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Incorporating an Entrepreneurial Mindset, Bio-Inspired Design, and STEAM Approach to Enhance Learning in a Computer Aided Design and Modeling Class

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Abstract

Traditionally, an introductory Computer Aided Design (CAD) and Modeling course involves students learning by drafting models and exercises primarily from textbooks. Whereas this method has been used for a long time and has been very effective in its intended purpose, it does not provide students with entrepreneurial and other professional skills that are increasingly becoming essential for engineers in industry. An interdisciplinary approach that integrates an entrepreneurial mindset, bio-inspired design, and STEAM (science, technology, engineering, art, and mathematics) could potentially provide students with skills they need to face the challenges in the job market and become creative thinkers and problem solvers upon graduation. In this study, an interdisciplinary approach was incorporated in the curriculum that involved students identifying problems in existing products to create new solutions. This involved dissection of an existing product, carrying out functional decomposition to understand the functional relationships between component parts, identifying gaps in the design, and bridging gaps in the designs by either improving the design or coming up with a new design. Given that students carried out these activities in groups, they developed teamwork skills, improved their communication skills, and enhanced their critical thinking skills. A photovoice reflection survey and a set of open-ended questions were used to evaluate the outcomes. Results showed that students were more motivated to learn the course and became more engaged with the projects they were involved in. These results also showed that employing an interdisciplinary approach to teaching an introductory CAD modeling course can have a positive impact on the students' learning experience.

1 Introduction

Modern manufacturing processes, computer-aided design and modeling tools are increasingly integrated to provide features that enhance productivity in manufacturing and design. CAD modeling and design software applications are becoming increasingly necessary within industry, academia and even among freelance designers involved in creating new products and processes. Traditional instructional approaches in CAD and computer aided engineering (CAE) related courses provide fundamental drafting lessons primarily focused on tutorials and exercises from textbooks. These pedagogical approaches limit learners to just understanding how to use the drafting tools in reproducing drawing models and assemblies and hence leading to lack of, or limited opportunities to develop creativity and problem-solving skills. The problem therefore is that engineering students lack opportunities to work on "wicked" or real-world problems.

Current approaches to providing experiential learning include students being exposed to co-ops, internship programs, summer undergraduate research programs [1], and through the integration of capstone design courses [2] in an engineering academic program. Other initiatives include the Kern Entrepreneurial Engineering Network (KEEN), which is a partnership of more than 50 colleges and universities across the United States that serves as a lab to test and showcase best practices in entrepreneurially-minded learning, influence on institutional curricular change for greater impact [3]. Another experiential learning experience is through the Virtual Student Federal Service (VSFS) program which is an eight-month unpaid remote internship program managed by the Office of e-Diplomacy in the U.S. Department of State's Bureau of Information Resource Management, for U.S. citizen students, college-level and above, who would like to make a real difference in the work of the U.S. government.

Internships, coops, summer undergraduate research programs and VSFS programs require buy-in from faculty and students. There is, therefore, a need for more research to expand the literature on curriculum interventions that promote a holistic approach that fosters curiosity, creativity, problem-solving, and faculty buy-in.

In this study, we provide an interdisciplinary approach to Computer Aided Design and Modeling curriculum that integrates an entrepreneurial mindset, bio-inspired design, and STEAM (Science, Technology, Engineering, Arts, and Mathematics) to provide real-world experiential learning to better prepare engineering students for entering the workforce. Such learning experiences will ensure that students develop employability skills, a lack of which could lead to graduates missing out on rewarding careers [4]. The proposed solution will ensure every student gets access to real-world learning.

The outcome of incorporating an entrepreneurial mindset (EM), bio-inspired design (Bio), and STEAM elements in a computer aided design and modeling class was evaluated in this study. According to Lau *et al* 2012 [5], integration is the ability to be involved in all aspects of an enterprise and being a strong systems thinker able to make sense of complexity. People who take an interdisciplinary approach can easily identify and evaluate opportunities, explore these opportunities, and create solutions that provide value to the stakeholders. Hence the research questions addressed in this study are: What are the student-perceived learning outcomes associated with completing an engineering project integrating the EM, Bio, and STEAM? What student perceptions result from participating in entrepreneurially-minded engineering coursework? To answer these questions, this study reviews the literature on the current approaches that provide experiential learning to students in an engineering curriculum and presents a case study of curriculum intervention that promotes an interdisciplinary experiential learning approach in teaching a computer aid design and modeling class.

2 Literature Review

Higher education plays a key role in the development of human capital in any economy. Engineering schools prepare graduates with the technical skills they need to address the challenges facing the world. However, technical skills alone do not adequately prepare these graduates to address the so-called real-world wicked problems. Further, the job market is rapidly changing to require that the graduates preparing to enter the market be equipped with not only technical but also soft skills for them to be competitive in the market. Studies have shown that 62.3% of graduates with technical degrees lack employment because of a deficit of employability skills [6]. Complex real-world problems require employability skills or transferable skills. Employability skills include the ability to "solve complex multidisciplinary problems, work successfully in teams, communicate effectively, practice good interpersonal skills [7], and approach problems with an entrepreneurial mindset [8]. This requires graduates to develop an entrepreneurial mindset influenced by their knowledge, experience, competency, and behavior [8]. Having an entrepreneurial mindset encompasses having the ability to see opportunities, marshal resources, and create value; such skills are of high demand in both for-profit and not-for-profit entities [8].

Current approaches to integrating employability skills in the curriculum include students being exposed to co-ops, internship programs, or summer undergraduate research programs [1], that are typically short-term often occurring during the summer. Another popular approach is incorporating a capstone design course [2] in the curricula, which is normally encountered towards the end of an engineering student's academic program, typically within the last two semesters of college. Another initiative is the Virtual Student Federal Service (VSFS) program. For more than a decade, the Virtual Student Federal Service (VSFS) program has been offering virtual internship opportunities for students, which they can do from anywhere in the country. However, there is insufficient awareness of the VSFS program's facilitation, expansion, and marketing [9] and therefore, it is unknown to most institutions and /or students.

In recent years the Kern Entrepreneurial Engineering Network (KEEN) has been working to address this problem by identifying ways of integrating entrepreneurial education in KEEN member universities [3]. This is achieved through providing grants to faculty to incentivize curricular change focused on three areas including developing pedagogical methods to build and instill entrepreneurship knowledge and skills in students, how to measure instilling of the entrepreneurial spirit in graduates, and how to measure commercialization of research outcomes from its member institutions [10]. However, not all institutions have joined this network, and not a lot of information is out there on these initiatives, especially for institutions whose members have not had a chance to attend the American society of Engineering Educators (ASEE) conferences.

To ensure that engineering graduates are empowered with the requisite skills they will need to get employment and to grow in a corporate environment, we incorporated an interdisciplinary project into the engineering/STEM/university classroom via three perspectives: EM, Bio, and STEAM.

An entrepreneurial mindset is a way of thinking that emphasizes creativity, innovation, risk-taking, and a focus on opportunity rather than problems. Individuals with an entrepreneurial mindset tend to be proactive, persistent, and adaptable in the face of challenges [11], [12]. According to Hassan et al 2017, [10] and Haung-Saad *et al* 2016 [13], integrating an entrepreneurial mindset into the curriculum will enable students to develop:

- A clear vision of what they want to achieve in their design and course related projects and be able to communicate it effectively to others.
- Creative thinking skills that enable them to constantly look for new and innovative ways to solve problems.
- An understanding of taking calculated risks without fear of failure.
- Resilience and being able to bounce back from setbacks and failures, learning from their mistakes and using them as a springboard for future success.
- Abilities to seek and identify new opportunities to create value and make a difference in the world.

- Abilities to make the most of limited resources and find innovative ways to get things done.
- Collaboration skills to work with others to achieve their goals and build strong networks of collaborators and supporters.
- Abilities to take action to turn their ideas into reality. They are not content with just thinking or talking about their ideas – they take action to make them happen.
- A habit of constantly seeking to improve their knowledge and skills; being open to feedback and willing to learn from their mistakes.

Therefore, incorporating an entrepreneurial mindset into the engineering curriculum can help students to become more well-rounded, adaptable, and effective problem-solvers. It can also open new career opportunities and help engineers make a greater impact in their work [14].

Bio-inspired design, also known as biomimicry or biologically inspired design, is an approach to innovation that looks to nature for solutions to engineering and design challenges [15]. By studying these natural systems, engineers and designers can gain insights into new materials, structures, and processes that can be used to create more efficient and sustainable technologies. Connecting between biological systems and engineering design requires critical thinking and investigation from numerous system levels and viewpoints, thus emphasizing systems thinking [16]. In applying bio-inspired design, functional modeling in engineering is performed analogous to functional decomposition of biological systems [17]. Integrating bio-inspired design approaches into an engineering course fosters creativity and innovation, enhances interdisciplinary learning, encourages sustainable and ethical design, develops problem-solving skills and provides opportunities for real-world applications [16], [18]. This effectively provides engineering students with a more holistic and innovative approach to learning, which can help them to become better engineers and problem solvers.

STEAM integration refers to the integration of science, technology, engineering, arts, and mathematics into an educational curriculum. Integrating STEAM into engineering adds an art and design perspective which helps students develop a more aesthetic sense of design and can contribute to better-engineered solutions [19]. STEAM helps students see the connections between different fields and develop a broader perspective on engineering problems [20]. STEAM integration also enhances problem-solving skills by providing a range of tools and techniques for approaching engineering problems. The arts and design elements of STEAM help students visualize STEM concepts through the viewpoint of the arts [20]. STEAM integration can also help students to develop digital literacy skills, such as coding and data analysis. These skills are becoming increasingly important in today's world, and their integration into an engineering course can provide students with a competitive edge in the job market [21]. Hence, integrating STEAM into an engineering course can provide students with a more comprehensive and interdisciplinary approach to learning, preparing them for careers in a wide range of fields. By encouraging creativity, critical thinking, and hands-on learning, STEAM integration can help students develop the skills they need to succeed in today's rapidly evolving economy.

The next section will explain our approach to incorporating this interdisciplinary project (integrating the EM, Bio, and STEAM) into the computer-aided design and modeling classroom.

3 Methods

This curriculum intervention has been developed based on a comparison of the conventional versus entrepreneur-minded approach to course delivery. Initially, the students were given an overview of the Computer Aided Engineering (CAE) design tools that focused on the fundamentals of AutoCAD and Inventor Modeling software. Thereafter, students in groups of 2-3 were asked to identify a design project based on their dissection and analysis of an existing product or device. The purpose of dissection and analysis was to identify functional relationships between component parts and identify gaps in performance, sustainability, and cost with the aim of coming up with an improved design and functionality. Upon completion and testing of their designs, students were asked to take an evaluation survey to highlight their reflections and experiences during the course as well as highlight the lessons learned during the study period. The survey was done using open-ended questions and a thematic analysis of the feedback from the students was conducted in which case major themes were identified. For a theme to qualify as a major theme it had to be supported by at least four statements from the students' feedback.

3.1 Intervention

In this project, students in a CAD design and modeling class were asked to form groups for the purpose of the hands-on projects that they were involved in during the semester. The major project involved students identifying and dissecting an existing product/device to discover opportunities for improvement or create a completely new design. In each group, each student was initially asked to identify at least one product and bring it for discussion and brainstorming during the group brainstorming meeting. Each group discussed all the products or components that were presented by its members and decided on the product or component they wanted to pursue. Each group then analyzed the functional components of the product, and identified and compared possible alternative environmentally sustainable materials, which could be used for their proposed changes to the existing design or new product. Each group also identified possible manufacturing processes that could be used for realizing the proposed improvement or innovation. The students then used AutoCAD and Inventor graphics software applications to create infographics relevant to both the existing product and the improved design and, clearly communicate the functional and aesthetic differences between them to various audiences. To ensure participants remained focused in executing their projects, they were given guidelines that focused on three focus areas: entrepreneurial approach, bioinspired design, and STEAM.

3.1.1 Entrepreneurial Approach

To help students develop an entrepreneurial mindset, we provided students with the following product dissection sample tasks adopted from Dieter & Smith, 2021 [22], which they could use or develop their own tasks relevant to the product/component they were working on.

1. Clearly explain how the product operates.
2. Identify the conditions necessary for proper functioning of the product.
3. Identify the mechanical, electrical, control systems, or other devices that are used in the product to generate the desired functions.
4. Identify the energy and force flows through the product.
5. Identify the spatial constraints for subassemblies and components.

6. Determine what clearance is required if any for proper functioning.
7. If a clearance is present, find out why it is present.
8. Identify the major subassemblies of the product.
9. Identify the key part interfaces if any.
10. Identify what material and by what process each part appears to be made of.
11. Identify what joining methods are used on the key components.
12. Identify what kinds of fasteners are used and where they are located on the product.

3.1.2 Bio-inspired design

In looking at nature for answers or solutions to design problems, the students were given the following sample tasks adopted from Dieter & Smith, 2021 [22], to guide their nature inspired approach to their design.

1. Properly and completely define performance requirements and service environments of the design.
2. Determine if there is a good match between the performance requirements and the material properties used in evaluating the candidate materials.
3. Fully consider the material's properties and their modification by subsequent manufacturing processes.
4. Find out if the material is available in the shapes and configurations required and at an acceptable price.
5. Translate design functions into required materials properties, and business factors such as cost and availability.
6. Investigate the candidate materials in greater detail, particularly in terms of trade-offs in performance, cost, manufacturability and environmental sustainability.
7. Make a final selection of materials to use for each design improvement.
8. Develop design data and a design specification sheet.

3.1.3 Communicating the design.

Communication is an important aspect of the design process, and to ensure students were able to clearly prepare and present their design, we provided them with the following guidelines.

1. Create 3D models of both the existing and the improved product clearly indicating and dimensioning its components parts as well as the final assembled device or product.
2. Demonstrate the functional relations of the product or device's parts through a simulation analysis in Inventor.
3. Conduct a stress analysis of the design in Inventor and create a summary report of the results.
4. Produce a prototype of your improved product/device through fabrication or 3D printing.

To ensure timely execution of these activities, students were given clear directions with due dates for each activity and a list of references/resources could refer to for further guidance.

3.2 Participants

The study involved 5 students taking a computer-aided design and modeling course (ENGR 1060), four of whom were in their freshmen year, and one student a sophomore. The class consists of four students majoring in General Engineering and one student majoring in Business Management. According to Johnson et al 2006 [23] and Heller & Hollabaugh, 1992 [24] the most effective cooperative learning groups consist of a team of two to three members .Students were therefore asked to form groups of 2 to 3 and choose a leader. The class was given clear guidelines on what was expected of them and the due dates for each of the activities. For each milestone related to the project, students were required to submit their progress reports by the respective due dates.

3.3 Data Collection Instrument(s)

Each student was asked to fill out a metacognitive assessment form adapted from [25], from which data was extracted. The form contained three photovoice reflection prompts and three open-ended questions. The photovoice reflection prompts required students to use three pictures (e.g. photos) to provide a 200-word narrative (e.g. voice) explaining how their learning experience incorporated an entrepreneurial mindset, bio inspired design and STEAM (arts) in the course. The following are the three photovoice reflection prompts the participants were given to answer.

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.*

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).*

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.*

Each open-ended question required participants to provide a reflection (200-word minimum) on their learning experience, insights on any lessons/skills learned and what they would do differently given another chance. The following are the three open-ended metacognitive reflection questions used in collecting data from the participants.

A. Interdisciplinarity: *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?*

B. Debrief: *What went well? What didn't go so well? What will you do differently next time?*

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?*

The anonymously collected photovoice was stored in an accessible folder in a shared drive and analyzed using thematic analysis. A thematic analysis is a step-by-step foundational qualitative process for detecting trends or patterns within the data [26]. Using this approach to analyze the data, we individually and thoroughly studied the data and developed at least six themes each. We then met and reviewed the themes to agree on four main themes to focus on in the study. We further revised the themes and corroborated them with quotes drawn from the data to allow readers to judge credibility, accuracy, and fairness according to Corden & Sainsbury, 2006 [27] approach. The survey results which were then narrowed down to 4 themes are presented in the next section.

4 Results and Discussion

From the photovoice reflections given by the students in the surveys collected, four themes were identified namely, 1.) increased engagement, 2.) enhanced inspiration/persistence, 3.) cultivating creativity, and 4.) increased skills proficiency. An overview of these themes and the supporting statements from students (in *italics*) for each theme is given below.

(1) **Increased Engagement**

Participants acknowledged that the newly developed curriculum helped them stay focused and engaged throughout the course.

> *"Specifically with AutoCAD and inventor, being able to completely use my imagination to create different objects, products, and many other things have helped me stay focused and engaged throughout the term."*

> *"I myself quite enjoyed the art side of the new STEAM approach. I truly believe that it not only helped better my understanding of engineering design, but has given me a reason to stay engaged with the material being presented to me not only in this class but others that I am taking alongside"*

> *"I enjoyed the class more especially because the projects we did enable me realize my potential, think critically, be more engaged and consistent in my work."*

> *"Given the diverse approaches that we took in every step of solving the problem, I became more glued to the processes and wanting to participate more in the group project I was involved in."*

> *"The interdisciplinary approach helped to broaden my understanding of the curriculum and gave me the freedom to think creatively. This enabled me to engage more deeply with the different elements of the learning experience."*

(2) Enhanced Inspiration/Persistence:

Participants expressed their interest in learning more about the topics being discussed in the curriculum/course. Additionally, some participants also felt that the course provided a positive learning environment, thus boosting their motivation and confidence levels.

> *"These skills and many things I learned have given me inspiration and a genuine interest in the course." "Being able to think about how the thing I've learned can relate to real-world pictures, settings, and even emotions have inspired me to continue with the course."*
>
> *"Being able to create something even if it is just on my computer and then get to show it off has to be one of the best feelings I have got to experience yet in my collegiate experience." … "I do believe that through the course the further I got along the more active and happier I was to do the work and want to enjoy it."*
>
> *"The complexity of a 3D printed house makes me think about all of the ways in which engineers have to develop to produce such a device. Knowing about the potential struggle these engineers could have faced and succeeding in making a 3D printer inspires me."*
>
> *"The approach our instructor took made me more interested to learn more, especially the fact that we were asked to come up with projects by just looking at things we use that we are not satisfied with gave me the motivation to understand functionality of things."*
>
> *"Given that we had to work on a project also gave me the motivation and inspiration to continue working and finding a solution knowing that my work may end up developing an invention."*
>
> *"I personally never felt too lost or behind even when I missed lab due to conflicts in my schedule or being out of town for athletic competitions. I personally like the hands-on approach and project-based class. Having the ability to create and show off projects in this class has not only boosted my confidence but has given me hope that I can succeed after college."*

(3) Cultivating creativity:

The participants felt that the new curriculum instilled creative thinking abilities and helped them explore new ideas and opportunities.

> "*The interdisciplinary approach helped to broaden my understanding of the curriculum and gave me the freedom to think creatively. This enabled me to engage more deeply with the different elements of the learning experience and allowed me to explore possibilities I hadn't previously considered."*
>
> *"The new curriculum incorporates the entrepreneurial mindset by taking new subjects and skills, requiring us, as students, to come up with new ideas and creations."*
>
> *"Especially in this class, the artistic skills developed are crazy, you can use them into a lot of fields in any kind of job, even jobs that don't need to touch a computer. Just by learning this stuff, it opens up an artistic part in your brain in the way you see images and drawings"*
>
> *"The new approach encourages ideation and creativity."*

(4) Increased skill proficiency

Integrating the 3 components, EM, STEAM and bio-inspired design, enabled participants to boost their skill proficiency.

> *"However, I feel that the team build tools such as being able to communicate in person and over many different forms of social media and email have also been great tools that I have been practicing in this class, whether it was intended or not."*
>
> *"I learned to communicate better, stop for a second and analyze what a person wants and how I can impact positively."*
>
> *"Furthermore, the ability to manage my schedule to come in out of class time to work on projects and homework was nice to use, however difficult it was in the beginning."*
>
> *"I'm normally a big-time procrastinator, but the project-based approach in this course and the fact that we work in a team has made me learn to program and manage my time better."*
>
> *"I think I have learned that I should set high expectations for myself and work more on my time management skills."*

4.1 Summary of Themes

Based on the analysis of student reflections, enhanced inspiration/persistence was the most dominant theme for the students. Particularly, as engineering students, they found it inspiring to go out of there way and critically analyze the functional performance of devices or products they are familiar with, with the goal of coming up with better designs incorporating both environmental and manufacturability aspects. Being able to decompose/dissect an existing product and developing engineering drawings that they used to come up with improved designs called for a substantial amount of effort and persistence. The hands-on experience approach taken in this course provided both experiential education and problem- based learning opportunities which are highly advocated for by Burke *et al,* (2009) [28]. The responses from the students also indicate that this approach resulted in increased engagement and increased skills proficiency. It is also apparent that embracing curiosity drives creativity and, providing an environment in which students can engage in activities, helps them tap into their creative potential. Collaboration between students also played a key role in sparking new ideas and providing valuable feedback to each other. According to Dochy *et al,* (2003) [29], entrepreneurial mindset is developed effectively when incorporated into the development of the students' technical skills and learning activities.
The four themes in this study align with and support the following three Accreditation Board for Engineering and Technology (ABET) student learning outcomes.

- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

- An ability to communicate effectively in both oral and written forms.

- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Figure 1 shows a visual summary of the different themes discussed in this study.

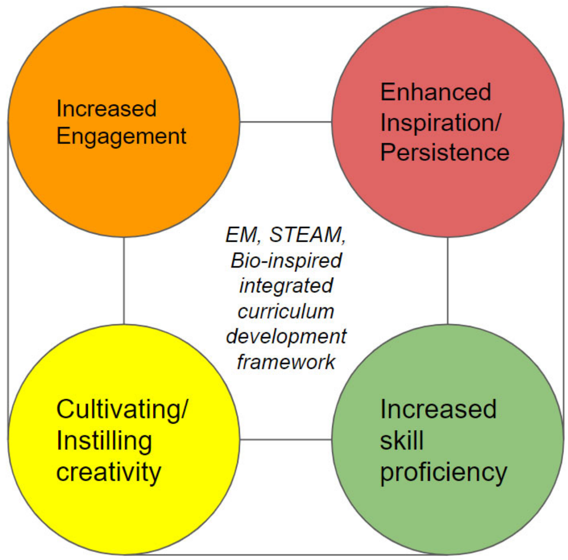

Figure 1: EM, STEAM and Bio-inspired integrated curriculum thematic findings

4.2 Lessons Learned

While students expressed satisfaction in the skills learned using the new approach that incorporates entrepreneur mindset, bio-inspired design and STEAM integration, they appeared overwhelmed and confused at the beginning of the intervention. This was because some of the skills that they needed in problem identification and functional decomposition were introduced one to two weeks into their project and hence they initially appeared to struggle. However, this quickly changed once they were introduced to the relevant concepts. For some students, the concept of having an entrepreneurial mindset didn't quite click initially because they were confusing it with entrepreneurship. It therefore requires clearly explaining to students that we are not training them to be entrepreneurs which they can pursue even while in college, but to have an entrepreneurial mindset, which is developing the thought process and ability to recognize and exploit opportunities to meet needs and create value for different stakeholders. To effectively engage students and cause a transformation in their mindset, proper messaging is therefore extremely critical.

Since this was the first course offering using this approach, students spent more time in identifying a problem, leaving them with insufficient time to accomplish the rest of the activities within the time duration specified for the project. It will therefore be important that in subsequent course offerings, more time be allocated to the project and the preliminary concepts they need for the project be covered earlier in the semester.

5 Conclusion

An integrated approach in teaching a first-year computer-aided design and modeling class that incorporates an entrepreneurial mindset, biomimicry (bio-inspired design) and STEAM components has proved to be beneficial to the participants in the intervention. The intervention enabled the students to develop and enhance vital skills that are important in the fast-changing and increasingly challenging job market. There was positive and favorable feedback from the participants and there was a clear indication that they benefitted and enjoyed participating in the program. Using reverse engineering to understand a device's functionality at the part or component level was especially useful for the students to be able to understand what goes into the design of a product. The students' reflections show that the entrepreneurial approach to the course helped them develop time management skills which are vital in a collaborative environment that is typical in real world engineering practice. The students further marveled how they can easily learn from and be inspired by how nature solves problems analogous to engineering problems that engineers encounter. They also realized that in almost every design that we can think of, there is an art component, be it the design features, aesthetics, quality or even the functional use of the product/device. Important in the design process is the ability to identify opportunities for improvement and generate relevant ideas that could lead to a better design or even an invention. The students' feedback showed that the protocols they were introduced to were very helpful in developing their creative thinking skills, becoming more engaged in the course, and enhancing their collaborative and professional skills.

This work provides some qualitative assessment of the impact of taking an interdisciplinary approach that incorporates EM, Bio-inspired design and STEAM concepts into an engineering curriculum especially in the early stages of the training of an engineer. To ensure a holistic learning experience, activities that ensured students developed an entrepreneurial mindset, reflected on nature to inspire their designs, and developed an artist's perspective were infused into the course curriculum. This research work documents the approach taken and the lessons learned to provide a framework for future improvement and for others to implement.

This intervention was carried out in the first six weeks of the semester over a period of five weeks. Given that the students were supposed to finish their projects within the short duration, it was indeed a fast-paced intervention. Students felt overwhelmed at first due to the amount of information they had to absorb and the activities that they were involved in, with a very short turnaround. It is recommended that such a project be scaffolded over the entire length of the semester. If, however, it must be implemented within five to six weeks, it would most likely produce more and better outcomes in the second half of the semester. The study involved very few participants (five) in a newly established engineering program. It would be interesting to see what the findings would be if the approach was integrated in an average full-size class of 20 to 25 students.

Further research is necessary to evaluate the impact the different components and interactions have on students' interdisciplinary learning and growth.

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