University-Industry Partnership to Develop Engineering Students' Professional Skills*

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Colorado State University has formed a unique partnership with its engineering industry colleagues to develop and deliver a program on engineering professional skills for undergraduate students. The Professional Learning Institute (PLI) has been a required component of our degree programs since 2009. It has been designed to address the professional skills components of our accreditation criteria, as specified by the ABET. The program includes regularly scheduled workshops presented by practicing engineers in five tracks: leadership, ethics, cultural adaptation, civic and public engagement, and innovation. Our graduates are now gaining a deeper awareness of these important skills through interaction with practicing engineers. This has resulted in them being more attractive employees to our engineering employers.

Keywords: professional skills; leadership; ethics; innovation; cultural adaptation; civic and public engagement; innovation

1. Introduction

Colorado State University (CSU) engages its industry partners in both developing and delivering our program for student professional skills development. We have actively involved our industrial partners in delivery of a critical and often neglected component of student development. An engineering education, even one of high technical quality, is of little use if it fails to equip students with the tools they need to succeed in a global collaborative professional environment. ABET, the National Academy of Engineering, the American Society of Civil Engineering, and other experts in the field of engineering education concur that the so-called "soft skills" (we prefer "professional skills") are necessary for students to succeed professionally upon graduation [1].

Our university has developed an approach for student professional development modeled on professional development workshops and seminars more commonly found in engineering companies than in a classroom. This Professional Learning Institute (PLI) provides students with a broad array of workshops, presentations, and experiential opportunities addressing cultural adaptability, teamwork, innovation, leadership, ethics, and public service topics, which are many of the same skills for which employers invest training and orientation resources for newly hired engineer graduates. Since 2009, the PLI program has been a mandatory extra-curricular requirement for all students graduating from the College of Engineering. Most PLI sessions are facilitated by leaders of the engineering profession who have teamed with the College of Engineering to provide high-quality programs for our students that incorporate real-life examples from years of professional experience. Since the pilot program first launched in the Fall 2006 semester, the PLI has grown and established itself as an indispensable component of our university's engineering curriculum—one that draws employers to seek out our students for employment and brings professionals from a wide variety of disciplines to our campus, eager to pass their knowledge, skills, and experience to the next generation of working engineers and thereby improve the engineering profession as a whole. The learning outcomes of the PLI workshops can be nimble and responsive to the ever-changing needs of our industrial partners.

This mutually beneficial partnership has many positive outcomes for our industrial partners, our undergraduate engineers, and the College and University as a whole. Our campus is not unique, receiving frequent and numerous requests from our industry partners for access to speak as guest lecturers in classes, but with time constraints on traditional classroom learning outcomes, faculty are increasingly reticent to surrender classroom time. The PLI program provides a forum for engineering professionals to reach a wide horizontal and vertical cross-section of the college, touching students of all levels and majors. Guest lecturers in the PLI program are frequently case-based learning exercises that expose students to current, relevant, real world design challenges, and leadership or ethical dilemmas. At the College's annual PLI day, held each year in November, we offer a full day of professional development workshops modeled after a professional conference format. In addition to the learning that takes place during formal workshop sessions, we are intentional about providing structured and unstructured networking times, where engineering students, Indus-

trial Advisory Board members, engineers, project managers, and human resources personnel are able to network and share their best practices in organizational training and development of the engineering workforce.

The Professional Learning Institute (PLI) was formalized as a graduation requirement in 2009 in the College of Engineering at Colorado State University [1]. The goal of the program is to complement engineering students' technical skills with a set of non-technical professional skills that will help students succeed as they enter the workforce. The College also has an interest in ensuring that students obtain professional skills because the attainment of such skills is required for the College's reaccreditation through ABET. Specifically, ABET requirements specify that engineering students must acquire: (a) ''an ability to function on multidisciplinary teams'', (b) ''an ability to identify, formulate, and solve engineering problems'', (c) ''an understanding of professional and ethical responsibility'', (d) ''an ability to communicate effectively'', (e) ''the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context'', (f) ''a recognition of the need for, and an ability to engage in life-long learning'' and (g) ''a knowledge of contemporary issues'' [2]. The PLI program is aligned to support students as they become proficient in these skills.

There are five competency areas covered by the PLI at Colorado State University: ethics, cultural adaptability, innovation, leadership and civic and public engagement. Students graduating in 2012 or later are required to earn eleven PLI credits, three from the ethics track and at least two in each of the remaining four competency areas. Students may earn such credits by attending workshops and seminars offered by the College. The College works with both campus and industry partners to create seminars that address the five targeted areas. Students may also use an alternative credit process to receive PLI credit for other relevant student activities, such as leadership programs sponsored by Colorado State University's Office of Student Leadership, Involvement and Community Engagement (SLICE).

2. Teaching-learning methodology

In the CSU PLI program we have taken the bold step to give our industry partners ownership of the teaching of our students the professional skills so often requested by these same partners. Numerous reports show that industry asks for greater professional skills from engineering graduates, e.g. teamwork, global awareness and competency, leadership skills, etc. At the same time, academics push back, indicating the lack of time to incorporate these skills into the already packed technical curriculum. To us it made sense to have industry take on this task with our students. This was based on several reasons: (a) industry knows better what those skills look like in the practical world of engineering than most faculty, (b) industry knows which skills are important, and why?, (c) industry understands the context of applying those skills beyond the sheltered academic world, (d) students are always looking for greater interaction with practicing engineers, and (e) students consider practicing engineers more credible on these topics than faculty, whereas faculty are considered technical experts.

Once this decision was made, the difficult aspect of designing and maintaining this program is to integrate industrial partners into the academic system such that they are providing excellent content and using appropriate pedagogies. In general, practicing engineers are not versed in educational methodologies. As will be discussed in the following section, this aspect of the program has been a focal point of much of our assessment of the program over the years.

In a typical semester we offer upwards of forty different workshops which the students can choose from to meet the minimum requirement of eleven upon graduation. In addition to the required number of workshops engineering students must attend, the PLI also offers graduates the chance to earn a 'certificate' indicating a higher level of effort in any particular topic area of the PLI. For example, students who choose to attend four advanced sessions, above and beyond the PLI program requirements, and complete a reflection essay are awarded a certificate in leadership.

The topic areas chosen for the PLI were jointly defined through a collaborative effort with our industrial partners. To get the program started, the authors visited numerous engineering firms within the region, both large and small. During these visits the authors collected best practices in the professional development activities used by the firms to maintain and enhance employees' professional competencies. The results of these many visits and meetings with our partners resulted in an initial design for the program. This initial program formed the basis of a voluntary set of workshops for engineering students. At the same time we were soliciting ideas about content, we also solicited presenters for the workshops. In fact, our visits and discussions with our engineering industry partners resulted in an overwhelming response on their part to participate as presenters. This response remains strong to date; we tend to have more volunteer presenters than we do slots for presentations.

One of the most important steps taken in the development of the PLI was a two year program where an industrial partner provided us with an 'executive in residence' at our institution. A senior executive from the IBM Corporation was loaned to us to work on the creation and implementation of the PLI. This provided invaluable expertise for us to draw upon for developing the content design for the PLI. At the end of those two years we had the final structure, described above, in place.

As noted above, a key element in this program is the use of practicing engineers to be the presenters for the workshops. This was the case from the beginning and holds true today. The one area where we sought external assistance outside the engineering community was for the cultural/global awareness workshops. This area has undergone a couple of transformations. It started, as did the other areas, with our engineering industry partners. Then we enlisted the assistance of the cultural diversity centers on campus to provide workshop presenters. Currently, we have moved to a system that combines the two approaches, as will be described below when we discuss the results of our assessment programs. The next section also presents further information on the teaching methodologies that have been incorporated over time into the PLI program.

3. Results/benefits

Measuring the results and benefits of this project have proven to be challenging for two reasons: first the inherent difficulty of measuring professional skills and second assessing a program that is mostly delivered by volunteers outside the confines of the traditional faculty. We briefly touch on the first point then spend more time discussing how we address the second point.

Regarding the first point above, how to quantify engineering professional skills in a manner conducive to measurement, we are only now starting to make progress towards a long-term plan. As programs are developed to address the need for students to have professional skills in addition to the technical skills learned in their traditional degree programs, the need to assess the learning of these skills arises. These skills are generally assessed using subjective measures such as behavioral observation, portfolio reviews, interviews, evaluation of presentation and internship quality, case studies, and role playing [1–3]. Often these appraisals are tied to high-stakes outcomes such as performance review or student grades, which can confound direct outcomes of the learning assessments themselves. In addition, these methods can prove costly in terms of time and money, as faculty are often necessary to carry out the assessments. Given these issues, and coupled with

the large population of participants often involved in such programs, program leaders often turn to more objective measures of professional skills learning [3, 5]. However, Mayotte [6] asserts that these objective measures are more limited than subjective measures and are, therefore, not appropriate for assessing professional "soft" skills.

Since its inception, the program has grown significantly in terms of student participation. As the program has grown, so has the complexity of the program and the professional skills considered as key competencies. Previous evaluations have been unsuccessful in capturing the intricacies of the program and measuring its impact on developing engineering students' professional skills. This is not surprising given the recognized lack of robust methods for assessing "soft" skills in technical fields [6]. Although the ABET lists specific professional skills as criteria for accrediting bachelors' degree programs, the literature on robust and effective measures to assess such skills remains sparse [7]. In addition to the inherent issues in measurement tools, the structure of the particular PLI allows for a high degree of variability amongst the content delivered to students each year and the route by which students choose to achieve PLI certification, an issue that is becoming more common in other semi-unstructured programs [8–9].

Our focus on the second point, assessing volunteer presenters, has been an area where we have been more successful. At the very beginning of the delivery of the PLI we designed an assessment system in a manner intended to provide the presenters with quick feedback on their presentations – notice the focus was not exclusively on student learning outcomes! We has quickly learned through assessments described next, that students develop expectations on presentation styles and content mostly based on the battery of classes that make up an undergraduate degree program.

The industry volunteers, on the other hand, find themselves in very new territory: undergraduate audiences that may have learning outcomes thrust upon them. Previously, industrial partners could come to campus and present to students in low-stakes environments where students were free to enjoy the contact without the need for 'formal' learning.

Our approach since the inception of PLI includes the use/creation of several different evaluation instruments:

- Instrument #1: Evaluation forms for PLI (borrowed from other similar workshop evaluation forms) measured students' perceptions of and attitudes toward the PLI to determine how to improve PLI workshops for the future.

- Instrument #2: Drawing on research and expertise from Becky Orsi and David Hibler (education research graduate students), the original PLI evaluation forms were revised to better gauge how the PLI can help engineering students gain relevant skills for the profession.
- Instrument #3: To better understand how students experience PLI, Orsi developed a battery of interview questions and facilitated focus groups.

In the following we describe some of the results of the use of these instruments in assessing the PLI. As alluded to above, as a means for providing quick feedback to the presenters, our approach was to summarize the data collected using these instruments soon after the presentations and sending those results to the presenters via email. Then, on an annual basis, we meet with many of the presenters during PLI day or during the annual advisory board meetings to summarize the assessments and solicit feedback from the advisory board.

Results from instruments #1–3 show a broad spectrum of responses to the workshops, from positive to negative, depending upon the presenter and presentation style. More specifically, in 2011, Student Diversity Programs & Services (SDPS) received negative feedback and constructive suggestions from students who attended the 2010 academic year workshops. The basis of this criticism was a lack of relevance to engineers and the engineering profession. Engineering students tend to be very focused on the engineering content and focus of their education. The presenters from the Diversity Programs offices have a history of working with a diverse group of audiences. During the annual advisory board meetings, along with the flow of feedback from the instruments via email to the presenters, changes are implemented to increase the learning during these workshops. Currently, the SDPS presenters now team with engineers from industry to jointly make the presentations. This has resulted in the students being exposed to real-world engineer scenarios that focus on global and cultural issues. This has raised the level of student satisfaction, and we believe improved development of their awareness and abilities to work in a global profession such as engineering.

Perhaps the most valuable information coming from these instruments has been the feedback to speakers on ways to improve their presentations. One main request from the students is to have more case studies included in the presentations. At the beginning, our industrial partners tried to mimic regular courses by focusing on content without fully sharing their own job experiences. Students felt that this was not very effective for their learning what these topics mean in professional practice.

Through the feedback continuously provided to the speakers, and the discussions at the regular advisory board meetings, we now work with the presenters to include their experiences as cases in the workshops. The industrial advisory board members indicate that this has improved student engagement during the workshops and improved the PLI program.

The second major assessment mechanism we use in addition to the above instruments are the annual advisory board meetings. Here is where we learn much more about what the students are learning in the PLI. For example, Mike Applegate, president/senior principal of Applegate Group, has been invited on numerous occasions to facilitate PLI workshops. After interviewing several recent graduates, he provided feedback about how students can improve the way they speak about their leadership abilities during interviews. Leadership is one of the major tracks in the PLI. The following quote from another board member provides insight into Mike's concerns:

> Most underclassmen will overestimate their awareness of all topics; most seniors will underestimate their awareness and understanding of topics.

This touches on two important aspects of the student learning, first, students' self-evaluation of their knowledge and two the level of learning taking place. Students are definitely learning leadership skills, or are becoming aware of those skills through the PLI but as Mike and others highlighted; they were not as successful at communicating their knowledge to future employers. This is now a topic many speakers attempt to explicitly address in their presentations.

The advisory board discussions have also focused on the level of student attainment that is possible while students are still in school. As noted above, awareness is an important starting point.
The majority of board members believe that we must start with awareness as evidenced by the following quotes from a recent board meeting (November 2011):

> Awareness is a great place to start for students, but most have not had a chance to apply this awareness. Perhaps with more opportunities to apply their learning, they could achieve deeper levels of understanding.

> The students won't have any opportunities to apply these topics until they're out in the workforce and are practicing engineers, so awareness is good place to start in assessing the PLI's effectiveness.

Although our focus remains clearly on developing student awareness, we are also looking at opportunities to have students demonstrate their skills in the areas covered by the PLI.

Schlumberger Oil Company, another significant contributor to our program, shared that students

tend to leave their assignments early due, in part, to challenges with adapting to environments quite different from Fort Collins, CO (the location of the CSU campus). Schlumberger recommended PLI workshops to help students learn how to prepare for adapting to different cultural experiences. Currently, there is much attention in higher education about the importance of working in a globally diverse profession, but what that means to an emerging engineering professional can be confusing. This was a wonderful example of how we need to help students take their newly developed awareness and apply it to their careers. We now include materials on not only having co-workers from around the world, but also discuss the challenges and opportunities to 'move' around the world in their jobs. As mentioned above, a major improvement to the diversity track has been the teaming of diversity training professionals with our industrial partners to provide joint workshops.

A recent CSU alumni, Matt Cain and other recent alumni are in the process of planning a new PLI workshop about how to build your personal brand, work with your supervisor, and engage in lifelong learning. These practicing engineers represent the first group of PLI instructors who participated in the program as students, and are now returning to campus to deliver content as presenters.

We believe that the unique approach to professional skill development that is driven by our employer partners provides a unique competitive advantage for our engineering graduates in Colorado and in the nation. We have been contacted by numerous universities asking how to implement a PLI type program at their universities and we believe our model of employer guided professional skill development can be widely adopted by other universities.

Data show Colorado State University students are among the most employable in the State of Colorado. During interviews and career fairs, we are seeing that employers are now asking students about what they have done outside the classroom to enhance their professional skills. Students are now taking responsible for self-directed ownership over their own professional growth choosing to attend sessions that are most relevant to their own professional development and interest areas within the prescribed requirements of the program.

Now in the 6th year of the professional learning institute we have alumni that helped to pilot the early years of the program that are now returning to campus as practicing engineers delivering PLI sessions on the topics that they wish they knew when they were in school. Our returning alumni have immediate credibility with our current students and represent the ultimate feedback loop.

4. Future issues

Continuous improvement in how the college evaluates and assesses its educational programs has compelled us to pursue instruments that provide direct measurements of student learning, especially since previous instruments for evaluation/assessment represent indirect measurements. As per Orsi's suggestion in her report [10], some forms of direct measurements may include portfolios, performance assessment, behavioral observations, or Multiple Mini Interviews. Unclear outcomes also point to the need for surveys with Likert scale options.

As discussed above, the advisory board members believe that students are definitely developing an appropriate level of awareness for the topics incorporated into the PLI workshops. Board members have not reached a consensus as to whether students can be reasonably expected to have opportunities to apply those skills while still in school. Despite this lack of consensus, we are moving in the direction of providing students with more opportunities to demonstrate their skills in the PLI. Currently under consideration are the possibilities of having students either maintain portfolios with reflective writing pieces showing their understanding on certain topics, or having them develop responses to well-designed case studies that require the skills imparted in the PLI. During the November 2012 Advisory Board meeting it was agreed that all future presenters will provide a series of questions that they believe students should be able to answer after attending their session. New forms are being developed that will require students to provide a short reflection on these speaker-provided questions. These reflections might then form the basis for students developing portfolios related to their learning in the PLI.

Also, a new track in the PLI is currently under development: career preparation. Students continue to struggle preparing for entering the job market in terms of proper planning for job searches, interviewing etiquette, and evaluating job offers. This new track was discussed during the November 2012 PLI advisory board meeting. One of the other needs identified during this discussion is the concept of job mobility. The advisory board members recognize students need to be prepared to change jobs, which requires additional skills. The advisory board overwhelmingly supports the creation of this new track and has offered to contribute to its success. As an example of how they already contribute the college recently hosted a career fair that included several informal meetings between graduating seniors, along with resume review sessions where employers held open sessions to review student resumes.

Finally, many of the employers attending our recent career fair also contribute to the PLI. They are in a great position to critique the plans for this new track in the PLI program. We are always looking to integrate potential employers with students both through career fairs and the PLI.

5. Conclusions

Since its inception, the PLI has delivered over 500 professional development lectures, presented by a robust speaker bank of 150 industry experts, representing close to 90 organizations. Over 750 hours of instruction have been attended by more than 13,000 student attendees. Engaging industrial partners to develop engineering graduates' professional skills has been considered a very successful approach at CSU. The use of practitioners provides several advantages over full-time faculty members:

- Professionals have a better understanding of the types of professional skills necessary for new engineering graduates to posses when entering the workforce.
- Students place great value on exposure to practicing engineers during their studies and these workshops provide an excellent venue for this type of interaction.
- Finally, practitioners remain in touch with the engineering college, providing feedback on our students and at the same time learning about the major current education issues in engineering.

There are also some disadvantages to this approach. First, practitioners are not experienced in teaching undergraduate students. This has been seen in the early reviews of the workshop where students expressed some dissatisfaction with the quality of the workshop presentations. Much of this disadvantage has disappeared as the presenters gain experience in the PLI and through the open sharing of the student reviews with the presenters. In addition to sharing the reviews, there has also been an intentional effort to help presenters develop their presentation skills by sharing different pedagogical approaches recognized as being valuable, e.g. the use of more case studies and examples.

The adaptive nature of the PLI program allows it to adjust to the ever changing needs, incorporate current topics, and integrate new industrial partners. Because the program is delivered by practicing engineers, presenters can integrate current, timely, and relevant case studies into sessions. Moving forward, the PLI program aims to be a nimble, responsive, and agile program that complements the sometime rigid technical curriculum.

References

1. T. J. Siller, A. Rosales, J. Haines and A. Benally, Development of Undergraduate Students' Professional Skills, *Journal of Professional Issues in Engineering Education and Practice*, **135**(3), 2009, pp. 102–108.
2. ABET Engineering Accreditation Commission, Criteria for accrediting engineering programs. Baltimore, MD: ABET, Inc., 2010, www.abet.org.
3. D. Beard, D. Schwieger and K. Surendran, Integrating soft skills assessment through university, college, and programmatic efforts at an AACSB accredited institution, *Journal of Information Systems Education*, **19**(2), 2008, pp. 229–240.
4. S. P. Hall and V. C. Bryant, Assessment of professional skills for students in computing and engineering programs, *Journal of Computing Sciences in Colleges*, **23**(4), 2008, pp. 146–152.
5. D. Briedis, Developing effective assessment of student professional outcomes, *International Journal of Engineering Education*, **18**(2), 2002, pp. 208–216.
6. S. Mayotte, Online assessment of problem solving skills, *Computers in Human Behavior*, **26**(6), 2010, pp. 1253–1258.
7. L. J. Shuman, M. Besterfield-Sacre and J. McGourty, The ABET "Professional Skills"—Can They Be Taught? Can They Be Assessed?, *Journal of Engineering Education*, **94**(1), 2005, pp. 41–55
8. R. Blake and O. Gutierrez, A semantic analysis approach for assessing professionalism using free-form text entered online, *Computers in Human Behavior*, **27**(6), 2011, pp. 2249–2262.
9. L. B. Sample McMeeking, R. B. Cobb and C. Basile, Evaluating long-term complex professional development: using a variation of the cohort control design, *Evaluation & Research in Education*, **23**(4), 2010, pp. 273–285.
10. R. Orsi, Professional Learning Institute—Assessment Tool Development Project—Final Report, Submitted to the Engineering Information Foundation, Colorado State University, 2001, pp. 33

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