2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #34202

Introducing Entrepreneurship and Innovation in a Design Course

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INTRODUCING ENTREPRENEURSHIP AND INNOVATION IN A DESIGN COURSE

Abstract

Engineers and technologists have a crucial role to play in today's world. Future directions are based on the decisions and actions that we make today. System thinking, problem finding, visualizing, improving, creative problem solving, and adaptability are the six types of cognitive abilities that engineering/technology students need to develop, as identified by the Royal Academy of Engineering. Employers are seeking engineers who are capable of solving problems by creating products from the concept to the market in a short period. It has now become essential for engineers to have an understanding of Innovation and Entrepreneurship. Innovation and Entrepreneurship are two closely related words that go hand in hand in this era. Innovation is about applying creativity to different engineering/technology problems. Coming up with unique solutions and entrepreneurship is about applying the same to bring ideas to life by making it feasible to work. It's also about making the business work.

To summarize, all entrepreneurs are innovative and but not all innovative products had been feasible. In today's world, engineers need to come with a product or a competitive service in the industry in terms of product performance and also perform equally well in the business perspective. In this paper, the authors introduce "Innovation and entrepreneurship" to an existing design course and equip the next generation engineers/technologists with an innovative and entrepreneurial mindset and related core skills.

Keywords

Entrepreneurship, Innovation, Engineering design

Introduction

In today's world, Innovation primarily dictates living standards. Innovation drives entrepreneurship, and entrepreneurship drives new jobs, creates wealth, and finally improves the economy to grow. In short, it's a cascading effect for a nation to be healthy, and it all starts with Innovation.

Most corporate leaders acknowledge that the key to business growth is Innovation, but they are most often challenged on leading and managing the same. They are often hurdled on building an innovation mindset, and usually, it is outsourced activity into the market research and development department in any corporation. Failure to deliver Innovation hurts the business and one's career aspirations within the organization that they work for the potential to improve a product and improve a process. Diversity in thinking and changing a mindset is the foundation for building an innovative mindset. Entrepreneurship is the next level of Innovation when an innovator tries to combine all the resources to come out with a product or process to solve a problem cost-effectively.

The global economy and job scenario trends have shown that the students should have the skills required for the jobs that have not yet been generated. This means that the students should possess a wide range of skills that would meet future requirements, which energizes the interest in Innovation and entrepreneurship programs in engineering and technology programs. There are also many reasons to study entrepreneurship in undergraduate and graduate programs. They are making predictions, visions, and directions with Innovation and producing products and services from the developed technologies. Innovative products are the driving changes, and finally, it's a mechanism to improve the spatial and temporal inefficiency in the economy (Shane, Venkataraman, 2000; Arrow, 1962; Kersner et al.,1997). The course also targets on improving designs based on design review meeting and enhancing multiple thinking within the engineering design process (Pasha Zaidi et al., 2015; Mohammed et al., 2016). Undergraduate curriculums still lack the value of Innovation and entrepreneurship in the curriculum, as the research suggests (Duval-Couetil, Reed-Rhoads, & Haghighi, 2012; Shartrand et al., 2010).

Curricula in Engineering and Engineering Technology programs

Accreditation Board for Engineering and Technology (ABET, ABET-ETAC) and Association of Technology, Management and Applied Engineering (ATMAE) are two leading non-government organizations that set standards for academic program accreditation and personal certification and professional development in the field of engineering and engineering technology. Both the organization haven't explicitly included entrepreneurship and Innovation in their program outcomes, but one can read between the lines that both the concepts are indeed there within the definition of the programs.

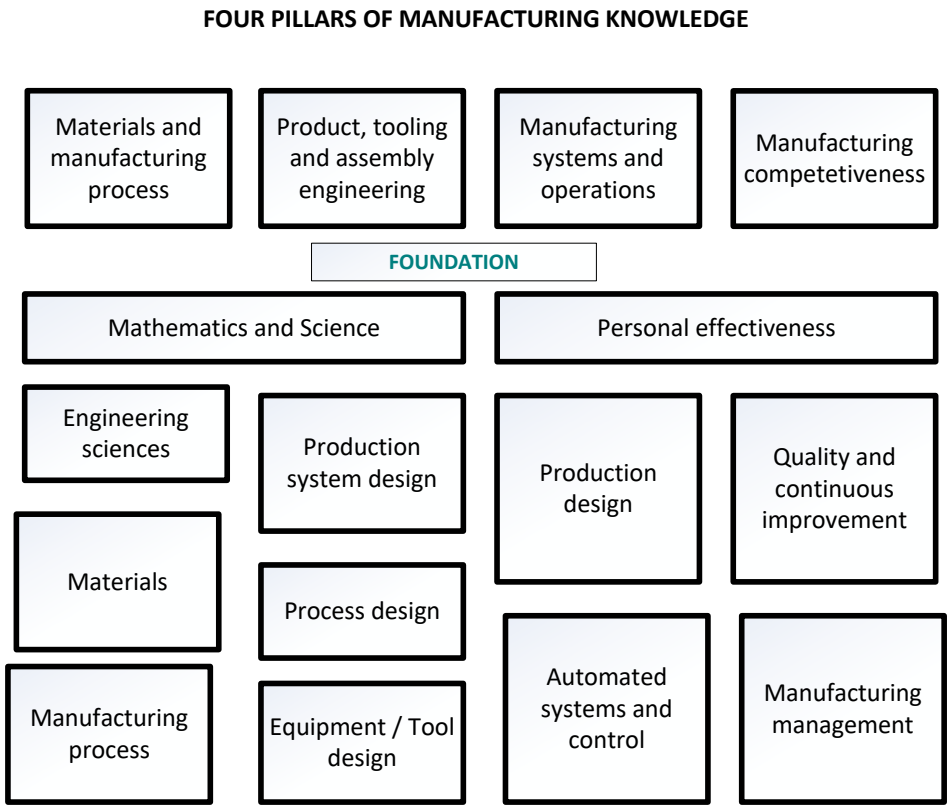
Exhibit 1: ABET ETAC program education objectives

Source: www.abet.org

1	an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2	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
3	an ability to communicate effectively with a range of audiences
4	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5	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
6	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7	an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Exhibit 2: 4 pillars of manufacturing knowledge

Source: www.sme.org

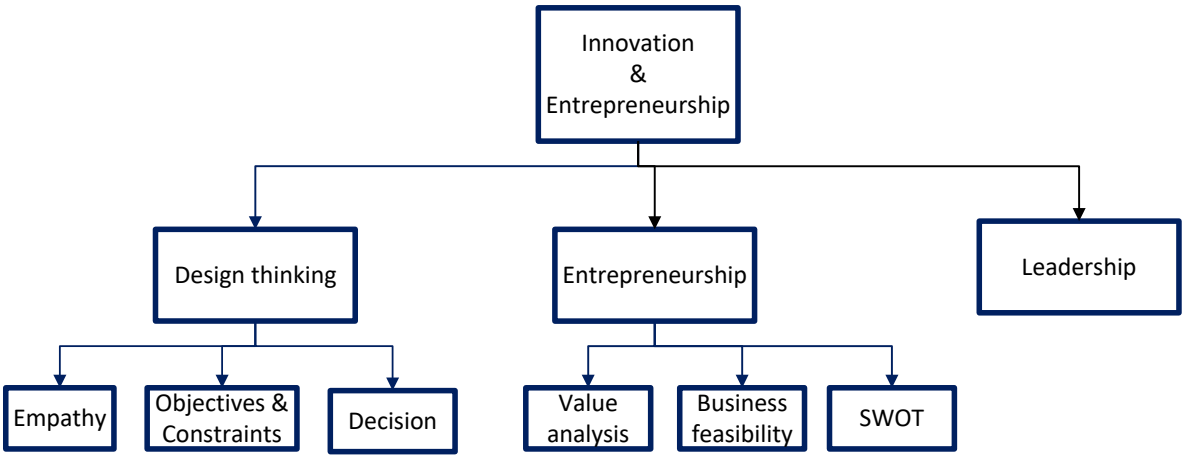


Unemployment is one of the significant economic issues around the world. Fresh university graduates struggle to find jobs that align with their academic backgrounds and qualifications (Brown). Entrepreneurship is one of the main drivers for economic growth, as many studies have shown [7]. Many universities have included entrepreneurship courses to increase entrepreneurship awareness and encourage students to be self-employed instead of only pursuing jobs [8]. The goal is to provide students with tools and skills to be job creators rather than job seekers [9]. All the programs (whether engineering or engineering technology) should document the program's educational objectives. Exhibit 1 shows the ABET's ETAC program objective. ATMAE's educational objectives are mapped to the four pillars of manufacturing knowledge developed by the society of manufacturing engineering (SME) as shown in Exhibit 2. ATMAE Accreditation has formally adopted this concept as a model quality improvement tool and encourages manufacturing programs to utilize components that apply to their programs. The Pillars apply to both technical manufacturing and manufacturing management curricula. A typical entrepreneurship and innovation curriculum consists of three components. The three components are designed to design thinking, entrepreneurship, and leadership. The various topics within each component are shown in Exhibit 3.

If one looks at typical components of an innovation and entrepreneurship curriculum, one could see that it could be easily blended into ABET's and ATMAE's (SME) educational objectives.

ABET's ETAC 1-7 criteria and SME's design components of the process, product, and production design could be well blended into an innovation and entrepreneurship curriculum.

Exhibit 3: Components of Innovation and Entrepreneurship

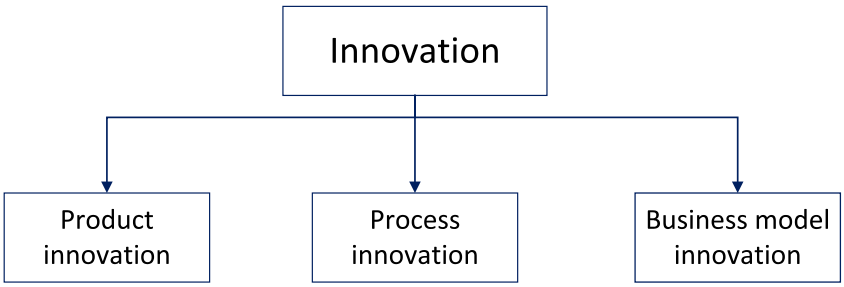


In this paper, authors would like to introduce "Innovation and entrepreneurship" to an existing design course and equip the next generation engineers/technologists with an innovative and entrepreneurial mindset and related core skills. The course that is used to introduce Innovation and entrepreneurship is Constraint-based solid modeling and production drawing (TEC 216), This is a course that is built on prior student knowledge and skills in the study of technical drawing and solid modeling. Students will be using product life cycle management software developed by Siemens (NX) to create intermediate-level solid models, assemblies.

Product Innovation

Innovation can be broadly classified into three types, as shown in exhibit 4. They are product innovation, process innovation, and business model innovation. Within these three types, the scale of Innovation could also vary.

Exhibit 4: Types of product Innovation.



Some of the innovations may be a new cutting-edge product/process/business model, and it might be a small change in how things are done. The introduction of the iPhone or Facebook could be considered a breakthrough product, and the different versions that have come every

year could be considered as incremental Innovation. Breakthrough innovation is rare and incremental innovations are much more common.

Exhibit 4 shows the different ways one can innovate. Any of these types of Innovation can either be a breakthrough innovation or could be incremental Innovation. For TEC 216 class, the type of Innovation that is introduced is the product innovation that would be incremental. This course is not a comprehensive introduction to Innovation and entrepreneurship, but a valuable starting point based on some of the most popular material.

Program outcomes and student objectives from TEC 216

The two program outcomes that are generated from the TEC 216 course are as follows.

- Utilize 2-D and 3-D computer-aided design systems to create designs and models for products, machines, jigs, fixtures, and other mechanical devices used in manufacturing environments.
- Read, interpret, and verify manufacturing documentation such as part prints, plans & specifications, technical models, schematics and diagrams, production plans, tooling plans, quality plans, and safety plans.

The student objectives from TEC 216 course are as follows.

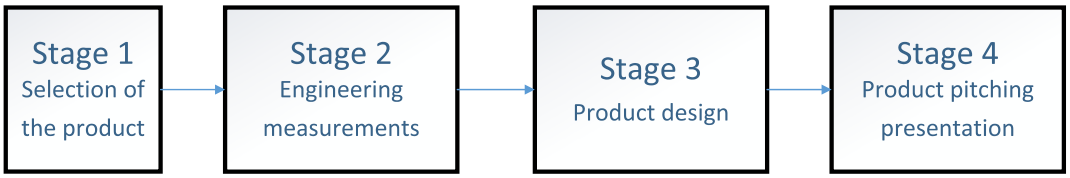
1. Communicate using fundamental concepts, terms, tools, and practices of technical drawing.
2. Understand the central role of CAD in the manufacturing process.
3. Use industry-approved constraint-based techniques in solid model creation.
4. Apply top-down and bottom-up approaches in assembly modeling.
5. Prepare and edit models for use in other CAD systems or other design or manufacturing applications.
6. Apply design knowledge and skills in the production of a variety of intermediate-level detail and assembly drawings.
7. Analyze the mass properties of, and perform necessary interference checks and stress analysis on CAD parts and assemblies.
8. Interpret industry-accepted dimension and tolerance callouts on blueprints.
9. Work in small groups to analyze, plan, model, and present an intricate product design.

The course grade is split between assignments (30%), exams (30%), and a final project with a presentation (40%). If one looks a the program objectives and the associated student objectives, it's quite evident that the topics of entrepreneurship and Innovation (E&I) don't touch. Entrepreneurship and Innovation are introduced as a part of the final team project that the students have to do. The project is introduced as a project management case study, splitting the project into four stages as shown in Exhibit 5.

The first stage and the fourth stage of the project is more focused on the entrepreneurship and innovation part. The second and third stage of the project mostly focuses on the product's design (engineering side). The project is on reverse engineering; the student teams identify a product and then modify a product or a design change on the existing product. The strategic plan aligned

with entrepreneurship and Innovation includes the following: creativity, a novel application of fundamental engineering science, and interdisciplinary activities.

Exhibit 5: Project stages



The product innovation of the identified product would be based on any of the following questions (not limited to)

- How can we reach our customers more effectively?
- How do we make our service more affordable for a larger customer segment?
    - It could be based on material selection / structural change etc.
- Is our product easy to use? If not, how can the product be modified to be ergonomic? What issues are clients facing with delivery?

During the first stage, it is pretty much on understanding and finding the sources of Innovation and strategy as simple rules. Engineering design plays a role in creating a flawless design that would suit the customers. In these stages, the discussion is also done on how to cultivate successful entrepreneurs' mindset and skills. Students would also be asked to add to the statement, "Entrepreneurship is doing much more than seems imaginable with much less than seems possible." Present the definition of Innovation and discuss why both creativity and implementation are crucial.

creativity + implementation = innovation

Creativity is about bringing old ideas to new products, people, and places; creativity is about creating new combinations with existing ideas and importing commonly thought-of things to unique places. Clarify what each term means and what is novel about Innovation related to the engineering design process and the product that they had selected. The focus on the first stage will also be to review types of constraints that appear during Innovation. Students need to understand that constraints, while inevitable, are not always negative. If approached correctly, constraints can propel teams forward in the innovation process rather than stall them. Students in this stage should also be able to differentiate innovative work from routine work and explore when they are appropriate. Communicate to students that Innovation is not something someone should do all the time in every situation, and it requires a different logic than routine work does.

The second and the third stage of the project is very much in the course content, and the final stage is the presentation where the students have to do a value analysis and business feasibility. Then they have to do pitching of the product. One of the essential skills for an entrepreneur is the skill to pitch for the product or to make a case for the product modification idea. Rather than doing a traditional technical presentation, students are required to pitch on the project idea where

they discuss the product, target market based on product innovation, project earning or feasibility analysis, and competition and advantage of the designed product.

Conclusion

A key hurdle for any established programs is introducing a new course to the existing curriculum unless there is a paradigm shift. Entrepreneurship and Innovation have become a big part of the new ecosystem, and academic institutions are at the center of the ecosystem and critical catalyst for the companies and corporations,

This paper has looked at introducing entrepreneurship and Innovation to an existing course and how they can generate the content that defines the start-up's product and can form a business around that product. The variables which describe this capability are the quality of the business, engineering, and technology schools. By this approach, universities can reduce the gap of introducing the E&I concepts and use their synergies with the engineering technology course contents to create an innovative mindset for students.

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