each "C" was present in the creation of the Eads Bridge. Curiosity is provoked by illustrating what, at the time, was an almost unthinkable project. Connections are highlighted by noting the economical considerations and material availability, given the early use of steel for the bridge. And, lastly, creating value is emphasized by the direct impact the bridge had on the rail industry coupled with the indirect impact it had on the steel industry. With this background and foundation in the 3 Cs, participants are ready to explore traditional technical topics with those 3 Cs in mind.

K'Nex Tower Design Challenge

The objective of this activity is to construct the most efficient tower to satisfy the design requirement and constraints that can support the design load [30]. Participants work in teams to design and construct a tower structure with a minimum height of 18 in. with a goal to maximize the viewing perimeter at the top, while minimizing the perimeter at the bottom to reduce the environmental impact of the structure. The structure must support 17.6 lbs (8 kg), all of which is supported from the viewing platform. Each team is scored based on an equation that accounts for height, weight, and top and bottom perimeter. Between the competitive environment and goals, structural stability becomes the biggest challenge with dramatic results and room for a discussion of the 3 Cs in this contextualized design problem (Figure 1(a)).

Flying Forces: Adding Lift to Statics

The objective of this activity is to apply the fundamentals required for 2D and 3D static system analysis and introduce 3D vectors in a statics course using social and financial design considerations [31]. The module presents participants with the challenge of locating the supports for a stayed energy generation system (nominally the balloon in Figure 1(b). A map of a community is provided that drives participants to consider the impact of their solution on people while they are also grappling with the ideal technical arrangement of the cables. Equilibrium of a point in 3D space is also explored with 3D-printed pulley systems to ensure the participants have the technical ability to solve a 3D statics problem.

Styrofoam Beam Design

The objective of the Styrofoam Beam Design project is to design the most efficient composite beam using rigid Styrofoam Insulation while accounting for shear flow and concentrated forces [32]. The Styrofoam functions as an analog to steel and participants must first determine its material properties. The Styrofoam is crushed and bent with postage and fish scales to measure force, to calculate tensile and compressive strengths for later design (Figure 1(c)). With axial and bending principles summarized, the discussion turns to connections, where hot glue is used as an analog for fillet welds in steel fabrication. Specimens are created to test welds in direct shear and the strength of the weld per inch is determined.

With material and connection properties in hand, participants are tasked with designing and constructing a Styrofoam plate girder capable of supporting two group members (Figure 1(d)). Each group must select their built-up shape from a variety of provided thicknesses and widths, then determine the member properties, and verify that the service stresses will be less than the allowable stresses determined from the material properties tests. The culmination of the module is where teams "load" their beam to see if it can support the design load. (Figure 1(e)).

Introduction to Steel Design Projects
The objective of this activity is to learn about other large-scale EML options for use in a steel design course. These activities are not possible to demo during the workshop, but may still be possibilities for faculty to use at their respective institutions. These large scale activities include physical demonstrations for elastic and inelastic column buckling, elastic and inelastic lateral torsional buckling of beams, and tension connection analysis and design [33] along with an actual industry-sponsored steel plate girder design project [34].

Introduction to Reinforced Concrete Projects
The objective of this activity is to learn about other large-scale EML options for use in a reinforced concrete course. The first activity presented was the Reinforced Concrete Frame project [35] which is a larger scale spin-off of the retired American Concrete Institute (ACI) Egg Protection Device Competition. Participants are also introduced to the ACI concrete bowling ball competition. Finally, participants are introduced to full-scale experiential learning modules for conducting full-scale beam tests as a part of an undergraduate reinforced concrete course [36].

24-hour Reinforced Concrete Beam
The objective of this activity is to design a reinforced concrete beam to safely support a defined load pattern [37]. Reinforced concrete design is explored in a module called 24-Hour Concrete Beams. A rapid-set mortar (gypsum cement) is used to simulate concrete, and threaded rod and tie wire are provided for reinforcement. Teams can design blockouts and other innovations to tailor a reinforced concrete beam to support load with maximum efficiency. The beams can be cast one day and tested the next, creating an opportunity for iteration that is not usually possible in reinforced concrete design courses. The module allows for curiosity and connections to be made as participants endeavor to create value with efficient and elegant solutions in concrete. Participants at various stages of the module are shown in Figure 1(f).

Challenge-based Instruction Module for Dynamics: Pulley Panic
The objective of this activity is to describe and predict the effect of a mass on the acceleration of a rigid body in an unbalanced two-mass pulley system [38]. The module serves as an example of how a single homework problem or class lecture can be converted into a robust EML activity. Participants are divided into groups and provided with a physical pulley system representing a

homework problem covering a difficult concept (Figure 1(g)). The facilitator leads participants through the exercise as students get to manipulate the model to discover the answer to the challenge.

Phone-based Measurements to Introduce Structural Mechanics and Dynamics

The objective of this activity is to model beam and frame structures using mathematical and numerical models and evaluate those models using static or dynamic responses measured by phone [39]. The link between static stiffness and dynamic behavior is explored in a module called Sticks and Stones. Structures are built using bricks, yard sticks, and grip clamps and are tested using fish scales as loading and non-contact displacement measurement performed using mobile phones (Figure 1(h)). Once the static stiffness is determined, the natural frequency of the system is estimated and then measured using phone-based accelerometers. Connections to structural design for static and dynamic loads are discussed and participants leave with a new awareness of structural behavior and their ability to make measurements with their phones.

Deflection of Beams: Part I and Part II

The objective of these activities is to determine displacements and reactions of determinate and indeterminate beams using virtual work and the force method and sketch the deflected shapes [40], [41], [42]. Participants are guided through two scenarios: 1) to load a determinate beam and determine the displacement at the free end and 2) to solve for the reactions of a beam that indeterminate to the first degree by first determining the redundant reaction. Participants serve as the point load and and use tape measures or yardsticks to measure displacements and postage scales to measure reactions for comparison to theoretical calculations (Figure 1(i)).

Assessment Methods and Results

Two of the primary goals of the EMCE workshops were to enable faculty participants to identify ways in which EML could be incorporated into the undergraduate civil engineering classroom, and to equip faculty with strategies to modify or develop their own EML content. To determine the impact of the EMCE workshop, participants were asked to complete a modified version of Teaching Facets of the Entrepreneurial Mindset survey [43] which asked participants, in both quantitative and qualitative questions, to share their understanding of EML concepts, implementation of EML activities in their classes, and feedback on the workshop. Participants were asked to complete the survey prior to the workshop. They were then asked to complete the survey immediately after the workshop, and after an implementation of an EML activity, an expectation of workshop attendance (approximately one semester to one academic year later).

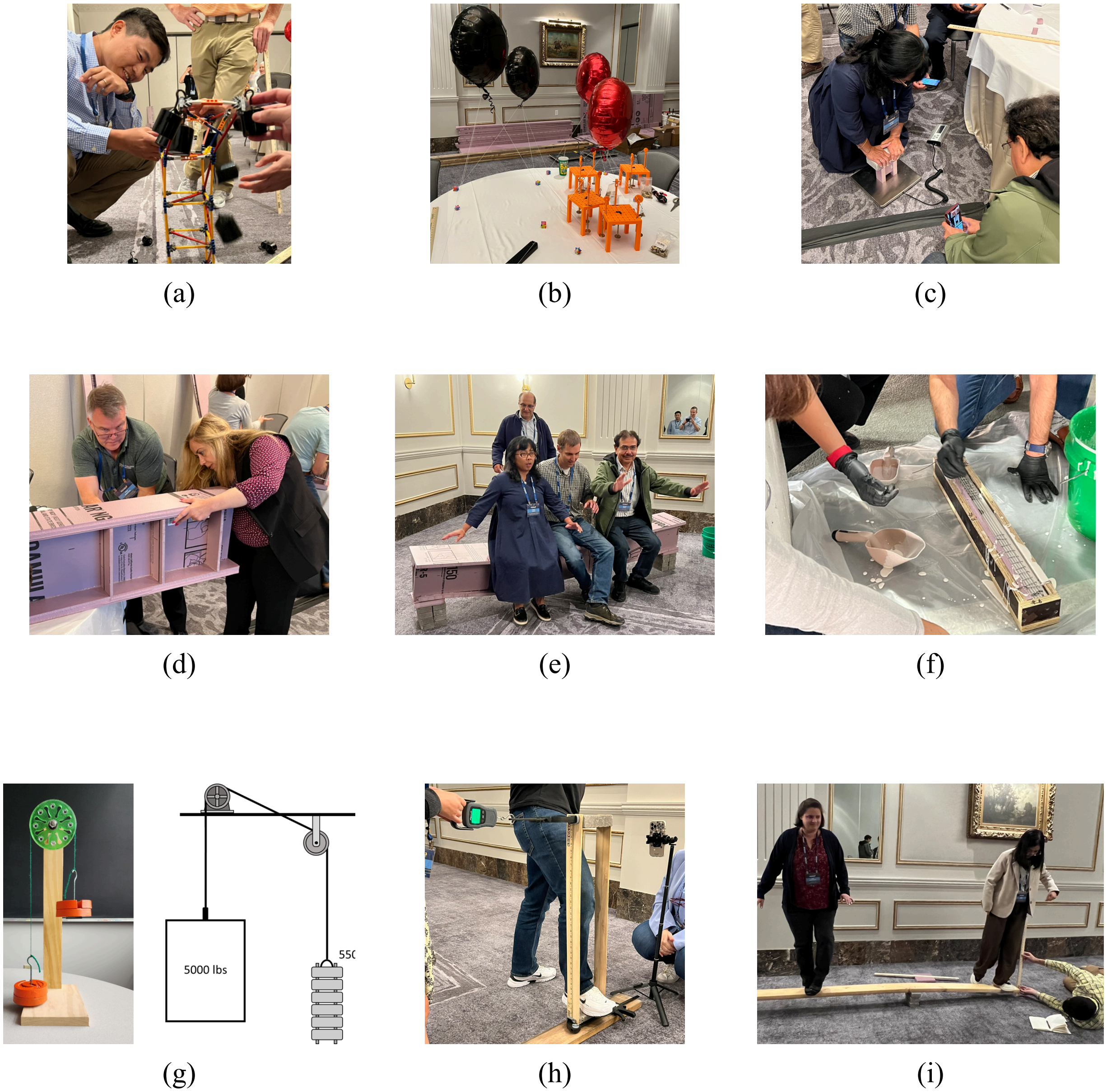

Figure 1. Examples of the modules including (a) K'Nex Tower Challenge towers under construction and loading; (b) Balloons bring excitement to the classroom and pose a statics and siting challenge for designers installing stayed aerial energy generators in a community; (c) Testing foam specimens for weld strength; (d) Rigid foam plate girder construction; (e) Plate girder testing; usually to failure; (f) 24-hour reinforced concrete beam construction; (g) Pulley panic model and physical demo; (h) Participants are using a contactless phone measurement application to determine the stiffness of wooden yard sticks; and (i) Deflections of determinate beams explored with participant loading.

Participant Demographics
As stated previously the 2023 EMCE workshop included 18 participants from 18 universities/institutions - 14 of the participants completed the EML pre-survey (Cohort 2023). The 2024 EMCE workshop consisted of 28 participants from 26 institutions - 28 of the participants completed the EML pre-survey (Cohort 2024). Respondents represented a variety of academic levels and appointments - Teaching Assistants / Graduate Students (2), Instructors/Lecturers (4), Assistant Professors (13), Associate Professors (14), and Professors (8). Participants were 69% male and 31% female, and 14% of the participants were from an underrepresented minority group.

Quantitative Assessment
Participants were asked to rate their personal understanding of the EM at each of the survey stages in the EML survey. Table 5 summarizes the results from the pre-event, post-event, and post-intervention EML surveys. Figure 2 shows the same information in box and whisker format to illustrate the change in perception over time. It should be noted that the response rates for both the post-event survey and the post-intervention survey are lower.

Table 5 - Participant Understanding the the Entrepreneurial Mindset

Participant Self-Perception of Entrepreneurial Mindset Proficiency								
Cohort	Timeline	N	No Experience or Proficiency	Basic Knowledge	Novice Proficiency	Intermediate Proficiency	Advanced Proficiency	Avg. Score
2023	Pre Event	14	0	5	5	4	0	2.93
2023	Post Event	10	0	2	1	4	3	3.80
2023	Post Implementation	7	0	0	2	5	0	3.71
2024	Pre Event	27	2	7	8	8	2	3.04
2024	Post Event	21	0	2	3	11	5	3.90
2024	Post Implementation	4	0	0	0	2	2	4.50

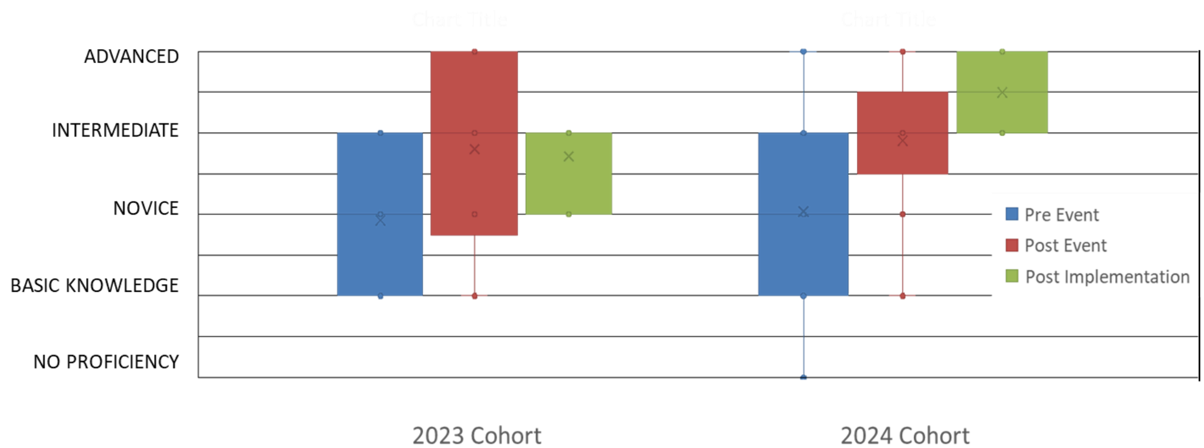

Figure 2. Box-Plot Comparison of Participant Proficiency with the Entrepreneurial Mindset Over Time.

Before the worksop, most participants reported having some basic level of understanding of EM principles. However, the results show that participants reported an increase in proficiency immediately after the workshop. There was also an increase in proficiency reported after the first implementation of EML activities by participants. While the data is too small to make sweeping conclusions, this data would suggest that the workshop is effective at helping faculty develop a better understanding of the connections between EML and the civil engineering discipline. As might be expected, the comfort and proficiency increased after having a chance to practice these activities independently.

Four additional questions on the post-event EML survey asked participants to rate their perception of the effectiveness of the workshop. The questions were framed on a five point Likert scale: Strongly Disagree (SD), Disagree (D), Neutral (N), Agree (A), and Strongly Agree (SA). Figure 3 shows the results from the four workshop effectiveness questions. As is seen in the Figure, responses to the effectiveness of the workshop were extremely positive - 40 of the 41 respondents agreed or strongly agreed that they felt equipped to incorporate EML activities in their classroom as a result of the workshop. Respondents also reported overwhelmingly that the card effectively prepared them to develop EM content (34/41 - A or SA), participate in active EML activities (40/41 -A or SA), and learn about best practices for incorporating EM methods using best pedagogical practices (34/41 - A or SA).

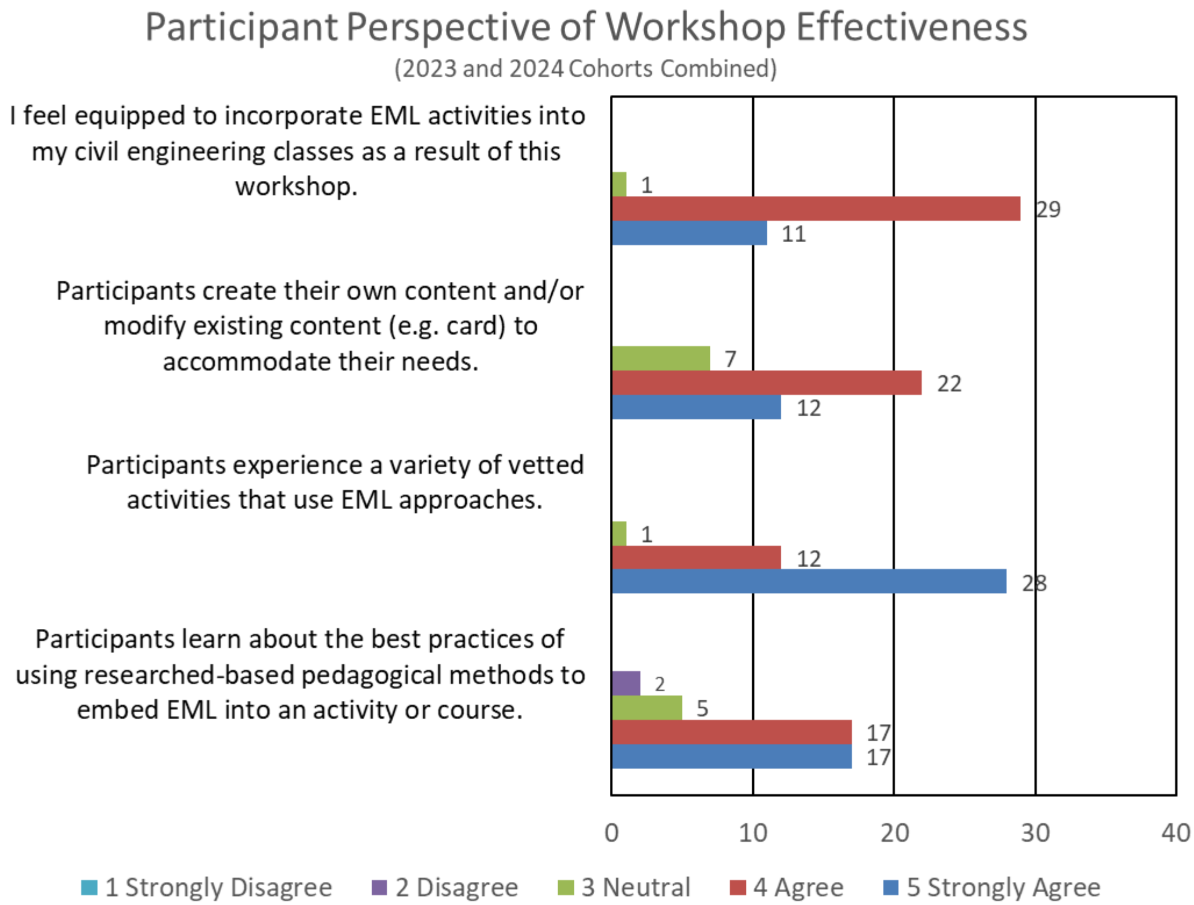

Figure 3. - Participant perspective of Workshop Effectiveness.

Qualitative Assessment

For the pre-event, post-event, and post-intervention EML surveys, participants were also asked to provide a definition in their own words for each of the following terms: Entrepreneurship, Curiosity, Connections, and Creating Value. The responses were reviewed and coded for themes. Since the response counts were low, in particular for the post-workshop results, a statistical comparison was not completed. However, differences in themes and quality of responses are discussed.

Entrepreneurship - Overall, pre-workshop responses tended to focus on foundational concepts like value creation, creativity, and proactivity, suggesting a general understanding of entrepreneurship as a blend of innovation and initiative aimed at solving problems or creating impact. Several responses related entrepreneurship to business or product development.

Based on the analysis of post-workshop responses, definitions of entrepreneurship showed a more nuanced and expanded understanding, with recurring themes including: value creation, innovation and creative problem solving, risk management, building ventures, collaboration and community, and thinking beyond conventional boundaries. Responses emphasized application and execution, moving beyond abstract creativity toward practical action. Responses also highlighted a broader societal perspective, incorporating collaboration and community impact.

Curiosity - Pre-workshop responses included the following themes: a desire to know or learn, exploration and questioning, openness, and innovation. The provided definitions reflect a traditional understanding of curiosity as a drive for knowledge, primarily centered on individual growth and intellectual exploration.

The themes that presented in post-workshop responses were quite similar to the pre-workshop responses, but they tended to be more in-depth. Discovery, exploration, and openness themes persisted. Responses also included a shift toward appreciation curiosity in relation to broader societal or collaborative contexts.

Connections - Themes between the pre and post-workshop responses remained consistent. Themes included collaboration (relationship connections, diverse perspectives), integration and synthesis (connections related to complexity), and creativity and critical thinking (connections of ideas). Responses in the post-workshop survey were more detailed rather than abstract.

Creating Value - Pre-workshop responses included generic terms like "better," "improve," "solutions," and "opportunities." Engineering, and Civil Engineering are mentioned in the responses, but the use is primarily as a contextual example. Post-workshop responses seem to make stronger alignment between professional responsibilities, leveraging opportunities for impact, societal purpose for creating impact, and motivating the pursuit of engineering.

In addition to survey data, the workshop facilitators gathered post workshop participation data. The workshop facilitators served as coaches to the participants after the workshop. The goal was for every participant to implement an EML activity in their class and document it with a card. As part of this process, each participant from the workshop met with a small group of three to five other participants four times during the academic year (September to May). Small groups were developed during the workshop based on interest area and upcoming teaching assignments. These meetings were also attended by two facilitators (coaches) from the workshop. The goal of these virtual meetings was to encourage implementation of EM ideas into their respective curriculum, help solve any implementation problems, and document the process and results in a formal card on the Engineering Unleashed website. In the year following the first workshop, approximately half of the workshop participants attended multiple meetings. While only five completely finished their cards out of the 18 participants, one third of the participants attended every followup meeting, 61% attended at least half of the meetings and half of the participants reported that they included an EM lesson or activity into at least one class or lab.

The timeline of the second workshop was changed to encourage more participation in EM activities after the workshop. Small groups were formed upon arrival at the workshop on the first day and additional small group time was dedicated to discussing possible EML activities for their individual classes. In addition, a draft “card” and at least one EML activity was created by every participant prior to leaving the workshop. The attendance at the small group meetings after this workshop increased. Nearly 41% attended all of the meetings and two thirds attended at least half of the meetings. Every member had a plan in place and most implemented at least one activity within the first four months after the workshop. Providing more time to tailor the activities to a participant’s classes saw improved implementation based on the small group feedback and participation rates.

Conclusions and Recommendations

The workshop discussed herein was the first civil engineering specific faculty development opportunity offered through KEEN’s *Engineering Unleashed* faculty development program. The workshop extensively uses active and experiential learning techniques to engage participants in example classroom activities to enhance their knowledge of the entrepreneurial mindset in the context of civil engineering and to help boost their creativity in their own EML-related content for their respective courses. Over the course of two offerings, 46 participants ranging from graduate students to full professors participated in the workshop. The assessment results showed an average increase from “Novice” to “Intermediate” in their self-reported entrepreneurial mindset proficiency when comparing participants’ pre- and post-survey responses. Furthermore, the majority of participants felt the workshop was very effective across the board and their knowledge of entrepreneurship and KEEN’s three Cs (curiosity, connections, creating value) appeared to grow in depth by how well participants defined each before and after the workshop. The workshop has filled a gap in faculty development by teaching civil engineering faculty about EML by using EML and active learning strategies. This approach has increased the call for more faculty development in other disciplines using a similar format, which is currently under development.

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