Using Mixed Methods Research Designs to Identify Challenges and Opportunities in Today’s Engineering Work

**Research Objectives**
- Understand the work and occupations of early career engineering graduates
- Improve academic programs and professional workplaces
- Facilitate the transition from undergraduate to early career

**Engineering Pathways Study (EPS) Qualitative Interviews**

**Protocol Design**
- Interview questions drew on outcomes from several components of the Academic Pathways (AP)
- Social Cognitive Career Theory (Lent, Brown, & Hackett, 1994) served as an overall framework

**Survey Description**
- Survey items were created based on findings from the EPS interviews, APS outcomes, and other career literature
- As with the interviews, Social Cognitive Career Theory served as a framework
- The final instrument featured 45 questions spanning 5 domains: (1) degrees and employment, (2) pre- and post-graduation learning experiences, (3) self-efficacy, outcome expectations, and interests, (4) career satisfaction and plans, and (5) background characteristics

**Analysis**
- The interview recordings were transcribed

**Selected Findings**
- **Work versus Graduate School?**
  - Fewer than half of participants were in the same job or graduate program as when they first graduated with a bachelor’s degree
  - More than half of the participants had earned or were earning graduate degrees, and many others anticipated future graduate studies

**Pathways of Engineering Alumni Survey (PEARs)**

**Sample**
- 87 participants were contacted in Spring 2011; all participants had earned bachelor’s degrees from 3 schools in 2007 or 2008
- 51 (59%) responded to the online pre-questionnaire
- 35 (40%) were interviewed and telephoned
- Sample included variation in sex, ethnicity, geographic location, and employment in engineering and non-engineering positions

**Analysis**
- The interview recordings were transcribed

**Identifying design challenges in an existing electronic packaging design**

**Diffusion of designerly finite element analysis at Sandia National Laboratories†**

**Goal:** Increased utilization of designerly finite element analysis (FEA) in the product design and development process—goals widely recognized across various disciplines and industries— is, at its core, an issue of methodology diffusion.

**Framing the issue: Context Assessment Survey**

As an online survey distributed to a wide audience in the product development community at Sandia National Laboratories in Livermore, California, revealed a variety of difficulties, past failures, and conflicting accounts of new reporting of the use of FEA.

- Submitted to approx. 160 Sandians
- CAS: 67 respondents
- CAS: Post-35 respondents

**The hypothesis: ‘Designerly’ FEA**

This research explores a designerly insertion of FEA into the design build-test product development cycle. FEA contrasts with more traditional approaches and may help overcome several of the identified hurdles to the use of FEA.

- Simplified FEA models
- Designer-friendly software
- Analyst embedded in product development teams
- Potential for use of FEA in design thinking

**Case study research method using participant-observation and mixed-method data collection**

Designed FEA was implemented in two case study projects by the research investigator, a designerly approach to generate a framework for describing how the use of FEA to build confidence in a product design is related to the process by which product development teams gain or lose confidence in FEA itself. Both teams were strongly representative of the Sandia product development community, as the findings should be applicable across a broad portion of the Laboratory’s development work.

**Recommendations to Sandia**

- Explore co-location of FEA analysts and design teams
- Facilitate training for design engineers
- Directing alignment between FEA and product development

**Synthesis: Confidence Model**

The resulting model describes how various factors identified in the investigation enhance (or erode) a team’s autonomous FEA expectations regarding the use of FEA, thereby increasing (or decreasing) their motivation to rely on it in their product development approach.

**Findings**

The case study data were analyzed using a theory-building approach to generate a framework for describing how the use of FEA to build confidence in a product design is related to the process by which product development teams gain or lose confidence in FEA itself. Both teams were strongly representative of the Sandia product development community, as the findings should be applicable across a broad portion of the Laboratory’s development work.

**The second case study included 7 participants and focused on the development of a new electronics packaging design.**

**Conceptual design**

- Participants did not have confidence in FEA prior to starting design
- Participants realized various sources of design knowledge to build confidence, but FEA served a supporting role
- Previous encounters with FEA strongly influenced their perceptions and expectations in the case studies
- Participants were impacted by FEA as a means to retain design confidence
- Participants were not expected to use tangential, indirect evidence of FEA impacting product design and design decisions

**Case studies**

The research drove case study applications of FEA in the area of packaging design for advanced electronic components. The first case study focused on preparing and focusing on a modification of an existing electronic packaging design.

**Methodology**

- Example comparison of design options
- Example comparison of design options

**Results**

- Example comparison of design options
- Example comparison of design options

**EFS and PEARs were funded by the NSF Engineering Pathways Study (EPS), DUE-1023644, (2010-2013).**

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† Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.

This research was funded under Sandia University Part-Time Program. Approved for public release under SAND2015-7107 C.