AC 2012-4083: PARTNERING TO IMPROVE ENGINEERING LEARNING AND PERFORMANCE

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Partnering to Improve Engineering Learning and Performance

Engineering Education Research to Practice (E^2R2P):
NSF Program: EEC Division of Engineering Education and Centers
Grant 1037808

Our effort addresses the question: How can successes in engineering education research translate into widespread instructional practice? Published research has provided a robust set of documented tools and techniques for transforming individual engineering courses from traditional lecture-based formats to those that emphasize project- and problem-based learning[1]. These new formats support transfer of learned skills to subsequent courses and the workplace. Unfortunately, the mere availability of such research has not resulted in its widespread adoption across engineering programs. The pace of adoption has been slow and sporadic, which has led researchers to identify a "Valley of Death" separating research and practice [2]. Attempts to encourage widespread adoption of research-based engineering education practices by "pushing" effective techniques on faculty via workshops have not produced consistent results. Nor has the redesign of single courses that produce "one-offs" that never lead to wider adoption of such instructional approaches across the curriculum. As shown in Figure 1, these efforts attempt to optimize subsystem performance (individual courses) to achieve a system goal (widespread adoption in departments and colleges beyond an individual course). To build institution-wide adoption of effective engineering instructional techniques, the team has created a transformational roadmap that uses the existing "push" resources in engineering education research and incorporates a "pull" component throughout the organization to promote adoption through collaborative efforts to:

- Align instructional goals based on stakeholder input (Problem Identification).
- Close gaps between actual and desired performance by creating solutions that target the sources of the gaps (Cause/Corrective Action).

This approach creates change to "engineer education" from the top down and bottom up.

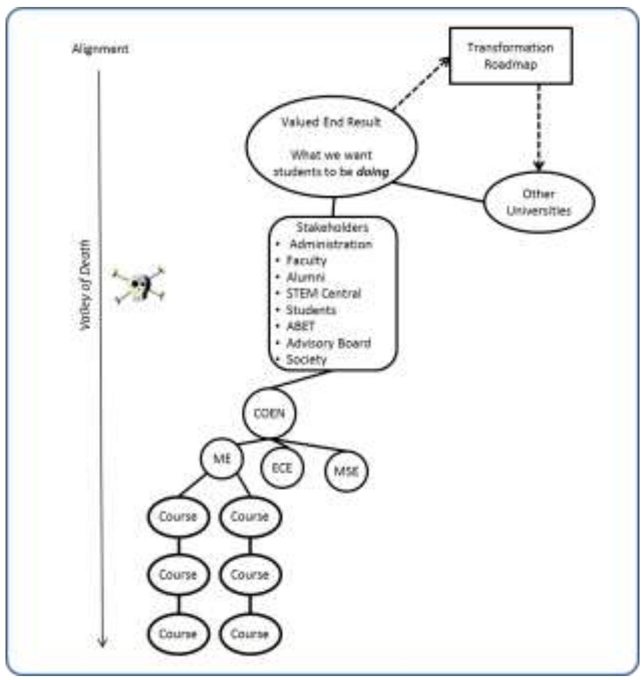

Figure 1: This schematic illustrates the alignment of goals from course level to departmental and college level based on the needs of the educational stakeholders.

Problem Identification

To produce valued learning outcomes, engineering education must be responsive to a variety of stakeholders. Thus, faculty, students, alumni, and industry advisory boards participated in the educational engineering process to identify potential gaps in student performance that occur between the university and the workplace. The overall goal of the project is to decrease ramp-up time for newly graduated engineers to achieve competent workplace performance. Faculty, department chairs, and deans can use this stakeholder input to align educational goals from the course to departmental to college level.

To achieve this end, the grant team met with the engineering dean and advisory boards of both the Boise State University College of Engineering (COEN) and Department of Mechanical and Biomedical Engineering (MBE). The COEN Advisory Board is comprised of representatives from the industries of energy, commercial construction, semiconductor manufacturing, local government, and venture capital. In addition to semiconductor manufacturing, the membership of the MBE Advisory Board includes representatives from the aerospace industry as well as industries associated with renewable wind, solar, and hydroelectric power projects and research.

In discussing these issues, the team first asked participants to state the business challenges that occupy their time; the following notable responses were provided:

- Reducing time to competent workplace performance. Board members reported that the process could take anywhere from nine months to three years in their organizations.
- Working across cultures and across time zones.
- Coping with out-of-state recruitment efforts that encourage engineering graduates to accept jobs in other states, creating an insufficient workforce in the state of Idaho; this situation is exacerbated by the poor economy.
- Coping with the potential shortage of newly graduated engineers to replace those who are retiring.

When asked what graduating engineers should be doing on the job that they're not doing now, the COEN and MBE advisory boards both agreed that newly minted graduates had a hard time applying topics they'd learned to real-world jobs in the engineering workplace. They also noted that soft skills were lacking, including:

- Letting go; i.e., sharing problems with others
- The ability to work in a team environment
- Collaboration with those in other departments
- The ability to communicate, including
    - Written English skills
    - Professional writing, especially abstracts and proposals
    - Writing concisely
    - Communicating both within and across groups
    - Presentation skills

- Entrepreneurial skills
- Willingness to ask questions about their job task or the status quo
- Thinking outside the box

These responses paint a partial picture of the current skills that are limiting the ability of engineering graduates to be effective in workplace situations immediately after graduation. Using this initial information as a guide, our research group will be conducting focus groups with additional stakeholder groups including program alumni and practicing engineering managers. These data will provide a more complete picture of the nature of the skills gap as it exists and help define a process to determine this skills gap (Problem Identification) effectively in the future.

During these focus groups, the team will use the Critical Incident Method (CIM) [3] to gather data on jobs and tasks that are essential for engineering. CIM involves gathering information on incidents that participants find relevant. This technique involves collecting and analyzing data to represent what newly graduated engineers can ***DO*** on the job. During this time, participants will:

Incident Card

Describe an incident in the workplace that occurred within the first six months to three years after you'd first started working.

Does this incident reflect (check one):
☐ Where you successfully performed a job task that you'd learned about in school?
☐ Where you were unsuccessful in performing a job task because your engineering education hadn't prepared you to do it?

What were the general circumstances leading up to this incident?

Specify exactly what you were trying to do on the job.

How did this incident affect the goals of your project, department, or company?

How long had you been on the job when this incident occurred?

Figure 2: Incident card to collect information about job-related engineering incidents.

- Describe incidents that initially occurred on the job after former students had graduated and first started working as an engineer. They will write these incidents on 4" X 6" cards (see Figure 2).
- Work with the team to categorize and condense the incidents to create statements describing performance to expectations and non-performance.
- Test the competency statements for criticality.
- Organize the competency statements.

The team will use these data to specify relevant engineering tasks and competencies and to identify specific performance gaps associated with each. The steering committee will use this information to identify a test bed solution to address one of the causes of the gap.

Closing the Gaps

To close the gap between actual and desired competent workplace performance depicted in Figure 3, engineering schools and industry must create solutions that target the source of this gap. To achieve this end, a test case that affects time to competent performance in the workplace, such as a multidisciplinary capstone course, will be specified

Figure 3: Academic institutions and industries share a gap between actual and desired workplace performance.

based on the responses from the interviews with the advisory boards and focus groups noted above.

Figure 4 illustrates how the dean, grant team, and other stakeholders will partner to create additional teams, including an analysis team, a steering committee, a redesign team, and a technical transfer team. Responsibilities of these teams are as follows:

Steering Committee: The steering committee will consist of approximately 12 people, including the College of Engineering (COEN) dean, members of the COEN and Mechanical and Biomedical Advisory Boards, ABET, Alumni, Students, Faculty, Members of the Idaho Society of Professional Engineers, and members of the grant team. The committee's role will be to provide strategic oversight, branding and marketing, dispute resolution, advising, advocacy, and governance for the Transformation Roadmap.

Analysis Team: The analysis team will be responsible for problem identification, escape analysis, and corrective action analysis. This team will be advocated by the dean and will provide consultative support. Their role will include the collection, analysis, and management of data.

Redesign Teams: The redesign teams will provide problem identification, root cause analysis, corrective actions, prototyping, usability testing, and lessons learned for specified test bed projects.

Technical Transfer Team: Technical transfer will occur in the form of reports, presentations, celebrations, news, workshops, online resources, Process Oriented Guided Inquiry Learning (POGIL), STEM Central Station/the Center for Teaching and Learning, and the evolving transformation roadmap.

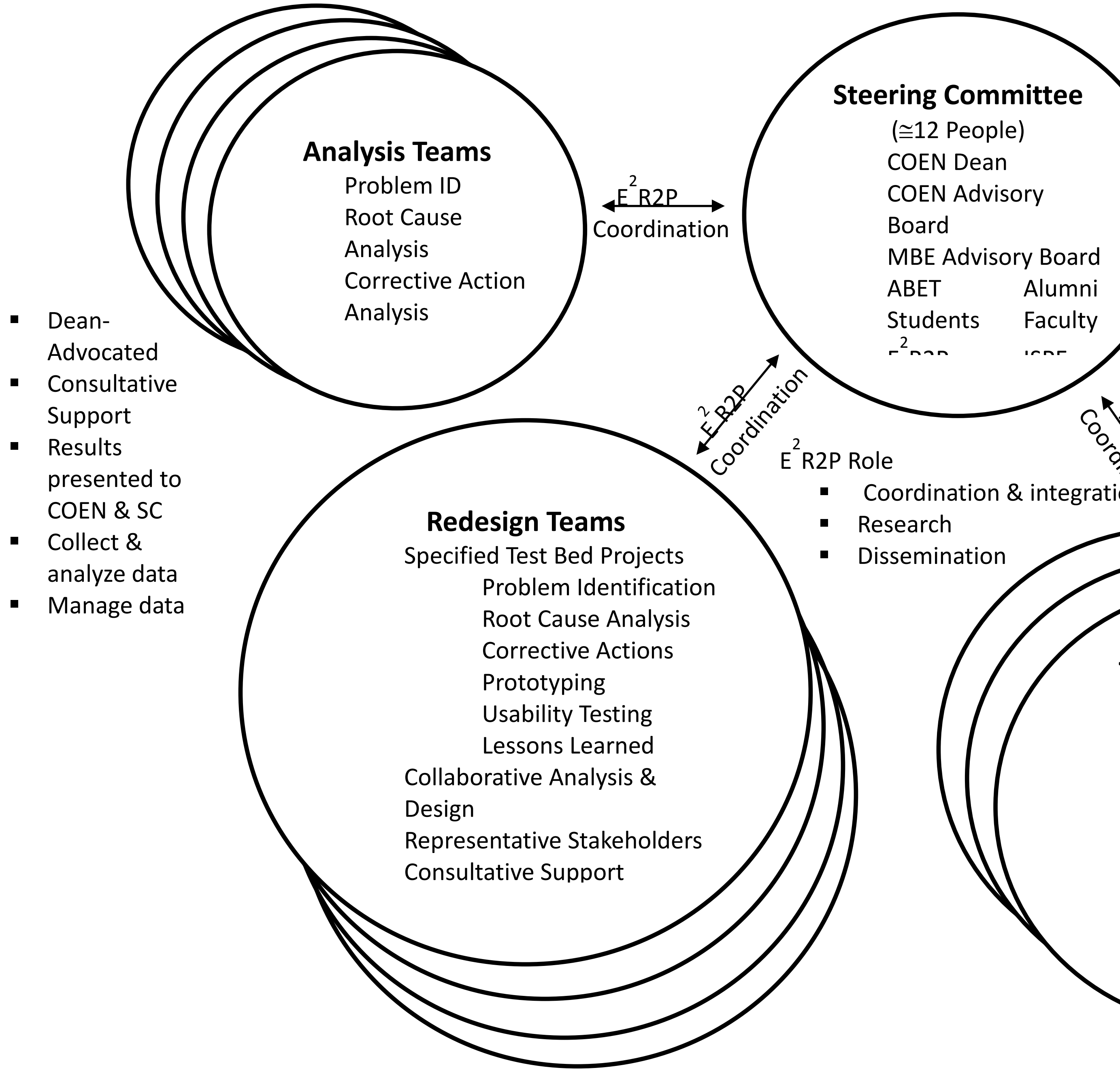

Figure 4: Project organization ensuring partnership and buy-in for creating change in instructional practices.

Future Work

To facilitate the desired change to widespread use of evidence-based instructional practices, the steering committee and the team will create a transformation plan comprised of a steady stream of communications reporting efforts to date and recognizing desired performances. They will also create opportunities where faculty can create and embrace the change that the adoption of such practices should bring about. The combination of these activities should foster adoption by providing opportunities for addressing emerging concerns by building awareness and curiosity, providing opportunities for mental and physical try-outs, and subsequent use [4].

References

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[4] D. Dormant, *The chocolate model of change*. np: Diane Dormant, 2011. Available at http://www.chocochange.com/index.html