“What are the knowledge, skills, and attributes that enable engineers to translate creative ideas into innovations that benefit society?”

Innovations are the lifeblood of companies and our economy. Innovations spawn new companies, create jobs and make our lives safer, richer and healthier. Engineers use science and technology to innovate but how do they really discover, develop, deploy and sustain innovations?

The goal of this 3-year NSF sponsored project by Purdue and Penn State faculty and researchers is to define engineering innovativeness and identify and measure the characteristics of innovative engineers.

**Major Phases of the Engineering Innovativeness Project**

**YEAR 1**
Identify Characteristics of Engineering Innovators

**YEAR 2**
Develop and Validate the Measurement Instrument

**YEAR 3**
Build the Benchmark Database

**FIRST YEAR HIGHLIGHTS**

A QUALITATIVE RESEARCH STUDY was completed in August, 2013 to define the characteristics of engineering innovators. Forty five engineering innovators were interviewed across the United States. Four of the significant qualitative research study findings are discussed below:

**FINDING ONE:** Engineering innovators unanimously defined an innovation as something new or novel that is a replacement for or improvement in a product or process. An innovation must also have value for its users and be implemented sustainably and profitably in a community or marketplace.

“In my mind innovation is recognizing a need, or a gap, or a circumstance that could be better and then bringing to bear new ways of putting things together, [things] that usually exist, to be able to meet that need, or that gap.” Richard*

“Simply put, it’s a new way of doing things. It’s breaking tradition and taking a new approach to solving an old problem. I think an innovation is actually only truly innovative if it is delivered to the world and widely adopted, and enjoyably used.” Riley*

*All names are pseudonyms
**FINDING TWO:** Engineering innovators defined the innovation process as first having a front-end or discovery and development stage and then a back-end or implementation and adoption stage. Engineering innovators also embraced a variety of innovation process models.

![Engineering Innovation Process Model](image)

“So an idea is a creative seed of what could be. An invention is the translation of the idea into something that could be viable but the true innovation has vetted the idea and invention and made it a sustainable business proposition.” Carol

**FINDING THREE:** Among the twenty characteristics of innovative engineers identified by engineering innovators, the following five characteristics were identified as the most prevalent characteristics.

<table>
<thead>
<tr>
<th>CHARACTERISTIC NAME</th>
<th>DEFINED IN ENGINEERING INNOVATORS’ WORDS</th>
</tr>
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<tbody>
<tr>
<td>Deep Knowledge</td>
<td>“Has depth and breadth of knowledge and experience, shares knowledge with others.”</td>
</tr>
<tr>
<td>Active Learner/Curious</td>
<td>“Asks questions/curious - with a love of learning.”</td>
</tr>
<tr>
<td>Vision/Caring</td>
<td>Thinks longer term, wants to make a contribution.</td>
</tr>
<tr>
<td>Team Manager/Leader</td>
<td>“Create(s) a shared direction that other people adopt and work together to make it happen.”</td>
</tr>
<tr>
<td>Risk Taker</td>
<td>“Accepts risk, willing to take risks, not afraid to fail.”</td>
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</tbody>
</table>

**Deep Knowledge** “So, having that exposure, that experience across the real broad spectrum of solutions was really helpful. The people in my career that have been really innovative have tended to basically [be] interested in virtually everything. And, they’ve got something beyond what I’ll call a cocktail party level of familiarity with subjects. They know a broad base of subjects deeply enough that it can provide meaningful contributions and information to problem solving.” Pierre

**Active Learner/Curious** “All the people I know who are really good innovators are inquisitive, constantly seeking new ways to do it better.” Doris

**Vision/Caring** “They’re forward thinking. They live in the future and that may be frustrating to those who want them to live in the present... but their heads are in the future.” Dana “[Innovators] want to make impacts. They want to change the world somehow. They get value out of that.” Ian

**Team Manager/Leader** “You find out that working with other people is much more enjoyable, that [you] can leverage not only their talents but some of their energy.” Aubrey

**Risk Taker** “[He had] just a total lack of fear of not knowing how to do something. He would go after it and pursue those things. And he would have fun with it. I think that’s the way his mind worked, to see the humor in situations, and go off on a bizarre tangent just for the fun of it and then come back [and say]: Here’s what we really have to address, and figure out what’s going on.” Toni
ACKNOWLEDGEMENTS: The Engineering Innovativeness Project Team wishes to thank the more than thirty individuals who introduced us to over fifty engineering innovators. We also are grateful to the 45 engineering innovators who gave freely of their time and ideas to help our research on engineering innovativeness.

Our interviewees averaged over 30 years of engineering and innovation experience. The formal training of our interviewees included Aeronautical Engineering, Architectural Engineering, Biological Engineering, Chemical Engineering, Civil Engineering, Computer Science, Electrical and Computer Engineering, Industrial Engineering, Materials Engineering, and Mechanical Engineering. The interviewees were also trained in Analytical Chemistry, Organic Chemistry, Business, Biology, Medicine, and product development processes such as TRIZ.
OTHER YEAR ONE OUTCOMES


SECOND YEAR ENGINEERING INNOVATIVENESS PROJECT GOALS

1) Development, testing and validation of the engineering innovativeness instrument:
   A) Critical literature review of validated innovativeness instruments.
   B) Item Pool Creation and pilot testing
   C) Full reliability and validation testing of instruments with engineering students and practitioners

2) Completion of a confirming study using the Delphi Study process:
   A Delphi Study is a collaboration of experts who develop a converging consensus answer to a question or problem. This Delphi study will confirm the characteristics of innovative and entrepreneurial engineers and includes the following rounds of anonymous information exchange:
   A) Reviewing and agreeing on innovative and entrepreneurial characteristic definitions
   B) Ranking characteristics in each stage of the innovative and entrepreneurial process and defining relationships between innovative and entrepreneurial engineer characteristics
   C) Commenting on or revising the rankings and relationship definitions

3) Building Phase Two of the engineering innovativeness model:
   A) Conducting additional engineering innovator interviews
   B) Exploring engineering innovativeness characteristic relationships

4) Dissemination of research results through conference presentations and journal papers; sharing results with study participants and through dissemination of results by our academic and corporate research collaborators and partners:
   Academic Collaborators include Lawrence Technological University, Lehigh University, North Dakota State University, Rose-Hulman Institute of Technology and Saint Louis University.
   Corporate Collaborators include Kimberly-Clark, Procter & Gamble and Walker Parking Consultants with interest in corporate partnering expressed by several other corporations.
   Dissemination Partners include the Kern Family Foundation’s KEEN Network of Engineering Schools, the Journal of Engineering Entrepreneurship [JEEN], The NSF sponsored Epicenter Project - The National Center for Engineering Pathways to Innovation at Stanford University and ASEE’s Entrepreneurship and Innovation Division.

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To inquire about becoming an academic or corporate collaborator or for more information about The Engineering Innovativeness Project contact:
Dr. Daniel M. Ferguson, at dfergus@purdue.edu in The School of Engineering Education, Neil Armstrong Hall of Engineering, 701 Stadium Avenue, Purdue University 47907-5819