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Measuring Students' Interdisciplinary Competence and Entrepreneurial Mindset based upon Exposure to a Holocaust Narrative

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Introduction

The responsibilities of engineers are constantly evolving to meet the demands of an ever-changing world. Today, industries are looking for engineers who possess skills outside of engineering, such as strong communication and interdisciplinary team-working skills [1]. As the responsibilities of engineers change, the educational methods for training engineers must also be modified to prepare undergraduate engineers for success in this new workplace. In order to meet the demands of this changing industry engineers must be able to think entrepreneurially, work with a wide variety of disciplines, and have strong interpersonal skills [1]-[4].This study seeks to understand if the use of an interdisciplinary narrative affects engineering students' entrepreneurial mindset (EM) and interdisciplinary competence.

Entrepreneurial mindset has many accepted definitions within literature [5]. One definition from McGrath and MacMillan defines EM as "[the] ability to rapidly sense, act, and mobilize, even under highly uncertain conditions" [6, pp. 15]. Other definitions relate more to "a growth-oriented perspective through which individuals promote flexibility, creativity, continuous innovation, and renewal" [7, pp. 968]. What these definitions have in common is that EM relates to a person's ability to react to changes and capitalize on opportunity. The Kern Entrepreneurial Engineering Network (KEEN) attempts to tie together these varying definitions of EM using the 3C's—curiosity, connections, and creating value—which encourages individuals to look for solutions outside of the boundaries of technical engineering [8]. Recent economic trends suggest that innovation and entrepreneurship are the key to economic growth, thus a more entrepreneurially minded engineer is demanded in the workforce [1]. The role of a technical engineer has also evolved into a "team-player entrepreneur" [3, pp. 2], someone who can provide engineering solutions in a much broader context.

Another important facet of educating the modern engineer is exposure to interdisciplinary experiences and projects. Like EM, the term interdisciplinary has many varied definitions [9]. One common definition of interdisciplinary competency is "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline or profession" [4, pp. 3]. Other descriptions state that "interdisciplinarity has often been characterized – and implicitly defined – as borrowing; researchers or instructors borrow concepts, theories, or methods from one discipline for use in another" [10, pp. 15]. What these definitions have in common is their emphasis on teamwork across disciplines. Engineers with this ability are desirable in today's industry, as new developments in research and social technology require interdisciplinary knowledge [1], [3]. Additionally, supporting issues of social change requires close collaboration with other disciplines [11]-[12]. Positive social impacts are created through solutions that are efficient, effective, and sustainable, which are pillars of engineering problem-solving [13].

As developing students' EM in undergraduate engineering education has grown in importance, interdisciplinary active learning is becoming more common [14]. Ireland et al. and Klein's definitions of EM and interdisciplinarity show that some engineering problems, the solutions to which are rooted in different disciplines, require a flexible, creative, and innovative perspective [4], [7]. Social enterprises are also interested in innovative, marketable solutions that ensure financial sustainability and feasibility for the organization, as well as creating a positive impact on the society they serve [11]-[12]. Therefore, not only are these ways of thinking important on their own, but it is practical to teach them together. This study seeks to understand how an interdisciplinary narrative embedded into an undergraduate engineering design class can contribute to students' development of EM and interdisciplinary competence. The interdisciplinary narrative used in this study involved testimony, biography, photos, and data related to the Holocaust, compiled into a "story" that the students followed over multiple weeks. The narrative structure was used because students tend to relate better to personal stories and information over traditional lectures – they are drawn to the lives and cultures of others to which they can relate [15]. Topics on genocide and crimes against humanity were chosen because these "hard histories" contain relevant STEM topics, but they are not the main focus. Rationale for using the Holocaust as a focal point in an engineering classroom can be summed up by Eric Katz, who writes that we should "begin with this fact: engineers, architects, and other technological professionals designed the genocidal death machines of the Third Reich." [16, pp. 572]. While the narrative and supplemental case studies which were presented for this study focused on the Holocaust and other human rights issues, the goal of their integration was to help the students make connections and think more broadly about the impacts their judgements may have in the engineering field.

Background

This section will provide an overview of entrepreneurial mindset and interdisciplinary competence integration within engineering to provide context for the study.

Entrepreneurial Mindset and Engineering Education

Entrepreneurship education (EE) has long been a popular field of research; EE began at the Harvard Business School after the conclusion of WWII [17]-[18]. This year will mark 75 years since the introduction of EE in the curriculum of higher education [19]. At the beginning of the 21st century, many disciplines outside of business took an interest in integrating entrepreneurship into their curricula, including engineering [17]. These programs have a wide variety of goals, spanning from creating new business ventures to developing an entrepreneurial mindset in students [20]. Most recently, there has been a push for incorporating EE into the curriculum for undergraduate engineering students, which includes developing students' entrepreneurial mindset (EM) [20]-[24].

A variety of methods have been explored for integrating EM into the undergraduate engineering curriculum. EM interventions are often found in classes that involve problem solving and design-based assignments, particularly in the first year of an engineering degree [21]-[23]. These interventions are usually experiential entrepreneurship learning activities, which can include "creating a business plan, consulting with practicing entrepreneurs, interviewing potential customers, delivering pitches, applying for grants, and prototyping a minimal viable product (MVP)" [21 pp. 2]. An example of in-class EM interventions might include a prompt that has students designing for a "customer" and encourages them to think entrepreneurially in response [21]-[23]. This type of work also typically involves working in groups [22]. Other faculty might choose a different approach to integrating EM into the classroom, such as using film to educate engineering students about the importance of entrepreneurship [24]. Still others might use more technical approaches, such as a CAD- or programming-based projects with a focus on EM [3], [22]. The broad scope of EM lends itself well to a wide variety of solutions for integration into the engineering curriculum.

Interdisciplinary Competence and Engineering Education

Similar to EM, there also exists a movement to integrate interdisciplinary skills into the engineering undergraduate curriculum. In the late 1960s, the Organization for Economic Cooperation and Development (OECD) conducted an international survey of interdisciplinary activities at universities [4]. It was found that there are five major origins of interdisciplinary activity: "Development of science, student needs, need for professional training, original needs of society, and problems of university functioning and administration" [25, pp. 44-48]. With collaboration with other disciplines more predominant than ever, these motivations are still relevant, and appear alongside some newer goals [4]. There has been a recent push to ensure that interdisciplinary content is instilled throughout the curriculum for undergraduate engineering students [1], [10]-[11], [14], [26]. Scientific progression and assessment is negatively impacted when disciplines are separated and do not communicate effectively [26], and addressing engineering problems might require work outside of traditional engineering disciplinary bounds [1], [11]. Hirsh et al. argue that interdisciplinary collaboration gives entry-level engineering students a good foundation in engineering design strategies, as well as helps them to gain experience in problem solving, communication, and teamwork, which will prepare them for advanced courses or industry [27].

Currently, there are not many widely accepted methods of integrating interdisciplinary concepts into engineering. Research shows that the majority of interdisciplinary teaching in engineering is through case studies, team-based work, cooperative learning/cross-disciplinary team projects, and industry collaboration [14], [28]-[29]. Barry et al. notes that the most common case studies in engineering classrooms are "Ford Pinto design issues (1970s), Three Mile Island accident (1979), Kansas City Hyatt Regency walkway collapse (1981), Chernobyl (1986), Challenger accident (1986)" [28, pp. 675]. Despite the ethical, business, and/or historical implications of these case studies, they are still restricted by their labeling as "engineering disasters" [28]. When it comes to cooperative learning, most engineering courses offer collaboration between engineering disciplines (intradisciplinary), not between engineering and wholly different disciplines (interdisciplinary) [27], [30]-[31]. This lack of collaboration with disciplines separate from engineering results in a narrowed perspective on the content being delivered.

Research Questions

This study seeks to answer the following two research questions:

1. How does a narrative-based interdisciplinary case study affect the development of undergraduate students' perception of the entrepreneurial mindset?
2. How is interdisciplinary competence affected by the participation in a narrative-based interdisciplinary case study?

Methods

This study was conducted at a mid-Atlantic university with three sections of a project-based, multidisciplinary engineering design course for sophomore engineering students. The study was conducted during the fall 2021 semester. This study consisted of a total of 54 students, 48 of whom consented to participate in the study. 37 students completed both the pre- and post-survey requirements. The survey for data collection was distributed in the first and last class. The survey consisted of questions from the Engineering Student Entrepreneurial Mindset Assessment (ESEMA) [32]-[33] and the interdisciplinary skills, reflective behavior, and recognizing disciplinary perspectives scales from the Educating the Engineer of 2020 Student Survey [9], [34], which, for the remainder of the paper, will be referenced as a measure of interdisciplinary competence [9].

Interdisciplinary Narrative

An 8 week humanities narrative discussing topics of genocide and crimes against humanity, mainly focusing on the Holocaust and its link to engineering, was used as the case study for this class. This topic was selected because of the connections that can be made between Nazi engineers and scientists, and their involvment with the crimes commited during the Holocaust. Due to the structure of a typical engineering program, there might not be space in the students' curriculum to take courses in history at all, possibly never digging into topics specific to the

Holocaust or other genocides. By relating these topics back to engineering, it is possible that students will understand these topics better, hopefully then being able to link them back to their work as engineers. Reinforcing this content knowledge with a direct application to student interests in engineering provides space for personal reflection and growth, which may otherwise be absent. The Holocaust serves as a strong historical foundation to discuss many types of human rights violations and other injustices which are still present today and that were impacted by decisions that were made by individuals serving in engineering and science based roles.

The narrative, which was created with help from faculty from the Holocaust and Genocide studies program on campus, focused on a labor subcamp of the Auschwitz concentration camp system. The camp, often called Auschwitz III Buna or IG Auschwitz, was active during the Holocaust and was one of the largest forced labor camps at Auschwitz. Auschwitz III Buna was created to supply Buna-N (nitrile) rubber, a German-created synthetic rubber, to the Third Reich for use in other manufacturing applications. This intervention was shared in documentary-style video segments and played aloud at the beginning of class. The narrative, which was crafted from a variety of primary and secondary sources, contained relevant photos and videos, as well as a voiced over reading of information pulled from relevant sources.

The Buna factory narrative was designed to have the students follow two specific individuals: Primo Levi and Otto Ambros. Primo Levi was an Italian-Jewish chemist who was imprisoned in the Auschwitz III Buna camp and was subjected to hard physical labor, and Otto Ambros was a Nazi chemist and the head of the rubber production installation at the camp. Focusing on these two men gave students the perspective of a prisoner in the camp as well as that of a Nazi scientist. This narrative was broken down into four main sections: creation and history of Auschwitz, Auschwitz III Buna camp conditions, Nuremberg Trials, and Operation Paperclip.

While students listened to a new chapter of the Buna story most weeks, there were a few other case studies which were added to help support student learning outcomes. These included Henry Ford's Fordlandia [35], the Challenger Explosion [36], and the Volkswagen emissions scandal [37]. These case studies were chosen because of their connection to the manufacturing and application of rubber in industry, or to the automobile industry which connected with the engineering lab activities (discussed in the following section).

All narrative information and case studies presented to the class were coupled with in-class activities meant to reinforce the learning objectives. These activities included individual written reflections, class-wide discussion, and group activities. Class-wide discussions and individual reflections typically consisted of questions requiring reflection on what was just played for the class, for example: "How do you think the story provided relates to engineering decision making?". Alternatively, group activities might encompass more of a hands-on approach, such as the following prompt: “Compare and contrast the two manufacturing environments (Auschwitz and Fordlandia), create a visual depiction in Mural that captures the similarities and differences”.

Engineering Labs

The engineering labs were conducted after the narrative and case study activities were presented each week and all focused on rubber manufacturing and its associated applications. This direct tie between the narrative/case studies and the engineering lab was made to help students draw connections between what they had just heard and what they were doing in their design projects. The semester was split such that the first third of the semester focused on rubber laboratory testing, while the last two-thirds focused on an engineering design-build-test project.

During the laboratory testing portion, students performed various strength tests on different types of rubber. This included tensile tests and puncture tests on unmodified rubber, as well as tensile tests on rubber samples that had been heat aged and submerged in liquid. Students tested nitrile (Buna-N), neoprene, styrene-butadiene (SBR), and silicone rubber samples and recorded their results. Students then documented their findings in an IMRAD style report. During the design project portion of the course, students were tasked with designing rubber tires and bumpers for a small robotic car. They were able to prototype their design using Shore 95A TPU filament to 3D print their designs. Teams then tested their designs by completing a set of challenges and an obstacle course. The theme of rubber and the automotive industry was carried through the narrative and case studies as well as the lab and design projects. This helped the humanities and engineering pieces feel cohesive and relevant at all stages of the project.

Survey Instruments

Two validated survey instruments were used to examine any changes students may have had in their EM and interdisciplinary competence as a result of participation in the rubber manufacturing narrative and design project.

<u>Engineering Student Entrepreneurial Mindset Assessment (ESEMA)</u>

The ESEMA survey was used as a tool for assessing students’ EM over the course of the semester. This survey instrument was developed based on the Kern Entrepreneurial Engineering Network’s 3C’s - Curiosity, Connections and Value-Creation [32]-[33]. This survey evaluated six constructs of EM, which included altruism, empathy, help seeking, ideation, interest, and open-mindedness. Students responded to questions using a Likert scale ranging from: 1 (“never or only rarely true of me”) to 5 (“always or almost always true of me”) [32]. A published copy of the ESEMA instrument used (derived from prior personal communication with Bekki) can be found in Jackson et al. [38]. Cronbach’s alpha values for data collected ranged from 0.733 to

0.950 for pre-survey analysis and 0.853 to 0.940 for post-survey analysis (Table 1) and are considered reliable [39].

Table 1. Reliability analysis for ESEMA constructs, Pre- and Post-survey

Construct	Pre-Survey	Post-Survey
Altruism	0.913	0.888
Empathy	0.782	0.872
Help Seeking	0.877	0.882
Ideation	0.733	0.853
Interest	0.950	0.940
Open-Mindedness	0.805	0.938

Measure of Interdisciplinary Competence

The second portion of the survey consisted of the interdisciplinary skills, reflective behavior, and recognizing disciplinary perspectives scales from the Educating the Engineer of 2020 Student Survey [9], [34]. These survey questions were used to measure students' interdisciplinary competence over the course of the semester. The survey scales assess eight dimensions of interdisciplinary competence: "1) awareness of disciplinarity; 2) appreciation of disciplinary perspectives; 3) appreciation of non-disciplinary perspectives; 4) recognition of disciplinary limitations; 5) interdisciplinary evaluation; 6) ability to find common ground; 7) reflexivity; and 8) integrative skill" [9, pp. 6]. Cronbach's alpha values for the scales ranged from 0.567 to 0.74 for pre-survey analysis and 0.802 to 0.842 for post-survey analysis (Table 2). The lower values for Cronbach's alpha in the pre-survey data indicate that the students were not answering questions relevant to these scales consistently. This result could indicate that students did not necessarily have familiarity with the language in the prompts that were used, which may have led to differing responses to prompts [40]. Apart from these two Cronbach's alpha values, all others were reliable [39].

Table 2. Reliability analysis for Measure of Interdisciplinary Competence constructs, Pre- and Post-survey

Construct (or Scale)	Pre-Survey	Post-Survey
Interdisciplinary Skills	0.623	0.842
Reflective Behavior	0.740	0.833
Recognizing Disciplinary Perspectives	0.567	0.802

Survey Data Analysis

After the survey data was collected, statistical analyses were performed to determine if any changes occurred in students' EM or interdisciplinary competence. Descriptive statistics including the mean for each construct as well as the associated standard deviations were calculated. Paired t-tests were used to determine if any statistically significant differences were observed. Wilcoxon matched pair tests were used to check the validity of the parametric paired t-test due to the lower sample size found in this study. Finally, Cohen's d was determined to measure the effect size associated with any observed changes in constructs over the course of the study.

Results and Discussion

This section will address the results associated with our posed research questions and how they are relevant to existing literature within the EM and interdisciplinary competence fields.

Research Question 1: How does a narrative-based interdisciplinary case study affect the development of undergraduate students' perception of the entrepreneurial mindset?

Descriptive statistics performed showed that all constructs had either no change or increases in their means, except for open-mindedness (Table 3). Two constructs, altruism and ideation, were seen to have or be approaching statistically significant increases between pre- and post-assessment [41]. These two constructs were also approaching a medium effect size, showing a greater difference between the pre- and post-survey results [42]. While there were changes in the other constructs, they did not show statistical significance in the paired t-test, and all had a low effect size [42].

Table 3. ESEMA descriptive statistical analysis results

	Pre-Survey		Post-Survey		Paired t-test	Effect Size
Construct (# of items)	**Average**	**Std Dev**	**Average**	**Std Dev**	**p-value**	**Cohen's d**
Altruism (4)	4.06	0.87	4.43	0.66	0.08	0.48
Empathy (3)	3.83	1.02	3.84	0.90	0.854	0.0104
Help Seeking (5)	3.41	1.11	3.46	1.18	0.666	0.044
Ideation (11)	3.23	1.00	3.57	0.88	0.001	0.36
Interest (3)	3.79	1.07	3.93	1.02	0.434	0.134
Open-Mindedness (8)	4.71	0.55	4.63	0.60	0.299	0.139

Altruism "measures an interest in making a positive contribution to the world" [32 pp. 5]. All of the constructs for the ESEMA survey instrument are represented in the KEEN defined 3C's, but the construct altruism aligns most closely with value creation [32]. The increase in the altruism construct could suggest that students have a better understanding of creating value. Altruism is a key trait in driving social change, as it relates to factors in solutions that aren't purely technical in nature [11], [43]. Students showed an increased appreciation for this approach to problem solving based upon statistically significant improvements in their responses to questions such as "I care about solving problems important to society" ($p = 0.014$) and "It is important to me to contribute to the good of society" ($p = 0.025$). Some claim that engineering should be inherently humanistic, and that interdisciplinary cross-over into a technical discipline presents opportunities to create value in a broader context; that is to say that solutions should be useful and create positive impacts [44].

The narrative presented to the students was grounded in crimes against humanity and genocide, with a primary focus on the Holocaust. Within the content of the Holocaust narrative, there were direct quotes pulled out from Primo Levi's first-hand account of the atrocities committed by the Third Reich at Auschwitz III Buna. In listening to Levi's story, it is likely that students could concretely identify and understand the relationship between cause (prejudice and lack of ethical leadership) and effect (poor working conditions and inhumane treatment), and hence better understand how they, as engineers, could have affected these events. Perhaps the emotional severity of these topics struck a chord with the students, suggesting that, following the case study, students were more interested in social justice and creating social change. Many people argue that engineering, while technical in nature, also plays a significant role in societal change and progression [11], [16], [43]-[44]. Increases in students' altruism indicate that following the interdisciplinary narrative, it was important to students to reflect on issues present in the world and create positive social change.

Another construct that had a statistically significant increase was ideation. The ESEMA survey defines ideation as a tool to "measure enjoyment in generating ideas and challenging the status quo and … persistence through setbacks" [32, pp. 5]. Ideation, similar to altruism, has some overlap in all 3C's, but aligns most closely with value creation [32]. Ideation can be difficult for engineering students early in their program as exposure to a variety of solutions and engineering problem-solving experience is low, so they tend to fixate on a single concept or idea [45]-[48]. Results obtained may indicate that students feel more confident questioning and challenging common solutions, and thinking more broadly about the problems they face as engineers. Students' understanding of the complexity that arises when approaching engineering problems was supported by statistically significant improvements in items such as "I tend to work on problems that do not have clear solutions" ($p = 0.017$) and "I would rather work with what is unfamiliar than what is familiar" ($p = 0.011$).

Other questions such as "I like to reimagine existing ideas" ($p = 0.011$), and "I prefer to challenge adopted solutions rather than blindly accept them" ($p = 0.010$) likewise showed changes that were statistically significant. This may indicate that participating students were able to understand the importance of diversity in problem solving, encouraging them to pursue multiple pathways in design task decisions [45]. Diversity in engineering problem solving can subsequently drive innovation and value creation, leading to a more “entrepreneurially minded” engineer [1], [3], [8].

Fundamentally, topics surrounding the Holocaust can be difficult for students. Seeing changes in altruism may not be overwhelmingly surprising due to the inherently emotional nature of the content. Both altruism and ideation are oriented towards value creation [32], suggesting that a possible outcome of this intervention is that students actively want to pursue positive social change by evaluating the perspectives of others and challenging current solutions [1], [11], [16], [44]. This hopefully pushes students to ask questions and consider the viewpoints of others while engaging in their own work, therefore potentially building a more humanistic approach to engineering.

Research Question 2: How is interdisciplinary competence affected by the participation in a narrative-based interdisciplinary case study?

Descriptive statistics and statistical analysis results for the measures of interdisciplinary competence were also compiled (Table 4). It was shown that there are statistically significant increases in interdisciplinary skills and recognizing disciplinary perspectives. Wilcoxon matched-pairs test results were found to support the results obtained from the paired t-test and likewise demonstrated statistical significant differences in these two constructs. Reflective behavior showed a small effect size, while interdisciplinary skills and recognizing disciplinary perspectives were at or approaching a medium effect size [41]-[42].

Table 4. Measure of Interdisciplinary Competence descriptive statistical analysis results

	Pre-Survey		**Post-Survey**		**Paired t-test**	**Effect Size**
Construct (or Scale) (# of items)	**Average**	**Std Dev**	**Average**	**Std Dev**	**p-value**	**Cohen's d**
Interdisciplinary Skills (8)	3.96	0.74	4.22	0.70	0.01	0.36
Reflective Behavior (2)	4.09	0.71	4.27	0.75	0.13	0.246
Recognizing Disciplinary Perspectives (3)	3.68	0.67	4.07	0.71	0.001	0.565

The interdisciplinary skills scale “assesses students’ perceptions of their abilities to think about and use different disciplinary perspectives in solving interdisciplinary problems or to make connections across academic fields” [9, pp. 8]. The increase in this construct may demonstrate that after the introduction of an interdisciplinary narrative in the classroom, students believed they improved their ability to see connections and opportunities in other fields, thus broadening their scope of problem solving to include more than just technical engineering skills. Example items that support this observation include “I see connections between ideas in engineering and ideas in the humanities and social sciences" (p = 0.014) and "Given knowledge and ideas from different fields, I can figure out what is appropriate for solving a problem" (p = 0.003).

In other research, participation in interdisciplinary curricular or co-curricular activities have shown that students' interdisciplinary skills improved; this could include a variety of activities, such as non-engineering clubs and projects, study abroad programs, and humanities-based engineering activities [34]. The intersection of engineering and other disciplines is powerful in engineering design value creation, so much so that some institutions have developed engineering curricula that have a strong emphasis on interdisciplinary content [14]. Combining experts from different disciplines creates value in industry and research [1], [26]-[27], so implementing interventions in engineering education can help ensure this competency is made before students graduate.

The other construct that showed a statistically significant change and medium effect size was recognizing disciplinary perspectives. This construct "taps students' perceived understandings of disciplinary knowledge, methods, expectations, and boundaries and how disciplinary knowledge might be applied in different situations" [9, pp. 8]. The increase from pre-survey to post-survey could indicate that the case study helped students understand how to apply knowledge outside of engineering to a variety of different scenarios. In particular, students shared improvement in this ability through statistically significant increases to the items "If asked, I could identify the kinds of knowledge and ideas that are distinctive to different fields of study" (p = 0.002) and "I'm good at figuring out what experts in different fields have missed in explaining a problem/solution" (p = 0.001).

Increases in recognizing disciplinary perspectives supports the notion that interdisciplinary competence in engineering students makes them more aware of ongoing social issues and can encourage widespread societal social change [11]-[12], [49]; the support of social change stems from close collaboration with other disciplines [12]. The narrative and case studies which were presented in the coursework focused heavily on situations where the motivation was social change and reform. The increases in students' perceived interdisciplinary skills and recognition of disciplinary perspectives suggests that they have confidence in their ability to design for good in their problem-solving work as engineers.

The intervention for this study was focused on coupling engineering and humanities rather than presenting these topics as separate. This approach helps students make connections between these disciplines, which otherwise may not have occurred. Engineers in industry are already required to design for perspectives other than their own [1], [14], [26]-[27]. Therefore, better interdisciplinary competence can further increase value in engineering design solutions [14], motivate positive social change, and benefit a larger community of customers [11]-[12], [49]. The narratives and case studies presented in the class may have helped students to better understand the application of these interdisciplinary skills within their own field. Engineers who are able to recognize disciplinary perspectives other than their own and apply these interdisciplinary linking skills to their design solutions will be more valuable in the workplace [1], [4], [10]-[11], [26]-[27].

Limitations

There were a few limitations to this study such as the small sample size and single institution implementation. Only 37 students completed both surveys and consented to participate. Due to the small sample size and focus on a single institution, the results may not be generalizable outside of this context. We also acknowledge that demographic factors could influence the results obtained and would be an important area of investigation in future studies.

Conclusions

As the engineering industry evolves to meet the demands of a broader society, engineers must be able to adapt to address these changes effectively. EM education embedded within the engineering curriculum has been shown to help prepare students for meeting these societal changes. In providing students the opportunity to develop an EM, it is also important to ensure they develop competency within other disciplines to encourage them to consider solutions not readily tied to engineering itself. Pairing EM with interdisciplinary competence as part of the engineering curriculum can allow engineering students to look at problems from different perspectives and potentially identify more innovative solutions.

This study exposed sophomore level engineering students to interdisciplinary content in a narrative style to make the content more relatable and personal. Analysis of changes in students' EM and interdisciplinary competence indicates that skills relating to altruism, ideation, interdisciplinary skills, and recognizing disciplinary perspectives, improved to the point of statistical significance, while all other constructs and factors (excepting open-mindedness) were maintained if not demonstrating increases (although not statistically significant). This suggests that the case study was successful at building both a better understanding of EM and interdisciplinary competence in undergraduate engineers. Improvement in these constructs could suggest that, following this case study, students better understand how to develop engineering solutions which might have components that are situated in other disciplines [1], [9], [14], [32]. The results of this study demonstrate that students are able to improve their interdisciplinary competency and entrepreneurial mindset through exposure to emotional, extra disciplinary content, which makes them an asset to growing technological industries and social enterprises [1], [2], [3], [4], [9], [11]-[12].

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