Group and Self-Regulated Learning: Industry Practices in the First-Year Engineering Experience

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Abstract – **Research in instruction and pedagogy in first-year engineering education has led to major improvements in the way we educate the engineers of tomorrow. Understanding the origin of faculty teaching practices in first-year engineering provides insight for best practices in teaching and learning. Knowing faculty have varying levels of teaching experience, this work explores how faculty experiences in industry translate into the classroom, and what that means for the first-year engineering experience. This study employs a qualitative methodology examining the relationship between faculty's industry experiences and their teaching practices through interviews with faculty in the engineering fundamentals department at a small, semi-private institution. Initial findings indicate that faculty members overwhelmingly adopt self-regulated and group learning strategies to teach first-year engineering courses to prepare students for the "real world" demands of today's engineer. Faculty members have been cited using these types of teaching practices because they used them in industry. Implications of this study provide insight into the role that faculty industry experience may have in first-year engineering and the curriculum as a whole.**

Index Terms – Evidence-based instructional practices, industry experience, teaching and learning

INTRODUCTION

Engineering departments are tasked with ensuring curricula meets ABET standards. As of late, more pressure is being placed on colleges of engineering to ensure they are producing engineers who meet the demands of today's industry leaders. In fact, industry demands have led to the formation of partnerships between universities and national labs [1] to "innovate the engineering curriculum to better respond to industry needs." For example, the Learning Factory model [1], an innovation project between Penn State, the University of Washington, University of Puerto Rico at Mayaguez, and the U.S. Sandia National Laboratory, was developed so that these institutions could integrate "the development of engineering professional skills and the awareness of business constraints through hands-on practice based activities with real industry projects."

As severe competitive pressure is placed on our nation's employers, that pressure changes how we educate engineers [2]. Today's engineers must not only have a strong fundamental knowledge of physics, mathematics, and chemistry, but they must also have an understanding of what drives engineering processes (i.e. product/system requirements, effective time management, integrated product development) [2]. U.S. companies have high expectations of engineering graduates, and fundamental engineering skills learned in the first-year experience are crucial to the success of these graduates.

How should first-year engineering classrooms look? Besterfield-Sacre's [3] quantitative and qualitative report of faculty, chairs, and deans at engineering departments across 156 U.S. institutions on identifying promising pathways for transforming undergraduate engineering education reveals, "engaging pedagogies" such as inquiry learning, problem-based learning, and just-in-time teaching are needed to "create engaging, relevant, and welcoming learning environments."

To successfully teach engineering design and promote outcomes-based education in the first-year experience, collaboration is key. According to Chandrasekaran [4], "a collaborative relationship between academic institutions and industrial expectations is a significant process towards analytical thinking (linking the theory and practice)." Project-oriented design-based learning (PODBL) has been noted as a successful instructional approach to meet today's industry needs. PODBL is implemented across engineering schools and departments around the world. Examples of PODBL strategies include group and self-regulated learning strategies (i.e. collaborative learning, inquiry learning, and problem-based learning).

With employers setting high expectations of engineering graduates, and many faculty members having previous industry experience, it is no surprise that industry practices are being translated into classroom instructional practices. For example, Wolcott's [5] Integrated Design Experience (IDeX), has been successful in the design and implementation of undergraduate engineering curriculum. Its integrated course structure "consists of lectures, discussions, guest speakers, seminars, and a design studio" all for the purpose of promoting problem-based learning environments where students interact to complete design projects provided by industry partners [5]. These types of experiences promote the usage of experimental design and critical thinking [6], which are expected of engineering graduates upon entering the workforce.

KNOWLEDGE TRANSFER OF GROUP & SELF-REGULATED LEARNING STRATEGIES

Borrego [7] asserts, evidence-based teaching in science, technology, engineering, and mathematics (STEM) education requires adaptation from an industry setting. Engineering faculty members teaching core engineering science courses have varying levels of knowledge of evidenced-based instructional practices (EBIPs), referred to as researched based instructional strategies (RBIS) by Borrego [8]. EBIPs include active learning, real-time assessment strategies, group learning, and self-regulated learning (Figure 1).

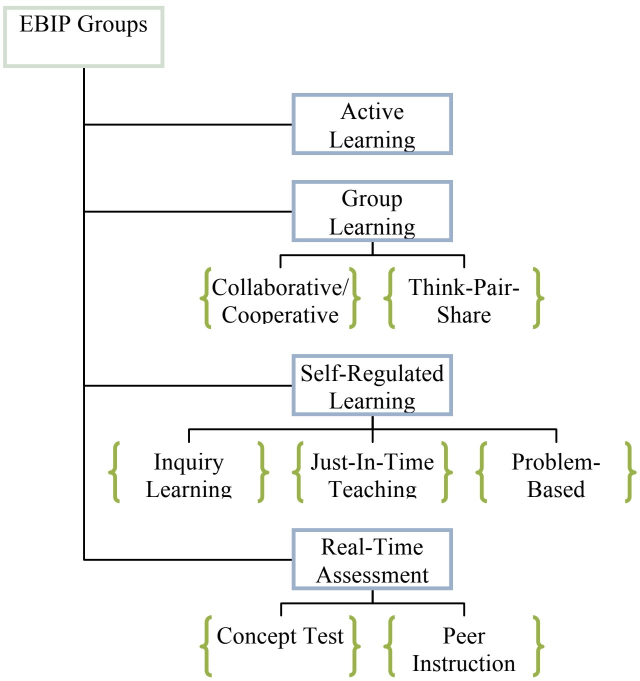

Fig. 1. Evidence-Based Instructional Practices (EBIPs) [8]

Engineering faculty learn about group and self-regulated learning EBIPs through a variety of interactions based on their own experiences and those with peers [9]. Knowledge of these EBIPs has been categorized into four categories [9]:

1. **Structured-peer interactions** – including engineering education conferences and personal feedback from faculty
2. **Unstructured-peer interactions** – including informal faculty conversations and observing other faculty in practice (teaching first-year engineering courses)
3. **Structured-organizational interactions** – including departmental meetings and educational conference presentations
4. **Unstructured-organizational interactions** – including cultural norms and past teaching experiences

Sources of adoption of these EBIPs also include faculty experiences as students and faculty beliefs about teaching. Jordan [10] asserts, "faculty belief structures have a strong impact on the persistence of educational practice and the ultimate recognition as a signature pedagogy in the field." Faculty experience these practices in their own experience as a student, and they persist because of their implementation of the practice. Oleson's [11] study on faculty experiences, sources of teaching knowledge, and how prior experiences shape their teaching practices suggests that professional teachers have a "preexisting craft" that influences their instructional goals and shapes their classroom practices. These preexisting roles include their experiences as students, researchers, and other non-academic roles. He asserts, "non-academic experiences played an important role in shaping their knowledge base for teaching" [11].

One area that has been less examined is the role that prior industry experience has on faculty teaching. This paper classifies industry work experience as any professional experience related to the engineering industry. Thus, this study seeks to explore how faculty industry experience translates to teaching in first-year engineering.

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study is to explore how faculty industry experience translates to teaching in first-year engineering. This study is guided by the following research questions:

1. Which evidence-based instructional practices carry over with faculty teaching first-year engineering because of their experience in industry?
2. How are evidenced-based instructional practices utilized in first-year engineering classrooms?

Thus, this study seeks to explore how faculty industry experiences translate to the first-year engineering experience.

METHODOLOGY

This study utilizes a qualitative research design to examine the relationship between faculty industry experience and their teaching practices, specifically, their usage of EBIPs in first-year engineering courses.

I. Participants

Twenty-one engineering faculty members of various academic ranks at a medium-sized institution were interviewed regarding their usage of EBIPs. Of the 21 participants, 16 had previous experience in industry. The participants included tenure and non-tenure track faculty with various teaching loads, years teaching experiences, and years industry experiences (Table I).

TABLE I. PROFILES OF PARTICIPATING FACULTY

Academic Rank	Instructor	1
	Adjunct Professor	5
	Visiting Assistant Professor	1
	Assistant Professor	1
	Associate Professor	7
	Professor	1
	Male	11
Sex	Female	5

II. Data Collection

The researchers interviewed each of the 16 faculty members using a modified version of Cutler's [12] interview protocol to assess their usage of evidence-based instructional practices. Faculty members were asked to describe their familiarity with the EBIPs outlined in Figure 1, to describe how they use the EBIPs, how they learned about them, and why they decided to use them to teach their courses:

1) *In your own words, please describe your understanding of [EBIP].*
    a. *How long have you been using [EBIP]?*
    b. *Where did you hear of [EBIP]?*
    c. *Why did you start using [EBIP]?*
    d. *In general, what are some benefits to using [EBIP] for you as the instructor and for the students?*
    e. *What are some difficulties or limitations with using [EBIP]?*

III. Data Analysis

Each interview was categorized for EBIP implementation based on the classifications of currently use, used in the past, heard but not familiar, and never heard of the approach. The interviews were then coded for faculty that mentioned the use of a specific EBIP with respect to their industry experience. Using these segments the interviews were open-coded for common themes regarding the role that industry experience has on their implementation of evidence-based instructional practices.

PRELIMINARY FINDINGS

Research Question 1: Which evidence-based instructional practices carry over with faculty teaching first-year engineering because of their experience in industry?

Collaborative/Cooperative Learning, Problem-Based Learning, and Inquiry Learning were commonly identified by research participants as practices that carry over in their teaching because of their experience in industry. For example, faculty members use inquiry learning to teach engineering design principles in first-year engineering because of past industry experience. This practice has been successful because inquiry learning drives learning through the introduction of a set of questions, problems, or observations [8]. In the following interview excerpt, a faculty member describes why inquiry learning is utilized in the classroom:

> "I think again, this probably came from, I had previous industrial experience and I thought that this was a good way to try to get the material across.

A second faculty member described using problem-based learning because of experience with engineering consulting. Problem-based learning allows the faculty member to act as a facilitator while students solve open-ended problems. The excerpt below provides insight:

> "Probably from my background. I like design and I was an engineer in a consulting firm before so I have personally learned green technologies and sustainable design from my previous work. So personally I believe this will help students in the long run, to help them get a job and to open their eyes and to understand new technology."

In summary, these preliminary findings suggest that group and self-regulated learning EBIPs carry over with faculty teaching because of their experience in industry.

Research Question 2: How are evidenced-based instructional practices utilized in first-year engineering classrooms?

Common themes in the faculty interviews include the usage of group projects and self-directed teams. Group projects are semester long assignments where teams of 3-5 students work to achieve a common goal. Self-directed teams are similarly semester long projects, but with little input from the instructor. The following faculty interview excerpts provide some context:

> "Since in engineering we work in groups so much, and a lot of the times it's hard to envision how powerful teamwork can be…I wanted to just use it so that they understand the good things of working in groups."

> "Almost 70 to 80% of the classes are project oriented. Engineering, it's always…I love students doing projects."

> "I often have students working in groups. They're supporting each other's correct use of those devices [calipers]. You'll often hear one say to the other 'no, no, you're doing it wrong' or 'you're supposed to read this next' especially with micrometers. So, they support each other when reading the measurements and making measurements."

When analyzing the interviews of faculty who did not have previous industry experience there appears to be a higher focus on group and self-regulated learning in first-year engineering courses based on the assumptions of industry needs (i.e. the "real world"). For example, three faculty describe why they use problem-based learning:

> "I think the benefits are that it's much closer to the real world. Some of the things that they see are actually starting to become clear to them, and that matters.
>
> "I guess in the real world, where you have to talk to your supervisor and customers."
>
> "I try to connect with the real world. I want them to instead of saying well this is a theoretical problem that I'm going to work on or this is very academic. I will present to the students, imagine you are in this scenario how are you going to solve this problem? And generally it's focused on one concept they are working on."

In summary, these preliminary findings show that faculty both with and without prior industry experience adopt group and self-regulated learning approaches in first-year engineering because of industry influence. These preliminary findings support the idea that faculty experience in industry carries over into their teaching pedagogy [10] in first-year engineering.

IMPLICATIONS & FUTURE WORK

Future work will include exploring how faculty in mathematical sciences and physical sciences translate their industry experience into classroom teaching practices in first-year engineering courses. More research regarding the role that prior industry experience has on faculty teaching could potentially support the adoption of evidenced-based instructional practices in first-year engineering

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REFERENCES

[1] Morell, Lueny, and Martina Trucco. "A Proven Model to Re-Engineer Engineering Education in Partnership with Industry." In World Engineering Education Forum, Buenos Aires, Argentina. (2012).

[2] Black, Kent M. "An industry view of engineering education." Journal of engineering education 83, no. 1 (1994): 26-28.

[3] Besterfield-Sacre, Mary, Monica F. Cox, Maura Borrego, Kacey Beddoes, and Jiabin Zhu. "Changing engineering education: Views of US faculty, chairs, and deans." Journal of Engineering Education 103, no. 2 (2014): 193-219.

[4] Chandrasekaran, Sivachandran, Alex Stojcevski, Guy Littlefair, and Matthew Joordens. "Project-oriented design-based learning: aligning students' views with industry needs." International journal of engineering education 29, no. 5 (2013): 1109-1118.

[5] Wolcott, Michael, Shane Brown, Melissa King, Deborah Ascher-Barnstone, Todd Beyreuther, and Karl Olsen. "Model for faculty, student, and practitioner development in sustainability engineering through an integrated design experience." Journal of Professional Issues in Engineering Education and Practice 137, no. 2 (2010): 94-101. Borrego, Maura, Stephanie Cutler, Jeff Froyd, Michael Prince, and Charles Henderson. "Faculty use of research based instructional strategies." (2011): 448.

[6] Koretsky, Milo, Christine Kelly, and Edith Gummer. "Student perceptions of learning in the laboratory: Comparison of industrially situated virtual laboratories to capstone physical laboratories." Journal of Engineering Education 100, no. 3 (2011): 540-573.

[7] Borrego, Maura, and Charles Henderson. "Increasing the use of evidence-based teaching in STEM higher education: A comparison of eight change strategies." Journal of Engineering Education 103, no. 2 (2014): 220-252.

[8] Borrego, Maura, Stephanie Cutler, Jeff Froyd, Michael Prince, and Charles Henderson. "Faculty use of research based instructional strategies." (2011): 448.

[9] Jordan, Kari L., Pembridge, James J., Williams, Sarah, Steinhauer, Heidi, Wilson, Timothy, and Holton, Douglas. "Knowledge Transfer of Evidence-Based Instructional Practices in Faculty Communities of Practice." In Proceedings of the 122nd ASEE Annual Conference & Exposition. Seattle, WA. (2015).

[10] Jordan, Kari L., Pembridge, James J., Steinhauer, Heidi, Wilson, Timothy, and Holton, Douglas. "Apprenticeship of Observation: Implications for the adoption of evidence-based instructional practices" In Proceedings of Frontiers in Education Conference. El Paso, TX. (2015). (in review)

[11] Oleson, Amanda, and Matthew T. Hora. "Teaching the way they were taught? Revisiting the sources of teaching knowledge and the role of prior experience in shaping faculty teaching practices." Higher Education 68, no. 1 (2014): 29-45.

[12] Cutler, Stephanie Leigh. "How Static is the Statics Classroom? An investigation into how innovations, specifically Research-Based Instructional Strategies, are adopted into the Statics Classroom." (2013).

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