

Integration of Imagination, Creativity, Design, Innovation and Entrepreneurship into Engineering Education

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Abstract

This paper focuses on innovation in engineering education. It outlines an innovative engineering curriculum which integrates the creativity of the arts and music, the perspective of the humanities, the theories of the sciences, methodologies of design, characteristics of innovation, the skill of business, the spirit of entrepreneurship and engineering professions to produce systematic changes in the way we currently educate engineers globally. It discusses the integration of creativity, design and innovation for successful and sustainable new venture creation. This paper addresses strategies and tactics to facilitate the development of new engineering curricular models in the global environment.

Keywords: *Creativity, Design, Innovation, Engineering, Entrepreneurship*

1. Introduction

Imagination, creativity, and design are integrally related to innovation and in the development of a successful entrepreneurial venture. Creativity is the conceptualization and synthesis of new ideas. Design is the language and mode of communication, giving the idea to a shape or form. Innovation is the process of transformation of imagination and creative ideas and design into practical applications. Innovation stimulates entrepreneurship. Entrepreneurs bring the innovation into the market place. This paper focuses on the integration of Imagination, visualization, creativity, design and innovation in engineering education. The core of the new engineering curriculum is a four course sequence: 1) Creativity, Design and Entrepreneurial Mindset, 2) Exploring Entrepreneurial Opportunity in Alternate Energy and Emerging Technology, 3) Design, Innovation and Entrepreneurial Venture Development I, and 4) Design, Innovation and Entrepreneurial Venture Development II.

2. Creativity, Design and Entrepreneurial Mindset

This introductory course is designed for freshmen students across the humanities, arts, engineering, science and business who love the initiative, ingenuity and excitement of putting creative ideas into design, innovation and commercialization. Within this course, creativity becomes the ability to see something in a new way, as if for the first time, and to articulate and communicate that insight through design. Entrepreneurial mindset becomes the processes, practices, and decision-making activities that lead to the foundation of innovation and entrepreneurship. The objectives of this course are as follows [1] [2]:

1. Entrepreneurial Mindset: To learn the characteristics associated with entrepreneurial mindset, to assess how each person relates to these characteristics, and how to develop mindset fostering entrepreneurial potential.

2. **Awakening Creativity:** To examine the concept of creativity, to elaborate the diverse creative processes, and to demonstrate creative behaviors. Awakening creativity through music, visual arts and performing arts.
3. **Channeling Creativity through Design and Innovation:** To examine the characteristics of design and innovation, to elaborate how to channel creativity through design and innovation.
4. **Entrepreneurial Opportunity:** To examine how to explore entrepreneurial opportunity and develop new venture plan.
5. **The Entrepreneurial Challenge:** To develop E-Teams that will define a long-term project and create a plan of action.

A wide variety of teaching strategies are used in this course, including lectures, classroom activities, guided discussions, video clips, peer group learning and presentations, outside entrepreneur speakers, online and web based interactions.

3. Exploring Entrepreneurial Opportunity in Alternate Energy and Emerging Technology

This is a project driven course designed for sophomore students to explore the entrepreneurial opportunities in alternate energy technologies. The objectives of this course is to provide students a broad understanding of entrepreneurial ideas and opportunities, observations, recognition, analysis and evaluation of opportunities in alternate energy technologies. Topics include analysis of alternate energies and emerging technology, strategies for exploring the opportunity, analysis of economic, social, technological political and regulatory changes, analysis of windows of opportunity, opportunity assessment by DIFA (Demand, Innovation, Feasibility and Attraction) model, connecting creativity, design, innovation with opportunity recognition. The class breaks into several entrepreneurial project teams (E-teams) and collectively develops strategies and preliminary plans for innovation and commercialization. This course also emphasizes on multimedia communication skills, team building and leadership developments.

4. Design, Innovation and Entrepreneurial Venture Development I

This is the first part of the two course sequence of capstone experience for students in the innovation and entrepreneurship concentration in which all elements of innovations are tied together. In this course students learn to develop a persuasive structure to make innovative ideas attractive and defensible. Design is an essential step in transforming innovative ideas into practical reality. This course focuses on the use of design as a form of expression, including development of functional prototypes of innovative ideas potentially leading to entrepreneurial ventures. This course focuses on conceptualization and synthesis of new ideas, channeling of ideas into creative design, and transformation of design into innovation with potential for commercialization and new venture development. In this course students are required to form multidisciplinary design/innovation/entrepreneurship teams (E-teams). Students gain the knowledge, understanding and skills related to developing creative ideas, design methodologies, characteristics of design and innovation, and the use of appropriate information, materials, tools and technology for innovation. Topics include tools of creativity and innovation, theory and practice of innovation, characteristics of innovation, design inspired innovation, prototype design, project management and commercialization of innovation. Special emphasis is given on innovation and commercialization projects related to “Grand Challenges for Engineers” [3]:

- Make solar energy economical
- Provide energy from fusion
- Develop carbon sequestration methods

- Manage the nitrogen cycle
- Provide access to clean water
- Restore and improve urban infrastructure
- Advance health informatics
- Engineer better medicines
- Reverse-engineer the brain
- Prevent nuclear terror
- Secure cyberspace
- Enhance virtual reality
- Advance personalized learning
- Engineer the tools of scientific discovery.

5. Design, Innovation and Entrepreneurial Venture Development II

This course is the continuation of the capstone experience on design, innovation and Entrepreneurial Venture Development I. In these course students performs extensive testing, evaluation and analyze the performance of their prototype and make necessary changes and develop a fully functional prototype for demonstration. Then each E-team project group performs a rigorous feasibility analysis (product/service, industry/market, finance and organization) and develops a comprehensive venture and business plan for commercialization of their innovation [4] [5]. Topics include developing the competitive design and innovation advantages and strategies, feasibility analysis, risk and return analysis, development of new venture and business plan, intellectual properties and legal issues, entrepreneurial financing, management and marketing. The outline of the venture development report is given below:

Business Description

Provide description of the proposed product or service in the most concise way beyond the characteristics of the product or service and experience that the customer currently receives from buying the product or service.

The Product/Service

- Unique Features: Benefits
- Unique Features: Limitations
- Stage of Development
- Legal restrictions and rights, Insurance Requirements
- Trends related to the product or service
- Production or service delivery costs.

The Industry and Market

- Current Industry
- Market Potential for this Industry
- The Competition
- The Customers
- Market Penetration.

Financial Projections

- Pricing
- Sales Revenue Forecast

- Cost Forecast
- Gross Profit
- Operating Expenses
- Profitability.

Future Action Plan

- Start-up Capital
- Sources of Start-up Capital
- Further Information
- Support Needed.

Writing a Business Plan

- Cover page
- Table of contents
- Executive summary
- General company description
- Explanation of products and services
- Marketing plan
- Operational plan
- Management and organization
- Financial information, including money needed and money spent
- Financial forecast.

In this course E-teams are required to defend their venture plan for commercialization of innovation to a panel of potential investors.

6. Conclusion

The integration of Imagination, visualization, creativity, design and innovation in engineering education challenges the boundaries of students' minds, transforming them to active learners, critical and creative thinkers, researchers, creators, innovators and entrepreneurs. All four courses are project driven. Throughout the curriculum the program offers opportunity for students to form multidisciplinary engineering and entrepreneurship project teams (E-Teams) for transforming creative ideas into practical realities, to form Start-up Company and to interact with alumni entrepreneurs. Technology plays a crucial role in all the courses because it is the frontier of learning. Students learn how to use technology to transform data into new information, analyze new information discovering new patterns, and synthesize new patterns creating new opportunity and innovation. The four course sequence is designed to educate students for their future. This curriculum can be easily adopted in other engineering programs globally.

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