Engineering educators' perceptions of the influence of professional/industry experience on their teaching practice

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Abstract –This preliminary study explored engineering educators' perceptions of the influence of industry experience on their teaching practice. Fifty American engineering educators were interviewed. There appeared to be a distinction in the extent to which influence on practice was reported, based on years of industry experience. Three themes emerged – influence on content and curriculum, influence on instructional strategies and the integration of real world components, and benefits of being a practitioner/educator. Implications and future research are discussed.

Keywords: engineering education, engineering faculty, industry experience, influence, professional practice, teaching practice

1. INTRODUCTION

The readiness of engineering graduates to engage in professional practice has been a topic of research for a while. Significant research on the need for engineering education reform to prepare undergraduate students to be the engineers of tomorrow informs us of the following: the traditional approach to engineering education may not be preparing students for complex, real world problems [2].

Research has been done into graduates' perceptions of their own readiness to engage in productive work [18], industry expectations of graduates [11], graduates perspectives after a period of professional practice [14], and academic-industry relationships [10]. These efforts cover forward-looking, in-situ, and retrospective views in support of the continual improvement of engineering education.

Additionally, engineering education endeavours to move to problem- and project-based pedagogies to prepare graduating engineers with a set of competencies laid out in CEAB [4] and ABET [1], and falls to the engineering faculty to ensure that these competencies are practiced and met by graduates.

The engineering faculty members play a key role in all aspects of preparing tomorrow's engineers, yet they seem to be an understudied population. More specifically, the

occurrence, importance, requirement, or relevance of industry experience for engineering faculty is not an area that has been researched to any great extent.

The purpose of this study was to capture the perceptions of engineering faculty members with regard to the impact of industry experience on their teaching practices. To that end, educators were asked about their industry experience and the time, if any, they spent in the workforce as a practicing engineer. The interview questions were:

1. Do you have industry experience?
2. Do you think that that experience has influenced your approach to teaching and, if so, how?

2. LITERATURE REVIEW

To establish the context for this preliminary study, this literature review endeavors to set context by looking at the academy's expectations for industry experience in engineering educators and by summarizing research on the impact of industry experience on engineering course content and design.

2.1. Industry experience for licensing/hiring

The American and Canadian licensure requirements for the Professional Engineer (P.E. or P.Eng.) designation appear to be similar with regard to academic degrees, professional examinations, and work experience. Both the Professional Engineers Ontario licensing guide [16] and the National Council of Examiners for Engineering and Surveying [12] state that the work/practical experience criteria for licensure is 48 months. Applicants are able to have up to 12 months allocated to pre-graduation experiences, up to 12 months allocated to advanced degrees (and more if conducting industrially applied research), and additional time allocated to teaching upper-year engineering courses) [17].

While the P.Eng is consistently identified as a condition of employment that must be in-hand or attained within 2 years of a faculty appointment date, industry experience as a hiring criteria appears to be positioned more as an asset than a requirement. Of five randomly selected engineering job postings from Ontario schools in

May 2017 (from the [University Affairs web site](#)), three mentioned industry experience. For example:

- *Industrial or postdoctoral experience in chemical or nuclear engineering is desirable.*
- *Related industrial experience would be considered an asset.*
- *It would also be preferable that the candidate have experience working as an engineer.*

The concept of practical experience seems to be somewhat flexible in its definition. The licensing criteria allow up to at least 36 of the required 48 months of practical experience to be pre-graduation, advanced degrees, teaching and research. These criteria constitute engineering experience, but not necessarily industry experience.

If the NSERC [12] call for Chairs of Design Engineering (CDE) can be considered a process of *hiring*, then the positioning of industry experience as criteria for hire is worth a look. The structure of the CDE indicates that training undergraduate engineers for practice (“relevant to Canadian receptor industries”) is a “significant component”. The attributes of the CDE with regard to industry experience, as indicated by these two statements, appear to deem practitioner experience *or* educator experience as equivalent:

- *have an established track record as a design engineer or design engineering educator*
- *be aware of current design engineering and/or design education practices*

2.2. Industry experience and engineering faculty

Researchers have studied the influence of industry experience on engineering educators’ beliefs and behaviours toward teaching and research [7], on course content [3][15], and course design [6]. These researchers tended to focus specifically on engineering design courses.

2.1.1 Beliefs and behaviours. Fairweather [7] defined industry experience as “employed full-time in industry for at least one job during their career” (p. 210), acknowledging that this said nothing about the amount of experience. At that time, he found that two-thirds of senior faculty tended to have industry experience, whereas about one third of the new faculty had industry experience. His results indicated that faculty with industry experience, even just one year, showed a greater commitment to teaching, spent more time on teaching activities (beyond their assigned classroom hours), and put less emphasis on publications as a primary source of promotion. They were also more likely to teach undergraduate students compared to faculty who lacked industry experience.

2.1.2 Course content and design. Burns [3] studied whether industry experience had an influence on content decisions made by engineering educators for a systems design course. His description of industry experience labelled educators as *practitioners* if they had more than 5 years of experience, and *non-practitioners* if they had less than 5 years of experience, differing from the definition that Fairweather and Paulsen [7] used. He found that there was a difference in how practitioners and non-practitioners made content and textbook decisions. Practitioners (97%) made content decisions based primarily on industry experience, feedback and trends, while non-practitioners made content decisions (68%) on the same basis. Practitioners (68%) also made textbook decisions based on experience, while non-practitioners (26%) made textbook decisions on the same basis. These findings were statistically significant.

Peters et al. [15] looked at how, what, and why engineering educators, with 2-28 years of teaching experience, made changes to their courses. The study had a particular slant to the adoption of research-based active learning pedagogies and their influence on course-level decisions. While Peters et al. [15] did not specifically speak to industry experience, the aspect of how decisions are made links to Fairweather’s study [7]. Overall, the engineering educators tended to make changes predominantly to their lectures (content, slides, and delivery style) in an effort to incorporate more active learning and real-world materials. In this study, the authors stated that “course components were considered real-world if a respondent mentioned the material being real-world, from industry, or used in practice” (p. 4). The primary resources that educators used to make these course-level changes were other colleagues, followed by design manuals and textbooks. The awareness and efforts to bring in real-world components is positive, ideally making links to engineering practice. However, the resources to support changes seemed to stay somewhat close to the academic environment.

Davis et al. [6] explored common and embedded knowledge (described as a way of thinking that is situated and contextualized in industry experience) in instructors and practitioners who taught entry-level undergraduate engineering courses, and how that manifested in an integrated curriculum. Researchers found that the common content or topic knowledge were similar between these two groups of educators, but differences were evident in the context brought to the learning environment. Practitioners were able to contextualize concepts and definitions, and speak specifically to scenarios, tools and resources linked to real-world settings and the practice of engineering. Instructors tended to speak more conceptually, tended to be more equation-based, and referenced mostly the textbook as a resource. The authors concluded that practitioners integrate and

demonstrate a way of thinking derived from practice. A focus on the design of the content with an eye cast to curriculum integration, more so than design of the class environment, is imperative to link learning to the practice of engineering.

3. METHODS

This qualitative study was an initial exploration of engineering educators' perceptions of the influence of industry experience on their teaching practice.

3.1 Participants

Fifty American engineering educators from 43 academic institutions across 24 states participated in semi-structured interviews. They were part of a larger study of the implementation of problem-based learning (PBL) into their teaching practices [19] and volunteered for interviews. Therefore, all these engineering educators were using PBL to an extent in their teaching practices. The majority were male ($n=38$, 78%), while female educators made up 24% ($n=12$) of the participants. Male educators had an average of 19.8 years teaching undergraduate engineering, while female educators had taught an average 13.9 years. Using the Carnegie Classification categories [5], the majority of participants (68%) came from research-intensive universities (categories 1-3), while 22% came from Master-granting universities (categories 4-6). The rest, 10%, came from Bachelor/Associates-granting or special focus (engineering) institutions (categories 7-11).

3.2 Data Collection

An interview protocol was developed and piloted. The researcher and three trained interviewers administered the protocol. Semi-structured interviews were scheduled for one hour and were digitally recorded and transcribed.

3.3 Data analysis

Data were analyzed with Atlas.ti 7 using preliminary codes drawn from the research literature. Data were coded by two independent coders to assess inter-coder agreement and to refine codes and their definitions. Each coder applied up to two codes to a portion of the data. The inter-coder agreement for Round 1 was 70%. After revisions, coding passed through 3 more rounds and resulted in a 100% inter-coder agreement, after discussion. The final codes were applied to the rest of the data by the researcher.

4. PRELIMINARY RESULTS and DISCUSSION

This study sought to capture the perceptions of engineering faculty members with regard to the impact of industry experience on their teaching practices. Preliminary themes are presented and excerpts from the participant interviews were included to support the interpretive summaries.

4.1 Industry experience

Overall, 82% of the engineering educators stated that they had industry experience.

Of those who do not have industry experience, 55.6% were from research-intensive universities and 44.4% were not.

Of those who do have industry experience, 70.7% were from research-intensive universities and 29.3% were not. Those who quantified their experience reported a range of 4 months to 31 years. Those who did not quantify their experience used words such as co-op, summer internships, and significant.

When asked if they felt their industry experience influenced the way they taught, educators' initial responses sparked a curiosity. Responses were analyzed based on years of industry experience.

Educators with 1 year or less experience [7] had these initial responses (sample quotes):

- Ah, yes (4 months)
- Uh I'm sure it has um I think probably more or less (8 months)
- Uh, I would have to say it must (co-op)
- Uh, sure (summer internships)

Educators with >5 years' experience [3] had these initial responses:

- Absolutely (10 years)
- Oh yes, without question (10 years)
- Absolutely...absolutely (11 years)
- Oh absolutely...that's a yes (14 years)
- Yes...100% (20 years)

While all educators indicated that they had engineering industry experience, participants with less experience seemed to be somewhat tempered and hesitant about the influence of that experience on their teaching practice. Participants with substantial experience were more confident and enthusiastic in their responses, perhaps indicating a stronger understanding of the relevance and application of their industry experience to their teaching practice.

4.1 Influence on content and curriculum

The educators in this study saw real opportunities to contribute to decision-making around course content, resources, and program development.

These educators indicated that their backgrounds offered them the insights to be able to contribute to decision-making from the ground up and focus course content based on current industry practices.

I said, ya know, there are some topics here that are irrelevant and they may have been important maybe 20 years ago, but they're not and there are lots of topics out there that are really important that you are missing completely. (Male, Associate professor, 14 years in industry)

I was asked to design and set up a materials testing lab for our undergraduates. I quite intentionally purchased equipment and designed the lab to look as much like a professional failure analysis/materials testing laboratory as possible. You won't find simplistic tabletop setups for canned experiments. You will find high-end analytical and testing equipment that the pros use. (Male, Associate professor, 5 years in industry)

I spent a lot of time as a practicing engineer and working with a lot of other practicing engineers, and seen very large projects implemented and very small ones. And it maybe gives you a different perspective on which areas of certain courses are more relevant. And the gaps, sometimes, between theory and practice, and trying to bridge that gap is a big part of what I do in some of those courses. (Male, Associate Professor, 10 years in industry)

Educators alluded to the utility yet limitations of working from the textbooks, and the approach in their teaching practice to move beyond the textbook.

There's a lot of things that you won't find in the textbooks, per se, and they're not short cuts. They're just circumstances that you need to be aware of. (Male, Lecturer, 22 years in industry)

On the other hand, no stupid problems. And that's the industry thing. I will not have a student do a stupid back of the textbook...back of chapter homework. So they're only going to do real ones. They're not going to do some arcane stupid thing that they'll never ever do again. (Male, Assistant professor, 7 years in industry)

I think the practitioner always has an advantage over the pure academic. That's the real world anecdotes about breaking the gas line and all of that stuff that gets in there. The practitioner has done it. He's seen it. He's seen all the ways that the textbook says will never fail that do fail. (Male, Full professor, no years stated)

4.2 Influence on instructional strategies - integration of real world components

This theme reflects the educators process of curriculum delivery (rather than the content and resources), an integration of instructional strategies with references brought in from the real world, such as stories or examples or context, reaching beyond the course and the program to enhance the learning experience.

The reason we use teams is because, in the actual practice of engineering, all engineering is done in teams. It's not done individually. We create the same environment they'll have when they graduate and go to work for somebody (Male, Associate professor, 31 years in industry)

I think the fact that I know how to bid a project and I know how to get a client and I know all those things that the academics don't really know but they somehow teach, I think that has influenced me to make my students do the same or mimic the same or learn to use a mechanical drawing tool or learn to use CAD as opposed to people who don't think that's very important. (F, Assistant professor, 5 years in industry)

What I try to do, is tie the textbooks and the theories and the equations to the application software, show them how those things are fitted together, tell them where the holes are and give them a sense of the language and perspective of the problems that are encountered in running a technical business. (Male, Lecturer, 13 years in industry)

I am able to bring into the classroom, things that I've experienced in the past. The students always remember that for some reason. They can't remember what's in a textbook, but they can remember anything I say that's outside the textbook, especially if it's real world. (Male, Lecturer, 22 years in industry)

4.2 Benefits to teaching practice

This last theme takes on a reflective note, where educators articulate the influence that their industry experience, or lack thereof, has had to shape them as engineering educators and how that has or could have added value to their practice.

In my ten years of experience in industry, it was all geared towards enabling me to learn better what I felt engineering education ought to do to improve the relevancy of what we do in engineering education. I went into industry because I wanted to learn more of what engineers really have to do...and so, that has had

a marked effect upon me as a faculty member. (Male, Full, 10 years in industry)

I always said that I learned as much in my first four years in industry as I did my first 8 years in a well as in my 8 years undergraduate, graduate school. I had a desire even as a graduate student, I had a desire to teach...I really enjoyed that, but on the other hand, I felt like that as an engineer that was going to teach engineering, it would be beneficial for me to have some practical experience in industry as well. (Male, Full, 10 years in industry)

I did a co-op and an internship as an undergraduate so I knew that this sort of thing was kind of important but I don't think I would have the context for why this stuff is important if I hadn't been in industry. (Male, Assistant, 5 years in industry)

Well I think if I hadn't worked in industry for a while I would probably just be teaching classes the way I was taught then. (Male, Associate professor, 3 years in industry)

I've always thought that some industry experience, more than, you know, four months, maybe a few years, would have given me a better perspective on what industry needs, and I'm almost certain that it would have made me a better teacher. (Male, Assistant professor, 4 months in industry)

5. IMPLICATIONS and FUTURE RESEARCH

The purpose of this preliminary study was to explore the perceived influence of industry experience on engineering educators' teaching practice. Participants indicated that there was, indeed, an influence on their practice, particularly in the area of curriculum and content development, as well as the integration of real world context into their teaching strategies. Participants also reflected that being an engineering practitioner contributed to making them a better engineering educator.

5.1 Implications

The implications span various stakeholder groups.

For engineering students, engineering educators with industry experience can bridge theory and practice, incorporate real world problems and constraints, apply instructional strategies that reflect a different perspective that aligns with the concept of embedded knowledge [6].

For engineering programs, the practitioner experience of these educators offers currency, relevance, and authenticity. Real world contexts and constraints can be brought into the learning experience to make the links to engineering practice.

At this point, though, the implication for hiring practices remains a curiosity. Industry experience is positioned as an asset, and not an imperative.

5.2 Future research

To expand on this preliminary research, an exploration of what informs the teaching practice of educators with limited or no industry experience would offer a balanced view to this currently one-sided investigation. This could inform not only professional development strategies, but also program/policy development to support the benefit of having educators with adequate experience as a practitioner.

Further research can also explore if, where, and how much industry experience makes a difference in the teaching practices of engineering educators and, by extension, to learner outcomes, to program development, and to hiring practices.

Finally, this study could expand to include the perceptions of Canadian engineering educators.

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