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Preliminary Work on Weaving Professionalism Throughout the Engineering Curriculum

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In September 1998, Hispanic Engineer and Information Technology Magazine recognized Rosales for her many contributions to her industry, naming her as one of its 50 "Women Who Make a Difference." The award honors Hispanic women who are inventing new technology, new processes, or are reshaping management. In 2004, the Society of Hispanic Professional Engineers presented their Corporate Achievement Award to Rosales at their National Career Conference. This award is given to a Hispanic engineer who has made significant accomplishments in the scientific, technical, or engineering arena. In September 2008, the Colorado Rockies honored Rosales with a Hispanic Leadership Award for her leadership and contributions to the Hispanic community. In October 2012, MAES presented Rosales with the Medallo de Oro (Gold Medal) Award for her service to MAES and the Latino STEM community.

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With nearly twenty years combined experience in higher education and private industry, Andrea Leland has distinguished herself as a dynamic communicator and tireless ambassador of engineering education and research. For the past twelve years she has worked in the Department of Electrical and Computer Engineering at Colorado State University to advance its mission through well-planned communication strategies and relationship building. Leland has played an integral role in engaging industry to guide the department's professional formation efforts to prepare students for an increasingly global profession. Leland holds a Bachelor's of Science in Organizational Communications and Marketing from the University of Central Missouri.

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Preliminary Work on Weaving Professionalism Throughout the Engineering Curriculum

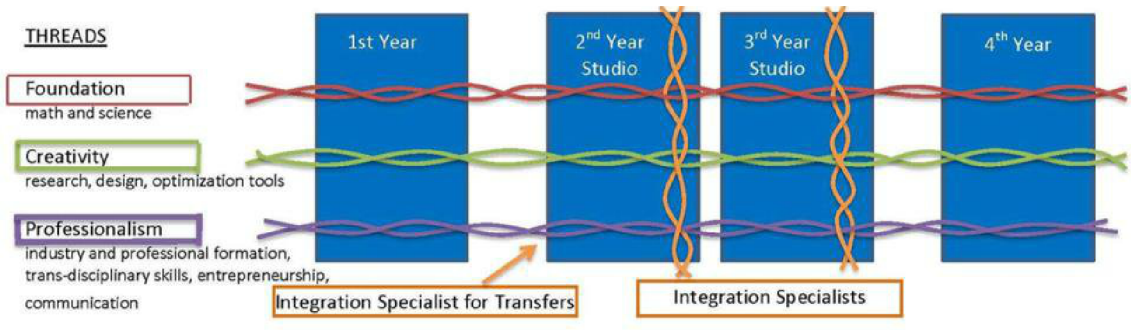
I. Introduction

A diverse team of educators are redefining what it means to teach and learn in an Electrical and Computer Engineering (ECE) department, along with the processes and value systems through which people become engineers.[26] As one of six schools charged by the National Science Foundation with revolutionizing engineering and computer science education for the nation, this paper describes how the project team is paving the way to change through organizational and pedagogical innovations that empower multifaceted faculty teams to embed professionalism throughout the curriculum. Working in close collaboration with industry, their work is reshaping professional formation to ensure that ECE students develop critical skills for the 21st century.

The team is implementing a new pedagogical model in the ECE department that builds on the concept of "nanocourses"[4,10] and emphasizes knowledge integration – a learning model well-grounded in education pedagogy and supported by research.[5] The approach combines rigor and flexibility to improve student understanding and efficacy through learning studio modules that cross traditional course boundaries. While area-specific learning modules have been in existence for years, such modules are usually supplements to the core curriculum and do not typically cover fundamental subjects vital to comprehending abstract topics, nor do they stitch together anchoring concepts to lay the groundwork for real-world applications.

Moving away from teaching courses in isolation, the undergraduate experience is treated like a complex integrated system, with faculty working collaboratively to show how topics connect across the curriculum and relate to the applied world of engineering. As shown in Figure 1, newly assigned integration specialists lead the effort to synthesize content for the learning studios, taking the form of vertical threads that demonstrate the intersections of knowledge and illustrate how fundamental concepts are interrelated. Thread champions are responsible for weaving horizontal threads throughout the curriculum: *foundations* (math and science), *creativity*

Figure 1: New teaching and learning model with a thread dedicated to professional formation



(research, design, and optimization tools), and *professionalism* (communication, cultural adaptability, ethics, leadership, and teamwork).

The professional formation thread – While the new pedagogical and organizational model dramatically changes the educational landscape in the department, with broad impacts to the culture and discipline as a whole, this paper focuses on the professional formation thread, and discusses how the innovative structure provides a framework for developing professional skills more effectively and meaningfully. It examines the important role of the professional formation thread champion – a former Fortune 500 executive – and her collaborations with industry and faculty teams to leverage the new model, expand previous work, and implement novel initiatives and assessments at touch points throughout the undergraduate experience.

For more than a decade, engineering educators have been exploring the best approaches to producing a new generation of engineers with skills to thrive in an increasingly global profession. [21, 22, 28, 30] Like many institutions across the country, the ECE department has joined in the push to instill professionalism in its students, but the work has come with a set of challenges. It has long been recognized that teaching professionalism can be particularly challenging for engineering faculty who must balance the need for deeply technical content with the demand for professional skills development.[29] Further, as Shuman points out, assessing students' attainment of professional skills is difficult, partly because of varying definitions of what attainment means combined with the fact that professional skills are harder to quantify than traditional technical skills. [29] Shuman also discusses the importance of "fidelity" in professional formation, which measures the extent to which training conditions emulate the eventual working environment.[29] Bolstered by a new partnership with an institution focused on professional skills assessment[25] (described in section V), the professional formation team aims to clearly define attainment, overcome the challenges associated with assessment, and create greater fidelity, or meaningful experiences, for ECE students.

Backed by current engineering education research and literature, [3, 6, 14] the professional formation thread emphasizes five key areas: c*ommunications, cultural adaptability, ethics, leadership*, and *teamwork*. These areas closely align with the skills required to be a professional engineer in the 21st century, [9] as illustrated in Table 1.

Table 1: Professional formation subject areas

Initial Professional Formation Thread Subject Areas	**21st Century Engineering Skills (Fisher, 2014)**
Communication	Interpersonal Communication Public Speaking Written Communication
Cultural Adaptability	Cross-cultural Skills Global Awareness
Ethics	Ethics
Leadership	Critical Thinking Organizational Management Self-confidence Self-direction
Teamwork	Teamwork

The professional formation thread encompasses the necessary skills for being a globally competent engineer, [6] and is in line with findings from the American Society for Engineering Education related to the desired technical, professional, and social knowledge skills for engineers, [3] which are consistent with the 21st century skills identified by Fisher. The subject areas also take into consideration, and build upon, the pillars of the Professional Learning Institute, a college-wide program that laid the foundation for learning professionalism at the institution. Once the initial subject areas of the professional formation thread are established, phase two will include additional areas highlighted in the research: civic and public engagement and innovation.

To help put the team's work into context and describe their efforts to reshape professional formation, the remainder of this paper is organized as follows: section II shares a history of professional formation in the department, explaining how industry has been a primary driver of strategic decisions related to professional skills development; section III discusses related work that is informing the team's efforts; section IV describes the processes used to implement the new pedagogical model, along with the nuts and bolts of embedding professionalism throughout the curriculum; section V reveals lessons learned and next steps to achieving the goals of the project; and section VI provides early conclusions, with a call for feedback and support from the engineering education community to join them in preparing engineering students for the grand challenges of the profession.

II. History of professional formation in Electrical and Computer Engineering

A. Professional formation guided by ECE Industrial Advisory Board

The Department of Electrical and Computer Engineering has worked for years to continuously improve its approach to professional formation, relying heavily on input from constituents ranging from alumni and corporate partners to faculty and current students. The most influential stakeholder group has been the department's Industrial Advisory Board (IAB), and for the past decade the IAB has driven a number of initiatives designed to teach and build capacities for professional skills, often called "soft skills." As shown in Table 2, the IAB's recommendations have been delivered in silos, mostly via the senior design capstone experience. ECE 202 Circuit Theory Applications – which now includes a project design component in the sophomore year – has served as the vital lower-level course for introducing the board's suggestions early in the curriculum, while other topics are covered piecemeal through the Professional Learning Institute, addressed in the next section.

Table 2: IAB suggestions and implementation points across the curriculum

Professional Topics from IAB Feedback	Senior Design	Sophomore-level mini projects	Professional Learning Institute
Project Management			
· Design early in curriculum		X	
· More interdisciplinary projects	X		
· Project management skills development	X		
· Multi-year, multi-phase projects	X		
Communications			
· Best Paper Contest (written)	X		
· Project presentations (oral)	X	X	
Teamwork			
· Address team dynamics	X		X

Given the real-world experiences that team projects afford, the bulk of the department's professional formation activities have occurred in the senior design capstone sequence. Beyond the initiatives outlined in Table 2, senior design also serves as a vehicle for teaching the importance of ethics through industry lectures and communications exercises. While students have benefited from these professional formation efforts, the department sees the value in developing soft skills earlier in the curriculum and reinforcing the knowledge at multiple points throughout the curriculum, rather than saving it for the senior year. This discovery validates the goal of the professional formation thread, which aims to embed professionalism throughout the curriculum. Whether illustrating the value of professionalism in the context of technical coursework or experiential learning, the professional formation thread will allow students to see that soft skills are essential to every educational component and vital to becoming an effective engineer in today's society.

B. The Professional Learning Institute

As passionate IAB discussions mounted about the critical need for professional skills development, a former ECE IAB member and Fortune 500 executive on loan to the university stepped up to take action. To substantiate the board's feedback, she set to work conducting interviews with individuals from a broad range of companies about the changing role of the engineer. Because the entire college was grappling with issues related to teaching and building capacities for soft skills, the scope of her work extended beyond the ECE department to include advisory board members from other engineering departments in the college. Propelled by input from these interviews – combined with a consistent message from well-regarded publications that speak to the desired attributes of engineers, such as *The Engineer of 2020*[22] and *Educating the Engineer of 2020*[21] – her work resulted in the 2007 launch of the Professional Learning Institute (PLI), a college-wide program to provide students with real-world professional skills to complement technical curricula.[30]

Featuring a series of talks and workshops led primarily by industry professionals, the PLI program addresses five topic areas, or pillars, which map to ABET's non-technical outcomes: cultural adaptability, civic and public engagement, ethics, innovation, and leadership. While the

PLI began as an optional program, all engineering majors are now required to participate in 11 PLI sessions distributed as follows: cultural adaptability (two sessions), civic and public engagement (two sessions), ethics (three sessions), innovation (two sessions), and leadership (two sessions).

Over the course of the PLI, the college has used different types of instruments to evaluate and assess the program. In 2010, it received a grant from the Engineering Information Foundation to develop tools to assess learning outcomes of the PLI. Because initial results indicated that there were no statistically significant differences between students regardless of the level of exposure to the PLI, the end phases of the project evolved to include focus group research with students who had participated in the PLI program. Among the recurring themes were concerns with content, delivery mechanisms, and lack of interactivity in the PLI sessions. [27] Comments from the 2010 focus groups included:

- "Just sitting and listening in a PLI seminar does not promote learning."
- "More field trips and "hands on" learning in the PLI program would be good."
- "The PLI should expose students to more business-world processes and thinking (e.g. budgets, product development, and actual ethical situations)."
- "The PLI program should be made to achieve its good end-goal; it doesn't do so now."

As a result of the previous assessment measures, strides have been made to make the PLI more relevant for students. The program now includes more hands-on activities and learning exercises, such as interactive games and case studies that emulate real-world scenarios, as well as field trips to local companies. A new online assessment process has also been implemented to continuously improve the quality of the workshops and the program overall, and presenters are now required to develop two student learning outcomes questions for their workshops, which are incorporated into the online evaluation that students must submit in order to receive credit for the workshop.

III. Related work

The rollout of the professional formation thread would not be possible without drawing on the successes of other institutions to inform the team's efforts. As discussed in the Introduction, and highlighted next in section IV, the findings by Fisher and the ASEE lay the groundwork for the professional formation thread thanks to their careful examination and validation of the required skills for professional practice. [3,9] The following programs also provide important insights into developing key professional skills within an engineering program. Of course this is not intended to be an exhaustive list of best practices; the department will continue to learn from a number of programs pushing the envelope to prepare students for the grand challenges of the profession.[8, 13, 19, 33]

Ethics – Georgia Tech is teaching ethics to engineering students through a methodology called "Teaching Ethics in Context," which frames ethical teaching as a part of engineering practice, rather than as a discrete issue.[12] The professional formation thread will also create scenarios that allow students to experience and work through ethical dilemmas as a way of teaching ethics throughout the program.

Leadership – As the team works to develop global partnerships to enhance professional formation, as well as meaningful assessments to measure effectiveness, they are looking to the contributions of the Engineering Leadership Development Program at Penn State University. As one of the first engineering-specific leadership programs in the United States, the program offers a minor in engineering, with an option to complete a leadership practicum abroad. It has also developed tools to measure the impact of the program on students' leadership abilities.[11]

Communications – The team is learning from North Carolina State University's vertically integrated hybrid model in communication, which pairs teams with communications specialists to explore communication issues and develop individual skills within the context of ongoing engineering experiments and design projects.[15] Similarly, the ECE department has experienced some success in teaching communication skills through individual consultations with industry mentors, as described in section IV B.2.a.

Teamwork – Rose-Hulman's ECE department has developed a three-year vertically integrated design thread for engineering students, starting in the fall of the sophomore year and culminating in an externally sponsored year-long industry project the senior year.[20] Not only does Rose-Hulman's project fit with the professional formation thread, the work is also relevant to the design component of the new pedagogical approach.

IV. Implementing pedagogical innovations

A. Establishing learning studio modules and knowledge integration activities

To give context for weaving professionalism throughout the curriculum, a general overview of the pedagogical changes is provided (see Figure 1 in the Introduction for a depiction of the new teaching and learning model). A detailed description of the curricular redesign is available in the companion paper, "Mastering the Core Competencies of Electrical Engineering through Knowledge Integration."[7]

Still in the first year of the five-year project, the ECE department is preparing to launch phase one of the pedagogical changes in fall 2016, and the cultural shift is already evident. Faculty are working in multifaceted teams to break apart seven ECE courses in the technical core of the junior year to create the first set of learning studio modules (LSMs). Each LSM is self-contained and addresses several anchoring concepts and a set of related concepts in a given core competency area.[7] While traditional courses will no longer exist, LSMs still provide a path for students to learn all the intended topics in a rigorous fashion, and the new structure affords curricular flexibility to allow students with different backgrounds to enter in the middle core years without having to repeat content.

To begin, the faculty team selected five anchoring concepts for each of the seven technical core courses, and then worked together to rearrange and synchronize the topics into 35 LSMs. When the team compared anchoring concepts of the traditional junior-level course sequence, they were able to see how topics connect across the curriculum and where the knowledge integration can occur. Instead of viewing each course in isolation, this process prompted each faculty member to think about the curriculum from a holistic perspective. Utilizing a precedence matrix, the faculty

then determined the relative weight and correlation of topics, and verified that all anchoring concepts are covered without unnecessary overlap.

Once the LSMs were established, newly assigned integration specialists collaborated with the faculty team to determine the timing of knowledge integration activities, which illustrate how fundamental concepts are interconnected and relevant in the real world. While LSMs represent multiple modules across a given semester, knowledge integration activities occur less frequently but go a step further to make overall learning more coherent. Using familiar applications such as the smart phone or digital media player, knowledge integration activities show students how anchoring concepts work together to form the basis of many modern day and future advancements.

B. Details of the professional formation thread

B.1. The building blocks of the professional formation thread

The creation of the LSMs and corresponding knowledge integration activities sets the stage for establishing content for the professional formation thread. Drawing on the current body of knowledge, coupled with feedback from the fall 2015 IAB meeting, the professional formation thread champion – who also spearheaded the launch of the PLI in 2007 – has identified and defined content for each of the five subject areas (shown in Table 3), giving special consideration to the knowledge, skills, and abilities (KSAs) as identified in the Transforming Undergraduate Engineering Education (TUEE) Workshop Report.[3] The contents have been reviewed and endorsed by key IAB members, ECE faculty, the project team, and partners in the College of Business.

With content for the professional formation thread in place, the thread champion is creating a blueprint for mapping professional learning to the newly established pedagogical framework. Working in close collaboration with the faculty and integration specialists, she is reviewing the sequencing and contents of each LSM and knowledge integration activity, and then determining the appropriate integration points, timing, and interactive tactics for weaving all of the content from Table 3. Whether delivering the material through in-class activities or industry led exercises, this process allows her to see how soft skills development can be integrated and reinforced across multiple points in the curriculum, and how industry partnerships can be leveraged to enhance the overall learning experience. The approach is unlike previous professional formation activities, which delivered professional content in silos. As an example, Table 4 illustrates how anchoring concepts and professional learning might come together in a knowledge integration activity.

Table 3: Content for professional formation thread

Professional Formation Subject Areas & KSAs Identified in TUEE Report	Definitions of Professional Formation Content
Communication: TUEE KSA #1 - presentation, public speaking, and writing. Students must learn basic steps to effective communication, such as knowing the audience	1. *Communication basics* - Overview of different types of communications, steps to communicating effec and bad communications. 2. *Oral communications* - Delivering effective oral communications, including elevator speech, basics of p with non-engineers, and communicating in an international environment. 3. *Written communications* - Delivering effective written communications, including creating engineering d studies, memos, and minutes of meetings. How to write, manage, and respond to emails is also a focus of of social media. 4. *Listening* - active listening techniques such as paraphrasing, clarifying, and reflecting. 5. *Visual communications* - How to create an effective visual image via a diagram, drawing, or poster. 6. *Nonverbal communications* - Recognizing and interpreting nonverbal clues. 7. *Presentations* - Instruction and practice in how to create and deliver an effective presentation to technica
Cultural Awareness: TUEE KSA #7 - nationality, linguistic, gender, sexual orientation	1. *Global awareness* - An overview of today's global workforce and global economy, and ethical issues in 2. *Working with different cultures* - Communicating across cultures, including working with different nati genders, and generations. 3. *Global dimension of engineering* - Ramifications of engineering in a global world including case studies engineering.
Ethics: TUEE KSA #9 - high ethical standards, integrity, and global, societal, intellectual, and technological responsibility	1. *Academic integrity* - Basics of acting with integrity and making ethical decisions while at the university. 2. *Ethics in engineering* - Review of the IEEE Engineer's Code of Conduct, international business ethics, a violations of environmental and safety laws, as well as goods and services that fail to meet requirements, 3. *Making ethical decisions* - The ethical decision making process and common ethical dilemmas, includin vs. cost, whistle blowing and retaliation, and opportunities to practice analyzing and making recommendati
Leadership: TUEE KSA #22. TUEE KSA#5 - lifelong learning TUEE KSA #6 - taking charge (self-drive and motivation) TUEE KSA #11 - risk-taking TUEE KSA#25 - emotional intelligence	1. *Leadership basics* - Overview of leadership styles, situational leadership, and case studies in leadership. 2. *Personal leadership* - Understanding your own preferred leadership style and how to "take charge" by e motivation, risk-taking, and participating in lifelong learning. 3. *Negotiation skills* - Negotiating for win-win solutions. 4. *Emotional intelligence* - Identifying and managing your own emotions and the emotions of others 5. *Manager vs leader* - The differences in managing people and leading people, and how to develop and de if you are not the designated manager or leader.
Teamwork: TUEE KSA #14 - teamwork skills and ability to function on multidisciplinary teams	1. *Teamwork basics* - Overview of teams, establishing a team charter, managing a team, stages of team de norming, performing, adjourning) 2. *Team composition* - Using standard assessment instruments, analyzing the composition of the team and together 3. *Project management* - Managing the team, include supervising, budgeting, planning, scheduling, reporti 4. *Team communication* - Communicating effectively with the team, including resolving conflicts, providi difficult conversations, and using technology effectively

Table 4: Example of how professional content maps to knowledge integration activity

Sample Knowledge Integration (KI) Activity		
Real-world application	**Anchoring Concepts**	**Integration of Professional Formation Content**
Transmission techniques in the smartphone	-Transmission lines -Signal modulation and demodulation -Signal spectrum harmonics -Antenna and its size vs. transmission frequency	**Ethics, Teamwork, Leadership, and Communications -** Create a scenario in which students form teams to work through an ethical dilemma about the impacts to prolonged exposure to microwaves, and explore the legal regulations. Require each team to give an oral presentation and/or written report to share their experience and validate their knowledge of the anchoring concepts. Activities may include industry engagement to reinforce connections to professional practice, e.g., individual consultations with teams about professional topics; students will have access to video-based modules to supplement learning, much like resources available through the NAE[23] and NSPE.[24]

B.2. Professional formation activities driven by personal passions of industry partners

B.2.a. Partnering with industry to build communication skills

Much like North Carolina State University's vertically integrated hybrid model in communication, the ECE department has experienced success in pairing senior design students with industry professionals to build and assess professional skills, and this is especially true in the area of communications.

Writing and presenting persuasive proposals – Engineers from a major instrumentation and testing company are working closely with senior design teams to help them write effective proposals for sponsorship, taking into account the project definition, roles and responsibilities within the project, goals, timeline, milestones, and budget. All writing submissions are entered in a competition for funding from the company, and finalists are selected to give an oral presentation about their proposals. Whether or not a paper is selected as a finalist in the competition, the lead engineer prepares thoughtful, personalized feedback for each team to help them improve future communications. Below are examples of the type of comments the students receive:

- "This is a general comment from me personally – simply because I have seen your team present a number of times. In past presentations, the team was very crisp and 'together' – this time, it felt a bit more harried and chaotic. This may have mirrored the actual state of the project at the moment – you confessed to a number of big challenges being faced – and it showed through."
- "Would like to have understood more about the engineering challenges the team was facing – we know the proposal is intended to be brief and to whet our appetites, but we felt there could have been a bit more technical detail to the overall proposal."
- "Though we appreciated the informal aspects of the team, we also felt the team could benefit from a more rigorous project schedule, problem descriptions, contingencies, dependencies, etc. You did describe some high level timelines and goals, but given the tough technical challenges we interpreted, we believe there is a greater call to depth, discipline, and rigor in the plans as a result."

Strengthening communication skills through individualized consultations – An exciting new initiative provides communications support to senior design students through individualized coaching and mentoring. Two industry volunteers meet with every senior design team for 45-50 minutes in the fall semester to assess their communications skills, project planning abilities, and team dynamics. The head of the senior design program sees great value in this initiative, as she has observed notable changes in student behavior after these meetings, and student feedback has been overwhelmingly positive:

- "It was very informative. He was able to find the key piece we need to make our presentation speak to people who both know of the system and those who don't."
- "This review was great for us because she worked in the same field. I don't think other groups had the same luxury, so maybe have more experts than just two."
- "Today's meeting was very helpful. It was nice to sit down with someone who has experience and hear his input. He also provided us with helpful advice."
- "Informative, gave us good industry perspective, encouraging!"

At the end of the year, the volunteer consultants host a special event to critique the students' project posters, offering useful advice to succinctly convey complex ideas to lay audiences through visual communications.

Creating well-written project reports – At the end of the fall semester, senior design students are also required to submit draft reports about their projects, which are then shared with industry volunteers who review and evaluate the papers. This process helps students continuously improve their writing skills, and also refine their reports in time for the annual IEEE Best Paper Contest in the spring. The contest, an idea spawned at an IAB meeting, provides students an opportunity to highlight their writing skills and compete for a cash prize. A panel of volunteer judges from the IAB and IEEE grade the papers based on technical content, organization, development, clarity, style, and grammar.

Mastering oral communications – In addition to written communications, opportunities are now available throughout senior design for students to hone their oral communication skills. Students present their projects to a broad range of audiences, including high school students, peers,

alumni, and industry. At the end of the semester, all students deliver a final oral presentation judged by a diverse panel of evaluators.

B.2.b. Industry support for other professional topics

While the IAB strongly believes in the importance of effective communication skills, industry volunteers have stepped forward to share with students their personal passions and expertise in other areas of professionalism.

Implementing a test plan – A representative from a prominent local company helps students by coaching and evaluating them on how to write an effective test plan. He provides each team with a primer that includes considerations for developing a test plan, elements of a test plan, and links to topics for further study. This engineer's support is invaluable to the department because he is exposing students to the test and validation process, which is not covered extensively in the curriculum. The engineer carefully reviews the test plans, and then provides each team with useful comments to help them now and in the future, such as the examples below:

- "This team has good specs from the competition and so they still need to understand how to translate them into tests for their design. We talked about using manufacturer's specifications as a means to characterize their design."
- "They seem to have a poorly developed set of design parameters and therefore poor testing plans."
- "They understood the need for lots of testing. I offered to observe their testing when they got to that point. It was all about designing the test scenarios and the elements of real-time program execution."

Developing effective project plans – Industry partners also review each senior design team's project plan. Three to four weeks into the fall semester, the plans are distributed to practicing professionals at a local robotics company for review and evaluation. After receiving these outside critiques, the students attend a lecture on effective writing, and then create revised project plans based on the feedback. Students must share the different versions at the end of the semester to show the evolution of their project.

Teaching ethics with real-world perspective –A seasoned industry professional gives a lecture on ethics, and then senior design students are required to deliver a two-page paper related to ethical concerns, as well as a three-minute oral presentation to summarize the ethical issues of their projects. The industry partner then reviews and provides feedback on each team's paper with scoring on a scale of 1 to 5 (1 - does not meet expectations; 5 - the team has shown extensive knowledge of different aspects of ethics).

B.3. Holistic initiatives to bolster professional formation

Running in parallel with the initiatives outlined in the previous section, holistic programs have been developed to embed professionalism throughout the program, reaching students at all levels, well beyond senior design.

Engineer in Residence program with the Institute of Electrical and Electronics Engineers – In fall 2015, the department launched a new Engineer in Residence (EiR) program – a partnership with the Institute of Electrical and Electronics Engineers (IEEE) that brings engineering professionals to campus to interact with students at all levels in a maker space laboratory. Serving as resources for career or technical advice, EiR volunteers span a range of companies and areas of technical expertise. The pilot program has significantly increased students' face-to-face interactions with industry, and early feedback indicates that students and industry alike feel the initiative is valuable and important. For the engineers, the EiR program provides many avenues of satisfaction, ranging from giving back to the community to recruiting promising graduates. For students, it affords a valuable outside perspective, including technical and career insights, validation of knowledge, and project support.

To judge the effectiveness of the EiR program and gather information for improvement, a survey (see Attachment 1) was given to more than 300 students asking for their use and awareness of the program. Results revealed high satisfaction levels for those students who had worked with an EiR member, but many students did not take advantage of the program, and therefore additional work must be done to educate students and encourage participation. Comments about the value of the EiR program included:

- "I really enjoy talking and getting their opinions on process – just to make sure we are getting it right."
- "It's very nice to be able to talk to industry engineers who have lots of experience."
- "The EiR members help in the troubleshooting process by asking us questions that we would normally not ask ourselves."
- "The experience they can give is beyond the knowledge we are given in lectures."

An analysis was also conducted of the electronic door lock in the EiR space to evaluate student traffic in the lab. Findings showed that the EiR schedule did not closely align with the most popular lab hours. By shifting the schedule, the contact probability is expected to increase from 22% to above 60%.

Novel mentoring program that emphasizes professional formation – Keysight Technologies has developed a new mentoring program, with the goals of raising awareness about its industry sector and filling the pathway with talented students. At the same time, the company is achieving the goals of the professional formation thread through its interactive approaches to mentoring. Students must apply for the mentoring program, and those selected for it will get one-on-one support from experienced professionals, along with an exclusive look inside the company. Moving away from the lecture format, the company is replacing on-campus "tech talks" with "tech interactions" to teach professional topics. For example, students chosen for the program will be invited to the company to learn first-hand about communications by witnessing a real-time design team review.

V. Lessons learned and next steps

As outlined in section IV.A, breaking up the courses in the junior year was a tremendously productive learning experience for the faculty teams, and it laid the foundation for embedding professionalism throughout the curriculum. Over the next four and a half years, the work will be refined and extended beyond the technical core to the freshman, sophomore, and senior years. Currently, the project team is finalizing baseline studies for the pedagogical and organizational change, including a survey of technical core faculty to identify perceptions about the extent to which the five professionalism subject areas are currently being taught in the junior-level core courses (see Attachment 2), which will be combined with structured interviews of faculty.

As the project continues to evolve, early lessons are emerging. The idea that people are resistant to change has been affirmed. Some faculty members question the pedagogical changes and resist the idea of blowing apart the existing course structure. Further, when outside industry partners get involved with the review and assessment of student projects and papers, some faculty oppose this sort of feedback and do not feel it should impact grades. The department is overcoming these barriers with increased communication and training to alleviate faculty roles strains, coupled with new criteria for annual evaluations and promotion and tenure, which should motivate faculty to change.

The professional formation thread champion has identified trends that are informing efforts to weave professionalism throughout the curriculum. Illustrated throughout this paper, it is clear the department has engaged industry to build professional skills, particularly in the area of communications, but the work does not go far enough because it has been isolated mostly to senior design or standalone lectures through the PLI. The new Engineer in Residence and mentoring programs are still in the pilot phase, but these holistic initiatives are early successes that show great promise for professional skills development at all levels. The thread champion and faculty teams can see the benefits of building on these programs to provide meaningful content and experiences in the professional formation thread.

The project team also recognizes an opportunity for growth in their assessments. These measures need to be thorough and substantive, getting down to the granular level that the new pedagogical framework affords.

Plans for professional skills assessment – The professional formation team has formed a new partnership with a multidisciplinary team at Penn State University to measure the impact and effectiveness of the professional formation thread. Sponsored by the National Science Foundation, the collaborators are developing and testing a set of standardized instruments designed to assess four professional skill areas (shown in Table 5), which closely align with the learning targets of the professional formation thread: ethics, teamwork, global awareness, and creative problem solving.[25]

Table 5. Professional skills assessed and primary learning outcomes

Professional Skills	Primary Learning Outcomes
Ethics (E)	Professional and ethical responsibility, ethical dilemma resolution, moral values, ethical conduct
Teamwork (T)	Effective communication, responsibility, respect, flexibility, availability, decision making, conflict resolution, collaboration
Global Awareness (GA)	Awareness of major global trends and different international settings, valuing diversity, adaptability to cultural differences, communication
Creative Problem Solving (CPS)	Innovative solutions, alternative strategies, in-depth analysis of the information, problem description, correct content knowledge

Retrieved and reproduced from http://sites.psu.edu/modl/assessments/ March 15, 2016.

The assessment approach is informed by the Model of Domain Learning (MDL), supporting the theory that a learner becomes an expert in a domain by going through three progressive and incremental experience-based stages, i.e., acclimation, competency, and proficiency. The MDL states that the nature of domain knowledge, strategic processing abilities, interests, as well as their interactions, are different across the acclimation, competency, and proficiency stages.[1,2,17]

VI. Summary and call to action

As shown throughout this paper, the team understands the critical need for professional skills development, and, if done right, they know the knowledge will set apart the department's alumni in the profession. Like many others in the engineering community, they believe traditional professional formation methods are not meeting intended outcomes, and a new approach is needed. The team believes that weaving professionalism threads throughout the curriculum not only reinforces knowledge to improve student understanding and efficacy, it shows how topics are interconnected by tying learning to the real-world. Industry feedback and support have been central to the department's professional formation efforts, and this paper has shown how the IAB has been a catalyst for a number of programs that the team should continue to leverage, particularly the partnerships that harness the passions of practicing engineers. The team is especially proud of their holistic initiatives, like the Engineer in Residence program, that threads professionalism throughout the undergraduate experience, while providing unique real-world perspectives. Finally, the team has initiated a new collaboration centered on the development of a professional skills assessment mechanism that will show the real impact of their work. They seek feedback and support from the engineering education community about these important issues. What insights, or tips, can the community provide to propel the project? Are there additional strategies or factors that the project team should consider? The department will know its vision has been realized when ECE students no longer need to ask questions such as: Why am I learning this, and why should I care? Will I ever need this information when I get a job? What does it mean to be an engineer?

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