Creating a Nature-Inspired Entrepreneurially Minded Manufacturing Podcast to Bolster Technical Communication Skills

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Abstract

Manufacturing-oriented engineering degree programs have traditionally emphasized strong scientific content but without a robust curriculum dedicated to communication across national, cultural, contextual and disciplinary boundaries. The interconnected economic environment of modern manufacturing requires graduates with the communication skills to thrive in an environment of entrepreneurially driven innovation and collaboration. The emphasis on socio-technical communication within the manufacturing-oriented engineering curriculum remains sparse. This calls for the need to develop innovative pedagogies that can help enhance the employability of students. In response to this need, an exploratory study was conducted at a satellite campus of a large, Midwestern research-focused university. The intervention included the implementation of an entrepreneurially minded and communication-focused project, developed by the instructor of an upper-level undergraduate manufacturing course. Post-completion of the project, a metacognitive reflection assignment was administered to the participants and subsequently, data was collected. Participant responses were qualitatively analyzed using thematic analysis which led to the discovery of three themes: (1) identifying value in nature-inspired design, (2) confidence in communication and self-expression, and (3) benefitting from peer feedback. The study aims to supplement traditional teaching techniques with an entrepreneurial and multidisciplinary-minded project that helps students reinforce skills that are relevant for the globally connected world. The results indicate that the intervention successfully motivated students to develop their communication and collaboration skills. The findings of this study showcase the effectiveness of entrepreneurially minded and communication-focused projects that engineering instructors should consider integrating into mid-level discipline specific engineering coursework.

1. Introduction

1.1 Problem Identification

The global connectivity offered by modern technology brings numerous advantages to advanced manufacturing, but this diverse interconnected social and economic network also introduces unique challenges to individuals entering the workforce. Manufacturing-oriented engineering degree programs have traditionally emphasized strong scientific content, but without a robust curriculum dedicated to communication across national, cultural, contextual, and disciplinary boundaries. The interconnected economic environment of modern manufacturing requires graduates with the communication skills to thrive in an environment of entrepreneurially driven innovation and collaboration. Unfortunately, limited literature exists which focus on socio-technical communication within manufacturing coursework. This is particularly problematic considering the high percentage of engineering graduates who enter the manufacturing workforce each year [1-3].

1.2 Current Approaches to the Problem and Associated Gaps

There are agencies and programs designed to address these needs. First, the NSF I-Corps program [4] applies customer discovery to assist with the translation of lab-developed technology into commercializable products and services. Such programs offer entrepreneurial

training, yet these programs external to the university that focus on impactful communication are often difficult to obtain. Furthermore, their intended participant is generally someone with the time allotted by their position to produce academically competitive applications, such as graduate researchers and research-oriented professors. These programs have the potential to exclude those with the most need such as core discipline instructors with a Clinical or Professor of Practice that often have no research obligation, but have a large impact on undergraduates due to their high teaching loads.

Second, accreditation bodies also recognize the need for communication, and require this element to be included in an accredited undergraduate engineering program. An example is in ABET's requirement in Criterion 3, Outcome 3, which is "an ability to communicate effectively with a range of audiences". While accreditation agencies do require communication-focused elements to be integrated within the curriculum, such activities are typically required only once over a four-year curriculum, which offers limited sufficiency to form a reinforced habit in the students.

Third, at the individual university or program level, a technical writing requirement is common for many undergraduate degrees in engineering and technology. For example, traditional technical writing courses tend to be required for many disciplines within a university and built from the viewpoint of the humanities. While these courses do introduce widely applicable fundamental skills, students will often miss the value as it relates to their chosen studies in technology due to the lack of engineering context and limited integration of modern digital media technology.

1.3 Proposed Solution

In response to the gaps highlighted previously, this exploratory work documents the implementation of an entrepreneurially-minded and communication-focused project that was developed by an engineering instructor for an upper-level undergraduate manufacturing course (MFET 37400 – Manufacturing Integration 1). To promote socio-technical communication skill development, students created audio podcasts using modern digital approaches to media production and content distribution. Unlike current approaches to improving entrepreneurially-minded communication skills in engineering students, which results in limited access and participation, this pedagogical approach allows all students within a class to obtain exposure to this type of skill development. In this way, the skill development has been integrated into a core discipline-specific course within the undergraduate curriculum, thereby offering both relevant professional context and an experience curated specifically for manufacturing engineering undergraduates. The following research question was used to guide this study:

- *What are the student perceptions of participating in the creation of an entrepreneurially-minded manufacturing podcast with a focus on digital distribution to a non-technical audience?*

2. Background

2.1 Entrepreneurially Minded Learning (EML)

Entrepreneurially Minded Learning (EML) is a pedagogical approach emphasizing discovery, opportunity identification, and exploitation to create value [5]. Engineering education,

in particular, is often seeking to create "real-world" experiences and to foster innovative thinking. As such, EML has been shown to be effective at developing these value creation elements in engineering students [6, 7]. While EML is widely accepted to be stackable with other pedagogical methods [8, 9], inclusion of additional material on top of existing coursework has the risk of overburdening students. Yet, a more balanced integration may add to the workload of instructors if additional training and course development is required. Also, despite adoption across a broad range of disciplines, EML is frequently defined differently based on in-discipline context [10], highlighting the critical role that transdisciplinary communication has in creating value, especially in the engineering classroom.

2.2 Technical Communication in Engineering Education

Employers have increasingly emphasized the need for engineering graduates to have training in communication to support effective collaboration across national, cultural, contextual and disciplinary boundaries [11]. In fact, technical communication training has been shown to have a positive impact on a graduate's ability to adjust to jobs and achieve career goals [12]. A technical communication elective has long been a requirement at top universities, but only a fraction require instruction that is integrated within the engineering context [13, 14]. Success has been shown when offering integrated experiences using appropriate tools, and in a diverse context [15], but inclusion of this type of curriculum is not as common as requiring traditionally structured communication courses. There are many opportunities to integrate communication-focused projects into the classroom using modern media such as audio podcasts.

2.3 Podcasting in the Classroom

Audio podcast usage in the classroom has been increasing over the last decade [16]. Both teacher- and student-produced podcasts have been implemented in K-12 and higher education settings in a broad range of disciplines such as in engineering, humanities, and mathematics [17]. Student-led podcasting has the potential advantages of engaging students by utilizing a modern and familiar format, deepening learning of the subject by requiring a translation from technical research to spoken media, and allows students to share their work broadly on a publicly accessible platform. However, podcast implementation within engineering education is more commonly used as a content delivery pedagogy by instructors [18, 19]. In cases where the podcasts are student-generated, content is often limited in distribution by sharing among in-discipline peers through non-public channels [20, 21].

This study showcases the results of an entrepreneurially-minded and communication-focused engineering class project. The work created with the following methods was intended to have students synthesize nature-inspired manufacturing-related research into a format appropriate for a general audience, produce podcasts with standardized tools, and distribute their work through publicly accessible services.

3. Methods

3.1 Participants and Study Design

The study participants included seven students enrolled in an upper level undergraduate course (MFET 37400 Manufacturing Integration I) offered at a satellite campus of a large research-focused university. This campus primarily consists of students in the Midwestern

United States that intend to remain in the region and join the manufacturing sector of the workforce upon graduation. Seven students participated in the assignment, consisting of five males and two females ranging in age from 18-22.

The nature-inspired podcast creation curriculum was implemented over a 16-week semester as six modules that occurred concurrently with the regularly scheduled weekly topic lectures and laboratory activities for the course. In general, the module flow guided students through researching their topic from multiple perspectives (Modules 1 and 2), translation of their compiled research to a format appropriate for a general audience (Modules 3 and 4), and finally to production and distribution of their podcast episode (Modules 5 and 6). The modules contained the assignments and schedule of completion deadlines that are shown in Table 1.

Table 1. Completion date schedule for assigned podcast development modules.

Module	**Topic**	**Weeks**	**Assignment and Deliverables**
1	Historical background research	1 - 3	Preliminary Research + Online Discussion: Research to find a manufacturing process of interest that was inspired by a biological process. Summarize your findings in a short paragraph on the course discussion board, review the other posts, and reply with your thoughts to two other posts with the least replies.
2	Entrepreneurial application research	4 - 5	Market Analysis + Online Discussion: Focus on the modern applications of your process from the first step. Identify the companies, products, and industries that are affected by this process. Summarize your findings in a short paragraph on the course discussion board, review the other posts, and reply with your thoughts to two other posts with the least replies.
3	Translation from technical research to storyboard	6 - 7	Present Storyboard: Present your findings with the class. Review supplemental material on podcasting guidance (storyboarding, tone, etc.). Create a storyboard for your podcast.
4	Storyboard revision	8 - 9	Peer Feedback: Class-wide 2-min Tuning Protocol (Appendix 6.1), then storyboard an informational 5-8 minute podcast again (or modify your original plan)
5	Production planning	10 - 13	Update Storyboard Based on Feedback: Look at and address provided revisions, practice for time and consider format items (intro/outro, other sound items?)
6	Podcast production and distribution	14 - 16	Final Project + Reflection: Produce final podcast(s) and upload for distribution. Complete the final Metacognitive Reflection.

3.2 Data Collection

The data was collected using a metacognitive reflection assignment consisting of two sections, with three questions in each section. The first set of three questions (Table 2) made use of photovoice reflection prompts [22] that asked students to reflect upon lessons learned by completing the semester-long project. The second set of questions (Table 3) was comprised of three standard reflection prompts that assessed the students' opinion of the course-level implementation, experiences, and transferrable skills obtained. Students submitted a single document containing their responses to the six prompts at the time of their final podcast submission.

Table 2. Assessment topics and prompts for part 1 of the data collected.

Directions	
Please respond to the photovoice reflection prompts using three pictures (e.g., photo) and writing a narrative (e.g., voice). The narrative (minimum of 200 words for entire response) should reference the pictures and their relationship with respect to your response.	
Assessment Topic	**Prompt**
Entrepreneurial Mindset	Photovoice Reflection Prompt A (Entrepreneurial Mindset): The entrepreneurial mindset is defined as "the inclination to discover, evaluate, and exploit opportunities." Explain how participating in the newly developed curriculum incorporated the entrepreneurial mindset, and lessons learned relevant to the entrepreneurial mindset.
STEAM	Photovoice Reflection Prompt B (**STEAM**): STEAM (science, technology, engineering, arts, math) goes one step beyond the well-known STEM to acknowledge the importance of integrating the arts and humanities into more analytical coursework such as that found within engineering. Art can be incorporated through pieces, process, and movements. Explain how participating in the newly developed curriculum incorporated STEAM (specifically, the arts), and lessons learned relevant to STEAM (specifically, the arts).
Bio-Inspired Design	Photovoice Reflection Prompt C (**Bio-Inspired Design**): Bio-inspired design uses the nature-focused context of sustainability, security, and/or biomedicine and health outcomes to motivate analogical thinking and improve the engineering design process. Explain how participating in the newly developed curriculum incorporated bio-inspired design and lessons learned relevant to bio-inspired design.

Table 3. Assessment topics and prompts for part 2 of the data collected.

Directions	
Directions: Please respond to the open-ended reflection questions with a minimum of 200 words per questions. Be sure to check assignment for spelling and grammar prior to submission.	
Assessment Topic	**Prompt**
Interdisciplinary	Open-Ended Reflection Question A (**Interdisciplinary**): The interdisciplinary approach of integrating the entrepreneurial mindset, STEAM (specifically, the arts), and bio-inspired design has been shown to improve student engagement, motivation and learning outcomes. How

	did this interdisciplinary learning experience affect your ability to engage with the newly developed curriculum?
Project Debrief	Open-Ended Reflection Question B (**Debrief**): What went well? What didn't go so well? What will you do differently next time?
Connection to Real World	Open-Ended Reflection Question C (**Connect to Real World**): What skills did you learn? Please consider both professional skills (e.g., communication, collaboration, etc…) and context specific skills (e.g., topic area). Why are these skills important for engineers in the real world?

3.4 Data Analysis

The authors performed a preliminary thematic analysis [23] of the qualitative data to determine common outcomes of the students' experiences. The three most prominent themes (e.g., patterns discovered across at least four students) were selected for discussion in this article, and direct quotes are included with this analysis to allow the reader to independently judge the conclusions drawn by the authors [24].

4. Results

The themes that emerged from the preliminary thematic analysis are (1) identifying value in analogous system solutions, (2) confidence in communication and self-expression, and (3) benefitting from collaboration and critique from multiple viewpoints.

4.1 *Identifying Value in Nature-Inspired Design*

It is critical for engineering professionals to have a firm grasp of fundamental technical principles, as well as an ability to assess value in existing systems. Engineering graduates entering the manufacturing workforce are expected to have the capacity to analyze existing systems and understand complex manufacturing methods regardless of their engineering discipline, and to apply those methods in other scenarios if necessary [25]. In general, students indicated that they recognized the value of nature-inspired design despite never receiving specific training on this topic, as evidenced by the following quotes:

- *The creation of a podcast about biomimetic engineering incorporated the entrepreneurial mindset by making me **realize that several important technologies today are derived from nature**, that these technologies could help extend the longevity of humankind on Earth, and these technologies have the possibility to be used everywhere.*
- *I was **able to see physical representations of a lot of real-life problems**. It was very inspiring for me and helped in changing the way I may try to solve complex problems.*
- *As a class, **we all discovered many instances in which nature inspired a technical design** that improved our world in some way.*
- *I felt that **this project was overall a great learning experience** to help us learn more about these nature-based designs.*

4.2 *Confidence in Communication and Self-Expression*

A key element of learning is the students' confidence in their ability to complete tasks. In general, the student data showed that there was an appreciation for the collaborative elements of

the project that was beneficial to their overall confidence in their communication and self-expression. Examples are demonstrated by the following quotes:

- *I feel **I could express portions of my own personality through this podcast** because I am the one who crafted the outlines, edited the music, and combined both information and sound into one unified podcast to my liking. This activity could be performed 100,000 different ways, but my own podcast is unique compared to other infinite amounts of podcasts out in the market.*
- *In the information age giving speeches to a virtual audience and editing is one that is very necessary to have. Thanks to this class **my skills in oral presentation and editing have gone up substantially**, and it may be a hobby I will put more effort into in the future.*
- *I learned communication and evaluation skills. During a certain activity, we reviewed each other's scripts with the constraints of what we could critique, and **it really helped me think about how to help others** in an efficient and orderly way.*
- ***I learned how to speak clearly**, and how to collaborate with others on personal projects. These are all important skills in the field considering oftentimes there is a need to work in teams or to properly critique work.*

4.3 *Benefitting from Peer Feedback*

In general, students can benefit from discussing their ideas with their peers, thereby gaining new perspectives and feedback from other points of view. Similarly, the challenges facing new graduates in technology are increasingly demanding that students are proficient in an diverse interdisciplinary setting. In response, engineering education is also de-emphasizing sorting information and training into silos, and increasing interdisciplinary offerings [26]. Dedicating time to receive peer feedback attempts to facilitate constructive feedback and reinforce its value. Quotes demonstrating this theme are as follows:

- *I liked how the course also allowed us to engage as a class versus solo work or small groups. **It was nice to be able to talk to everyone and get high quality work from their feedback.** It felt unreal that everyone was so invested into the project and actually seemed to enjoy it as well.*
- *Instead of seeing dead ends, **we have been taught to see a world of opportunities** just waiting for us to take advantage of.*
- ***I enjoyed the variety of the lessons and how we were able to learn and apply features from technology and the arts**. The final product was fun and felt fulfilling.*
- ***I felt very engaged in the different aspects of this class and thoroughly enjoyed watching them all come together.** It helped focus on the different pieces and implement them together.*
- *I thought the slow progression of the project went well. I enjoyed researching the topic, then writing about it, then using the past discussion boards to help in writing a script and eventually recording. **I also really enjoyed the activities we did in which we all reviewed each other's script and helped each other out.***
- *While very similar to communication, speaking is probably the most difficult form of communication so **practicing speaking and revising the script will help a lot** with public speaking and presentation skills.*

4.4 Summary and Discussion

The analysis of the data with regards to the research question, *What are the student perceptions of participating in the creation of an entrepreneurially-minded manufacturing podcast with a focus on digital distribution to a non-technical audience?*, can be supported by relating the themes present in this work to education theory. Motivation is critical to the success of students in rigorous technical programs, and a valuable outcome of implementing this curriculum. Ambrose et al. defined the key ingredients for motivation are in the student seeing value in the activity, believing in their ability to succeed, and having a supportive environment [27]. The interaction of these three characteristics and how they contribute to the student's learning mindset is depicted in Figure 1.

It can be seen that the first theme of the podcast project data, *identifying value in analogous system solutions*, aligns directly with seeing value. Realizing the value of their individual perspective is reinforced by seeing the benefit to their peers. Awareness of this value can increase confidence in their ability to achieve a desired result, indicating alignment of our second theme with efficacy. Finally, the quotations supporting the third theme, *benefitting from collaboration and critique from multiple viewpoints,* indicate a supportive environment. The alignment of the major themes from this study with the factors in motivation implies that this curriculum was effective at motivating the cohort of engineering students during their introduction to the entrepreneurial mindset within an advanced manufacturing context.

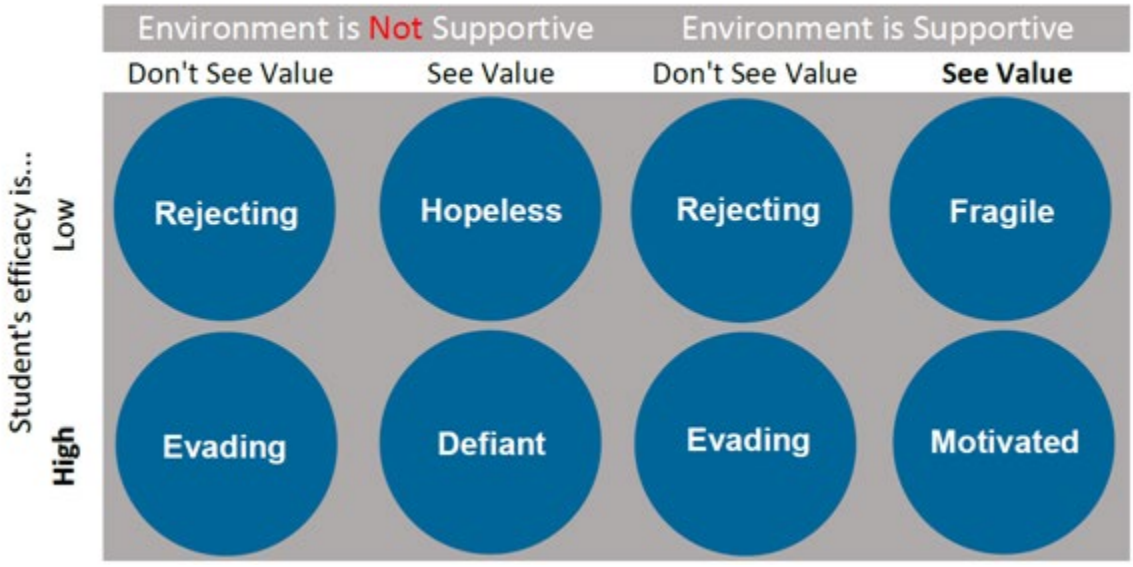

Figure 1. Interactive Effects of Environment, Efficacy, and Value on Motivation [23]

4.5 Lessons Learned

There were a number of practical lessons learned throughout the implementation of this project that could help educators looking to replicate this pedagogical approach. First, students benefitted from practice exposure to photovoice reflections at multiple stages of the project. This eliminated confusion related to the format of the final data collection assessment. Next, it is recommended that instructors verify that the software selected for each module is accessible and supported by asynchronous examples and documentation. This will allow students to make self-

paced progress, at a time of their choosing, and without interrupting the flow of required course content. Finally, instructors should consider encouraging the participants to discuss the project with each other and make space for occasional informal guided discussion in class to keep them motivated. This can be done by offering a forum on the university's learning management system or allowing time at the end of class for discussion. Details of the software used, and additional implementation strategies can be found in the Engineering Unleashed Card URL (https://engineeringunleashed.com/card/3148) in reference [28].

5. Conclusions

5.1 Practical Summary

Albert Einstein is famously credited with the quote, "If you can't explain it to a six-year-old, you don't understand it yourself." This sentiment captures the spirit of educating engineering and technology students in communication with a broad audience, across disciplines, and in diverse contexts. Novel approaches to teaching technical communication are needed to fully convey the critical skills asked of future graduates in interdisciplinary manufacturing-related disciplines. The work outlined in this article aims to supplement traditional teaching techniques with an entrepreneurial and multidisciplinary minded project that helps students reinforce skills which are relevant for the globally connected world. Due to the effectiveness of these types of projects, as demonstrated in the Results section, engineering instructors should consider integrating these types of projects into mid-level discipline specific engineering coursework.

5.2 Limitations and Future Research

This exploratory study must be considered within the context of relevant limitations. First, this early work was developed within a single Manufacturing Engineering Technology course for junior and senior level students, and with a small initial student sample. The impacts of this work have yet to be explored in detail across other technical disciplines. Due to the limited curriculum run thus far, only a single software suite was explored and superior alternatives may exist. Future work will include quantitative data collection and explanatory analysis, and will seek to implement this content in additional courses.

5.3 Acknowledgements

This content was created through the author's work with the Kern Entrepreneurial Engineering Network (KEEN) and ASU Mentorship 360 programs. For more information and additional shared content, go to EngineeringUnleashed.com.

6. Appendix

6.1 Two-Minute Tuning Protocol

The two-minute tuning protocol is a process used to generate constructive peer feedback. There are six steps that are repeated for each participant in the group, and each member takes a turn in the "presenter" role. The six steps to be performed are:

1. **Summary of Plan (2 min)** - The presenter summarizes their work to the group without interruption. They will be cut off at 2 minutes.
2. **Clarifying Questions for the Designer (2 min) -** Clarifying questions are to understand procedural, or contextual matters of fact. The presenter's answers are

one sentence or less; often yes or no. Save substantive questions (the "whys" and "hows") for the "I wonder" section. Example questions are:

1. "Will you give us the project prompt first or the content instructions first?"
2. "What is the initial prompt?"
3. "How much will the materials cost?"

3. **Silent Reflection (2 min**) - Everyone silently reflects/re-reads any provided materials to prepare for the feedback rounds.
4. **Feedback Round 1 (3 mins)** - Participants provide feedback beginning with "I noticed…" to comment on what was presented. The presenter does not respond.
5. **Feedback Round 2 (3 mins)** - Participants provide feedback beginning with "I wonder…" to provide additional feedback on topics to explore or expand. The presenter does not respond.
6. **Presenter Reflections (1 min)** - Presenters can now speak and reflect on what they heard. They don't need to respond to individual comments, this is their time to share how their thinking has changed as a result of what they heard. It's acceptable to just say, "Thank you."

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