Entrepreneurship Mindset in Undergraduate Engineering Education
Theoretical and Practical Aspects

Agamemnon Koutsospyros PhD
Professor and Graduate Coordinator of Environmental Engineering
University of New Haven, West Haven, CT 06516, USA.
akoutsospyros@newhaven.edu
Presentation Outline

• The Information Age & Requisite Skills
• Entrepreneurship: an Educational Platform?
• Entrepreneurship & Entrepreneur
• Entrepreneurially Minded Engineer
• Metacognitive Model of the Entrepreneurial Mindset
• Entrepreneurship Program Models
• Recent Trends in Entrepreneurial Activity

• Attributes of an Entrepreneurial Engineer
• KEEN’s 3 C’s of Entrepreneurial Mindset
• Building an Entrepreneurial Mindset at UNH
• Curricular Activities
• The Flipped Classroom Instructional Model
• Integration of e-Learning Modules
• Module Content Curriculum Integration
• Assessment of Entrepreneurial Mindset
Our Era: The Information Age

- Globalization
- Increasing importance of information
- Use of information to increase productivity
- Increasing proportion of “knowledge workers”
- Innovation transforming processes
- Networked economies and societies
- Constantly changing images and messages
Information Age Demands Engineers with Set of Diverse Skills

- Content Knowledge
- Learning & Innovation Skills
- Information & Media Technology Skills
- Life & Career Skills
Content-related Literacy

Content Knowledge

Disciplinary
- Language Arts
- Arts
- Mathematics
- Natural Sciences
- Economics
- Social Sciences

Interdisciplinary
- Global Awareness
- Business & Entrepreneurial Literacy
- Civic Literacy
- Health Literacy
- Environmental Literacy
Entrepreneurship an Educational Platform for Attaining Additional Skills?
Entrepreneurship & Entrepreneur

- Entrepreneur
  - A fully engaged thinker and motivated tactician, who has multiple cognitive strategies available, and chooses among them based on goals, motives, and needs.

Entrepreneurially Minded Engineer

= an engineer instilled with the entrepreneurial mindset

Places product benefits before design features

Leverages technology to fill unmet customer needs.

Entrepreneurial Mindset

- The ability to sense, act, and mobilize under uncertain conditions


Metacognitive Model of the Entrepreneurial Mindset

Metacognitive Knowledge
- Strategy
- Tasks
- People

External Environment ↔ Motivation

Metacognitive Awareness

Metacognitive Strategy

Cognitive Response

Metacognitive Monitoring

Metacognitive Experience
- Intuitions
- Affective Experiences
- Emotions

### Engineering Entrepreneurship Program Models in the U.S.

<table>
<thead>
<tr>
<th>Business School</th>
<th>Engineering School</th>
<th>Multi-School</th>
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<tbody>
<tr>
<td>• Formal technology entrepreneurship curriculum developed through collaboration with engineering or science or courses serving engineering/science students</td>
<td>• Formal technological entrepreneurship curricula that co-exist with curricula offered by the business school</td>
<td>• Formal technological entrepreneurship curriculum developed with active collaboration of a business school and one or more technical schools</td>
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Features of Entrepreneurship Educational Programs

Character of Entrepreneurship Programs
- Non-traditional interdisciplinary programs
- Administered/funded/delivered by multiple academic units or centers

Teaching/Administrative Human Resources
- Rely predominantly on non-tenure track faculty or practitioners

Institutional Culture
- Extent to which entrepreneurship is valued and encouraged
- Infrastructure for intellectual property, technology transfer, and business incubation
- Support for academic programs by stakeholders

Entrepreneurial Ecosystem
- Mentors, internships, other experiential opportunities
- Funding
- Talent necessary to start and grow new ventures

Recent Trends in Entrepreneurial Activity

U.S. Population Engaged in Entrepreneurial Activity

10-12%

U.S. Students (grades 5-12) Interested in Starting a Business

77%

Recent Trends in Entrepreneurship Education

- 400,000: Students enrolled in E-courses
- 2,200: E-courses available
- >1,600: Institutions nationwide
- 277: Endowed faculty positions
- 44: Academic journals
- ~150 Research centers

% of 888 accredited M.S. and Ph.D. granting institutions offering entrepreneurship courses/degrees

90%

## Attributes of an Entrepreneurial Engineer

<table>
<thead>
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<tr>
<td>Curiosity</td>
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<tr>
<td>Integrity</td>
</tr>
<tr>
<td>Tenacity</td>
</tr>
<tr>
<td>Ethics</td>
</tr>
<tr>
<td>Creativity</td>
</tr>
<tr>
<td>Intuition</td>
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<tr>
<td>Knowledge of engineering fundamentals</td>
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<tr>
<td>Ability to engineer products for commercialization</td>
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<tr>
<td>Inclination for lifelong learning</td>
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<tr>
<td>Ability to see how his/her ideas fit into the larger context of society</td>
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<td>Proficiency in communicating his or her ideas</td>
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KEEN’s 3 C’s of Entrepreneurial Mindset

**Curiosity**
- Demonstrate constant curiosity about our changing world
- Explore a contrarian view of accepted solutions

**Connections**
- Integrate information from many resources to gain an insight
- Assess and manage risk

**Creating value**
- Identify unexpected opportunities to create extraordinary value
- Persist through and learn from failure
The Kern Entrepreneurial Engineering Network (KEEN)

- **What is KEEN?**
  - “A collaboration of U.S. universities that strive to instill an entrepreneurial mindset in undergraduate engineering and technology students.”

- **KEEN’s Mission**
  - “To graduate engineers with an entrepreneurial mindset so they can create personal, economic, and societal value through a lifetime of meaningful work”

- **KEEN Learning Outcomes**
  - 12 outcomes grouped in 4 categories
    - Engineering thought and action (4)
    - Collaboration (2)
    - Communication (2)
    - Character (4)
The 12 KEEN Learning Outcomes

<table>
<thead>
<tr>
<th>Engineering Thought and Action</th>
<th>Character</th>
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<tr>
<td><strong>Expressed Through</strong></td>
<td><strong>AND</strong></td>
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<tr>
<td><strong>Collaboration</strong></td>
<td><strong>AND</strong></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td><strong>AND</strong></td>
</tr>
<tr>
<td><strong>Applied</strong></td>
<td><strong>Founded On</strong></td>
</tr>
<tr>
<td>APPLY creative thinking to ambiguous problems</td>
<td>IDENTIFY personal passions and a plan for professional development</td>
</tr>
<tr>
<td>APPLY systems thinking to complex problems</td>
<td>FULFILL commitments in a timely manner</td>
</tr>
<tr>
<td>EVALUATE technical feasibility and economic drivers</td>
<td>DISCERN and PURSUE ethical practices</td>
</tr>
<tr>
<td>EXAMINE societal and individual needs</td>
<td>CONTRIBUTE to society as an active citizen</td>
</tr>
<tr>
<td>FORM and WORK in teams</td>
<td>CONVEY engineering solutions in economic terms</td>
</tr>
<tr>
<td>UNDERSTAND the motivations and perspectives of others</td>
<td>SUBSTANTIATE claims with data and facts</td>
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The KEEN Model

Developing an Entrepreneurial Mindset at UNH: Four-faceted approach

- **Faculty**: Developing an entrepreneurial mindset amongst faculty
- **Curricular**: Providing curricular components that advance specific student knowledge and skills
- **Environment**: Structuring the physical environment to promote entrepreneurial minded learning
- **Extra-curricular**: Offering opportunities for students to engage in meaningful extra-curricular activities

Erdil, N. O., Harichandran, R. S., Nocito-Gobel, J., Carnasciali, M. I., & Li, C. Q. (2016). Integrating e-learning modules into engineering courses to develop an entrepreneurial mindset in students, 2016-June.
Curricular Activities Infusing an Entrepreneurial Mindset

- Self-paced
- e-learning using Bb
- Integrated into engineering and computer science courses

18 short modules

Each module contains

- Readings
- Short videos
- Self-assessment exercises

- Contextual activities to reinforce content

Flipped classroom instructional model

Erdil, N. O., Harichandran, R. S., Nocito-Gobel, J., Carnasciali, M. I., & Li, C. Q. (2016). Integrating e-learning modules into engineering courses to develop an entrepreneurial mindset in students, 2016-June.
The Flipped Classroom Instructional Model
An Active Learning Paradigm

Image Source: http://thesecondprinciple.com/wp-content/uploads/2015/05/flipped-ms.jpg
Integration Components of e-Learning Modules

- Deliver content via short Online Module
- Assess through Project & Final Exam Question
- Engage students through (Blackboard) Discussion
- Reinforce learning through a Class Project
Module Content Curriculum Integration 1/2

1. Generating new ideas based on societal needs and business opportunities
2. Developing customer awareness and quickly testing concepts through customer engagement
3. Thinking creatively to drive innovation
4. Learning from failure
5. Establishing the cost of production or delivery of a service, including scaling strategies
6. Determining market risks
7. Designing innovatively under constraints
8. Financing a business
9. Developing a business plan that addresses stakeholder interests, economics, market potential and regulatory issues

Introduction to Engineering (Fr)

Project Planning and Development (Fr)

Project Management and Engineering Economics (So)

Applied Engineering Statistics (Ju)

Transport Operations II Mechanics and Structures Lab Software

Project Analysis and Design Junior Design Laboratory

Fundamentals of Mechanical Design System Engineering Concepts and Design (Ju)

Engineering Entrepreneurship (Ju)

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Module Content Curriculum Integration 2/2

10. Marketing a product or service
11. Adapting a business to a changing climate
12. Delivering an elevator pitch
13. Resolving difficult ethical issues
14. Building, sustaining and leading effective teams and establishing performance goals
15. Building relationships with corporations and communities
16. Applying systems thinking to complex problems
17. Recruiting and servicing clients
18. Defining and protecting intellectual property

Engineering Entrepreneurship (Ju)
Disciplinary Senior Design Courses
Professional Engineering Seminar Social & Professional Issues in Computing Professional and Ethical Practice (Ju)
Chemical Engineering Laboratory Soil Mechanics Laboratory Junior
Design Laboratory Mechanics Laboratory System Engineering Design Process (Ju)
Mandatory internship
Disciplinary Senior Design Courses

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Extra-curricular and Experiential Activities

Mandatory Internships

Immersive Experiences

Non-competitive
- 24-hr Imagination Quest and Start-Up Weekend
- 10-day KEEN Summer Interdisciplinary Design Experience
- 1-hr events (e.g. Engineering Challenges)
- Discussion Dinners for our Entrepreneurial Engineering Living/Learning Community

Competitive
- Intercollegiate regional/national competitions
- Senior design project competition
Assessment of Entrepreneurial Mindset

An assessment instrument to measure the entrepreneurial mindset of engineering students has been developed.

The questionnaire consists of two broad sets of items to measure:

- General entrepreneurial characteristics (curiosity level, personal experiences, and family influences)
- KEEN learning outcomes
KEEN Universities

University of New Haven

TAGLIATELA COLLEGE OF ENGINEERING
Entrepreneurship can be used as an educational platform for stimulating the development of valuable life and career skills for engineering students.

An entrepreneurial mindset is deep-rooted into the cognitive and metacognitive domains.

Entrepreneurship educational programs have flourished in recent years reflecting changes in society and global economy.

The UNH program for infusing an entrepreneurial mindset to engineering students is a modular approach (easily integrable to engineering curricula) combining:

- e-learning delivery methods
- The flipped classroom instructional model
- A variety of extra-curricular & experiential opportunities.