IDENTIFYING AND ASSESSING KEY FACTORS OF ENGINEERING INNOVATIVENESS

Fourth Quarter 2013

A Collaborative Research Project from
Penn State University and Purdue University

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"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

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

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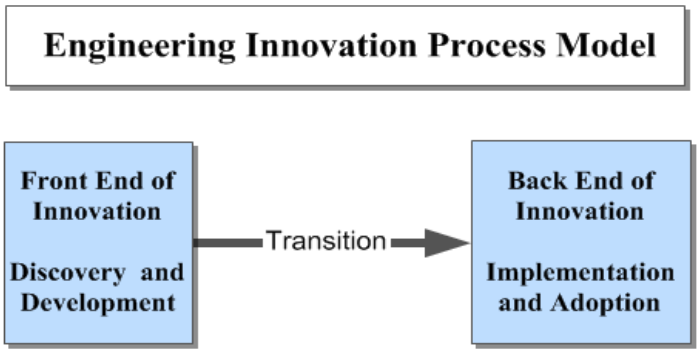
FINDING TWO: Engineering innovators defined the innovation process as first having a front-end or discovery and development stage and then a back-end or implementation and adoption stage. Engineering innovators also embraced a variety of innovation process models.



"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.

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

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

FINDING FOUR: A non-innovative engineer's behavior was described by engineering innovators as opposites of an engineering innovator's behavior:

An Innovator:	**A Non-innovator:**
is a collaborator	is a non-collaborator
is a risk taker	minimizes risk
has long term focus	has short term focus
is persistent	is not persistent
challenges rules	sticks to rules

"I can describe people that don't [innovate]. They tend to stay within the system, and stay within the rules. They stick to their objectives and to an extent that they oftentimes can't achieve their objectives because they're not networking." Aubrey

"[Non-innovators] are the ones that cannot get out of the short-term, or say this is the way we've always done things. I see that a lot ...whether they don't see [the value of the innovation], or they think it's too much work. Gee, if I've got to develop a whole supply chain, that's too much work." Ted

THE ENGINEERING INNOVATIVENESS PROJECT TEAM

Dr. Kathryn W. Jablokow, Pennsylvania State University, Philadelphia, Pennsylvania. Dr. Jablokow is a Principle Investigator in the Engineering Innovativeness Project and an Associate Professor of Mechanical Engineering and Engineering Design at Penn State University. A graduate of Ohio State University (Ph.D., Electrical Engineering), she is a Senior Member of IEEE and a Fellow of ASME.

Dr. Şenay Purzer, Purdue University, West Lafayette, Indiana. Dr. Purzer is a Principle Investigator in the Engineering Innovativeness Project, an Assistant Professor in the School of Engineering Education and is the Director of Assessment Research for the Institute for P-12 Engineering Research and Learning (INSPIRE) at Purdue University. Purzer has M.A. and Ph.D. degrees in Science Education from Arizona State University and has a B.S. degree in Physics Education and a B.S.E. in Engineering.

Dr. Matthew W. Ohland, Purdue University, West Lafayette, Indiana, Dr. Ohland is a Co-Principal Investigator in the Engineering Innovativeness Project and a Professor of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. Ohland is a Fellow of ASEE, Past Chair of ASEE's Educational Research & Methods division, and was 2002-2006 President of Tau Beta Pi.

Dr. Daniel M. Ferguson, Purdue University, West Lafayette, Indiana. Dr. Ferguson is a Co-Principal Investigator in the Engineering Innovativeness Project and the recipient of three NSF awards supporting research in engineering education. Dr. Ferguson is a serial intrapreneur and entrepreneur, a graduate of Notre Dame, Stanford and Purdue Universities and a member of Tau Beta Pi.

Ms. Jessica Menold is a doctoral student in Mechanical Engineering at Pennsylvania State University.

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

Presentation: Ferguson, D. M., J. Cawthorne, B. Ahn and M. Ohland (2012). "Engineering Innovativeness", *Proceedings ASEE Annual Conference*, San Antonio, TX, Paper 3100, 18 pages.

Journal of Engineering Entrepreneurship: Ferguson, D. M., Cawthorne, J. C., Ahn, B., & Ohland, M. (2013). "Engineering innovativeness" 4(1), 16 pages.

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:
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