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Creativity and Propensity for Innovation in Engineering

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Introduction

Research across education & business fields has attempted to measure individuals' creativity and innovative behavior.

Research on creativity has **most** often been conducted in K-12 education.

Research in innovation has focused on workplace measurement.

- Business research has attempted to link metrics of innovation to entrepreneurship.
- Educational research has not broached this connection.

Literature split as to whether creativity & innovation are domain or disciplinary characteristics or traits, or whether they can be measured in general form.

Such research has not been focused on engineering or the sciences.

Both engineering and scientifically focused industries are expecting innovative and entrepreneurial skills from their degreed employees.

- Particularly apparent at the management of product development realms.

The Engineering Creativity & Propensity for Innovation Index

- **Instrument Development Process: 3-year iterative process:**
- Initial scales were designed based on combined work in K-12 and business fields
  1. Survey scales were adapted for engineering students based on cognitive interviews with (a) a group of engineering students and (b) a group of CEOs in Engineering; a content and construct validity technique (Woolley, 2006; Karabenech, 2009)
  2. Items were tested for reliability (using Cronbach's reliability statistical techniques; within scale reliability) and factor analyses.
- **Current ECPII has 6 important constructs.**
  - Closely aligned to cited combined research on creativity and innovation and domains specific to engineering.
  - Includes two important structures (outcome space): (1) A 6-point Likert type component (2) a set of three problem sets, for which the students respond to one.

Content Validity Interview Results

- **Experts believe:**
- Creativity and innovation are linked but not synonymous
- Tied to domains
- Constructs are NOT generic!
- Must be measured to guide university programs in improving and cultivating characteristics for future of engineering industries

ECPII Constructs- Combine Creativity with Innovation

***Engineering Initiative**:* Students' ability to take action to work within the discipline without cuing or prompting. Involves an innovative behavior benefiting creativity with regard to self-starting, proactivity, persisting to overcome difficulties in the pursuit of goals, and even contributing more than requirement.

Engineering Inquisitiveness: Students' level and depth of curiosity about engineering processes, how things work, and diverse problem solving approaches within and beyond the engineering discipline.

***Engineering Individuality**:* Students' openness and independence in thinking in engineering contexts. In this realm, openness refers to ability to take in, process and utilize new and non-traditional information with self- efficacy and drive.

Engineering Disciplined Imagination and Design Thinking: Students' ability to imagine diverse problem solving approaches within the engineering discipline coupled with their ability to use diverse , forward thinking and planned engineering problem-focused design processes in the face of distractors.

Engineering Flexibility: Students' broad-based diversity in thinking processes within and beyond the engineering mindset in related settings. Encompasses cognitive persistence and ongoing engaged motivation in potentially adverse or unfamiliar situations.

***Engineering Fluency**:* Students' depth of understanding of diverse aspects of engineering problems solving and how it relates to to broader world.

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Research Purposes

- Explore ways to measure students' innovation
- Determine the dynamics of innovation and links to creativity
- Understand the disciplinarity and interdisciplinarity of innovation
- Study the impact of pedagogical factors associated with innovation.

Current Research Sample

- 2142 undergraduate and graduate engineering students from 13 universities
- ~ equal numbers of undergraduates and graduates

General Research Findings

- Multilevel research analyses utilized to understand dynamics of creativity and innovation
- Propensity for innovation changes resulting from students' experiences
- Changes (typically increases over time
- Team experiences, prolonged international experiences increase innovation
- Particular pedagogical practices and exposure and practice of the design process increases propensity for innovation
- E.g. innovation garage, interdisciplinary degrees, innovation practices w/in course and industrial linked experiences

Discussion

Results of this pilot study on ECPII reveal that students are both creative and innovative.

Indicate that graduate students are more advanced than undergraduate students suggesting that creativity and innovation can be nurtured and "learned."

Results are preliminary as they represent a "one-time" measurement of the constructs with a limited sample.

Future work: Comparative results across years of engineering educational experiences may reveal more powerful results and those that can be most accurately attributed to particular pedagogical practices.

Has potential for informing engineering education practice as it may be used to help engineering educators design programs that inspire creativity and innovation.

May be particularly helpful if measure is used in combination with diverse pedagogical practices and engineering education models as "interventions."

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