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Engineering Educators in Industry: a Case Study of a Doctoral Internship

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With the current direction of education reform, and the national priority to improve STEM education, a focus on engineering education has become vital for universities in order to produce engineering graduates that meet industry needs, and educators equipped to teach the next generation of engineers. Engineering Education Programs are popping up at universities across the country. Purdue University created the School of Engineering Education (ENE), the world's first such academic unit, in 2004. Since then, universities such as Virginia Tech and Utah State University have created engineering education programs, and other universities such as the University of Texas and Tufts have created STEM Education programs. The degrees offered from engineering education programs vary: some universities offer bachelor's degrees or minors in engineering education, while some schools offer only graduate degrees. One of the concerns for engineering education programs, is where do the graduates belong? Engineering education research is, in many cases, not considered adequate or competitive in tenure procedures among other engineering disciplines. Thus for the growing number of graduates with engineering education degrees, it is important to consider where these students might be placed.

One opportunity for engineering education graduates is the education technology market, with both products and services, that targets engineering education in K-16. Companies that create education technology products many times develop accompanying curriculum and professional development for their products, all of which can significantly benefit from the expertise and perspective of a formally trained engineering educator. Texas Instruments Education Technology recognized this potential value and invited a Doctoral Candidate in Engineering Education to help them explore this market.

This paper describes a single case study of a Doctoral Candidate in Engineering Education who sought a summer internship in an industry setting. The student worked for Texas Instruments, a Fortune 500 company, that was eager to learn more about the K-12 engineering education market. The paper outlines how the partnership was built, the process for how the objectives were defined and expectations set, a description of the work conducted, and experiences of the student. This paper aims to provide insight into a unique college-industry partnership in engineering education, and serve as a model for potential opportunity and placement of Engineering Education students in industry settings. The paper concludes with six "lessons learned" that will be beneficial for students, and student advisors.

Method

The guiding research question for this study is: *What are the lessons learned from an Engineering Education internship in industry?* The methodology used is that of single case study research, and the author of this paper is also the case study. For the sake of readability, the paper is written in third person.

Yin's [1] definition of case study research establishes it as an "all encompassing" method, which converges the logic of design, data collection techniques, and specific approaches to data

analysis. Thus, the case study is not limited to being a data collection tactic alone or even a design feature alone [1, 2]. A case study is an in-depth exploration of a contemporary phenomenon, in this paper – a single case study of a Doctoral Candidate in Engineering Education industry internship.

The data sources for this case study include all correspondence and documented interactions between the student and hiring company, but the primary source of data are the personal reflections of the process, interactions, and communications recalled by the student.

Study Context

This section explains the study context and describes the intern, hiring company, and the internship.

Doctoral Candidate. The student, Meagan, is a female, white, non-traditional student. The student's undergraduate degree is in Computer Science, and she holds a Masters in Electrical Engineering. This student is no stranger to internships. After her first year of undergraduate, she was invited for a two month internship at Texas Instruments (TI). During this work, Meagan networked and arranged for another internship the following school year, but for ten months. Her Masters program included a six month internship, also at TI, where her thesis research was conducted. After graduating, she went to work as an engineer in the same group at TI where she last interned. Two years later, 2009, Meagan began her Ph.D. in Engineering Education. Two and half years in, Meagan earns candidacy, and five months later, she completed the third year of her Ph.D. before beginning the internship. Also in 2009, Meagan began a K-12 STEM education and gender equity consulting business.

Business. Texas Instruments (TI), a Fortune 500 company based out of Dallas, Texas, is a global leader in semiconductor and educational technologies that are driving profound change. TI first reached into the consumer market in 1967 and transformed math and science education with the invention of the handheld electronic calculator. TI Education Technology (ET) has been committed to STEM education ever since, and continues to innovate products and services to improve education. ET has historically marketed their products to mathematics education, and focused additionally on the specific needs of science education since 2011. K–12 engineering education is an area of growing national interest, winning attention not only in the engineering community but within the general education community as well. ET recognizes the growing presence of K-12 engineering education, and seeks to understand the needs and state of this particular market.

Summer Internship. Meagan was looking for an opportunity to return to industry and work at the intersection of engineering and education. Meagan approached two companies with education technology businesses and proposed a research project exploring K-12 engineering education as a market. She reached out to two executives who were within her network in November of 2011. Both responded, but the other company described that they were unable to pursue a partnership at the current time. Given Meagan's background and network at TI, it is not unreasonable to assume this had great influence on securing this opportunity. After a few email correspondences, and conference calls, an agreement was established with TI ET in January of 2012. The agreement was made for a three month internship, mid June through mid September of 2012. Meagan was asked to move to Dallas, Texas, to best engage and interact with the team. Meagan

had a cubicle for office space, and travelled as needed for research purposes. The internship was paid.

Establishing the Role & Expectations

This section describes the process that the role and expectations were developed. This includes how the objectives were set, job defined, and deliverables identified.

Setting the objectives. This area of interest was new ground for TI ET, and they were not accustomed to graduate level interns. This was unlike Meagan's previous intern experiences at TI, where the previous roles and projects were mostly pre-defined. Meagan worked with two people to develop the project objectives and goals, the Director of Marketing and Product Strategy Director. Through conversations, active listening, and lots of specific questions, Meagan then wrote her job description (Jan 2012). Once she began work in June, Meagan spent the first week meeting with dozens of team members. Through these conversations, Meagan was able to ascertain how she could help answer their questions, established her working objective and developed a research proposal. Meagan capitalized on her consulting experience, and her engineering background. She utilized strategies of user-centered design, the qualitative research skills acquired in her Ph.D. program, and project management skills for this process. The objective for the summer internship became: To contribute engineering education knowledge and expertise to the North American Marketing division and Engineering Solutions team, and to conduct research that identifies and informs a robust engineering solution for TI Education Technology.

Job Description. After initial discussions, Meagan wrote this job description for her role:

> TI works with educators throughout the world in designing and developing classroom technology. As a result, our products, training and support materials are well-researched and tested, providing appropriate solutions for every classroom. K-12 engineering education is a growing market, and we are interested in developing a robust, systemic solution including both products and services, similar to what we provide for math and science classrooms. This research opportunity will address the following three questions. First, what is the need and opportunity, from a market standpoint, for a K-12 engineering education portfolio of products and services? This portion will require a literature review and market analysis. Second, from a teacher perspective, what is the current application of TI education technology products in an engineering classroom, and what are the gaps that TI can work to address? Finally, from an administrative perspective, how are schools aiming to address the E (engineering) in STEM, and what are the implementation needs (i.e. services) for this process?

Defining the Deliverables. Meagan used an iterative design process during the first week of work for the creation of a research proposal. As she met with new team members, she was able to refine her questions, but they did not vary much from the original job description. What did see the most iteration was the proposed deliverables. Meagan had proposed lengthy monthly reports as deliverables that were not well received by the engineers and marketing team. Meagan realized she had adapted to an academic setting and needed to adjust back to industry mode: succinct PowerPoint slides and short reports with bulleted lists. While Meagan still created a full report and write-up from the research, she also created and presented succinct presentations, and

executive summaries. In defining the deliverables, Meagan was very explicit about her desire to have a final product that could be publishable on TI ET's research website. (The work and final results were still protected by a non-disclosure-agreement and intellectual property rights at the time of this paper's publication.)

The Work

This section describes the work completed by Meagan during her three month internship at TI ET. This includes a summary of the research project, how the research was conducted, and an un-descriptive overview of the final product.

Summary of Research Project. The overarching goal for the study was to gather information that informs a robust engineering solution for TI Education Technology. The stakeholders in K-12 engineering education approached to contribute to this goal are (in no particular order): policy makers, academic researchers, teachers, administrators, and developers of curriculum and professional development. Volunteer participants were recruited in three different ways. They were either identified through the researcher's (Meagan's) network, were recruited at an event where the researcher was observing, or they completed an online survey distributed to contacts within the business' database or engineering teachers listed in the Market Data Retrieval database. Thirty-eight interviews were conducted and averaged 28 minutes in length. Open ended responses from 128 online surveys are also included in the analysis.

The research questions that guided the study were:

1) What are the overarching needs - both current and future, for K-12 engineering education?
2) What do schools aim to accomplish by implementing engineering?
3) How are schools implementing engineering, and what are the needs for this process?
4) What are the current or potential applications of TI Education Technology products in an engineering classroom?

The results of the study were presented as 4 key findings, and 4 recommendations for an engineering solution for TI Education Technology. The full report illuminates the intersection of this study and the research literature, providing a more comprehensive account of the capacities and urgencies of K-12 Engineering Education as a market. TI has requested the results of the study remain as proprietary intellectual property until further notice.

Conducting the Research. Meagan felt she had likely undertaken too large of a project for a three-month internship. She had requested that TI make the list of people to interview before she arrived, but they waited for her to do that when she arrived. This proposed a challenge initially, but Meagan successfully navigated recruiting participants. Fortunately, TI paid for the interviews to be transcribed to save time for analysis.

Ideally, she had hoped to run the research project under IRB protocols, but TI did not have an Internal Review Board and they did not want to use Meagan's University. The purpose of doing an IRB would be for Meagan to publish the work, and TI wasn't interested in external publication at the time. While Meagan tried to explain the value and importance of the procedure, and even created an internal document of consent with Legal, this lack of priority will limit the usefulness of the data to the research community if proprietary restrictions are lifted.

The final products. In the last three weeks of the internship, Meagan presented her data and recommendations six times, including an exclusive meeting with the two Directors and the President of TI ET. She created targeted messages for each group with recommendations supported by data. Besides the final presentations, Meagan submitted a 35 page report with an extensive literature review, market analysis, research results, and recommendations for engineering product strategy, professional development, and marketing teams. A two page executive summary was also provided.

Lessons Learned

Six key lessons learned emerged from the experiences within this case study. These will be useful as a reference for other Engineering Education students who are seeking or participating in an industry internship.

Internships are recommended. Research shows that the combination of university coursework and internship experience of practice allows the learned content to become meaningful, and the student develops a better overall competence as a professional [3]. Meagan sought this internship intentionally to explore the intersections of her experience as an engineer and engineering education researcher. She was able to directly apply what she learned in her coursework in a setting she was familiar with as an engineer. This culmination allowed Meagan to bridge the gap between her educational experience and professional engineering practice. It is recommended that both graduate and undergraduate students seek opportunities to develop their engineering competence through internships.

Own your education. It is futile to expect others to craft the education experiences that best suit your interests[3]. Meagan took the initiative to create this opportunity, unlike her first and third internships at TI which were somewhat preordained as requirements for her university programs. While the role with TI ET explained in this paper materialized somewhat quickly, she had tried the year before for similar opportunities to no avail. Meagan chose to "own her education" and actively, with persistence and dedication, seek an internship opportunity to gain the experience she desired. It is recommended that students pursue opportunities to explore their interests, better hone their career objectives, and improve professional competence.

Network intentionally. One important note, is that Meagan already had people in her network to reach out to, and she reflects on the saying, "The network you need tomorrow, you should be nurturing today." If a student doesn't have a strong network, it is recommended that they not only begin nurturing the connections they have, but explore where those connections extend. Don't be afraid to ask for an introduction. The online professional social network LinkedIn is a useful tool for managing your network and exploring potential connections.

Industry is not Academia. While this may seem like an obvious observation, Meagan found the transition from academic researcher mindset, back to an engineer in industry mindset to be challenging. Negotiating priorities of "rigor" was a constant struggle for her. Adjusting from personal priorities to academically publish, to aligning to the priorities of the company, helped appease some of these concerns. In addition, the contrast of both worlds and the experiences in both, have proven to be invaluable expertise to draw on as she engages with both communities. It is recommended that even a future faculty member consider the benefit of an industry internship experience.

Can you quantify that? Industry is (again – obviously) fiscally motivated, and everything Meagan presented came back to this priority. One of the tasks given to Meagan was to quantify the K-12 Engineering Education market. When even the National Academy of Engineering committee commissioned to study K-12 Engineering Education[4] can't quantify the market, there is some signal that it can't accurately be done. As a practicing engineer, Meagan recalled often having to make design decisions based on sometimes limited available information. Drawing on this experience, Meagan managed the tightrope between the two worlds and creatively pulled data from a variety of sources and was able to make educated estimates to meet TI ET's need. As a researcher, this "creativity" was very uncomfortable. Though from a business standpoint, it was paramount, in order to move quickly and be ahead of the market. For an engineering education researcher working in an industry environment, it is recommended to anticipate the fiscal priorities and be prepared to make hypotheses and assertions that move the business forward.

Be a Consultant, Not the intern. While Meagan is a novice engineering education researcher, she was the expert at TI ET. She learned that people would rarely ask questions or advice of her in meetings. Once she adjusted her thinking from "I'm an intern," to "I'm the expert," her confidence to contribute her perspective significantly increased. After all, she was hired to not only do research, but to advise the engineering, professional development, and marketing teams as they considered an engineering solution. In addition, this mindset to *Be a Consultant, Not the intern* was key to designing, conducting, and disseminating the research. As an intern previously, Meagan had lots of mentoring, coaching, and support. In this role, Meagan was almost solely self-managed, and this required tremendous discipline and project management skills. The transition of identity is a result of an engineering professional competence (and confidence) garnered through the application of learned content in practice[3]. While every internship role will vary, as will the expectation of the intern, the message to take away from this lesson learned is to have the confidence to speak up, and share your knowledge.

Conclusion

With an increase of Engineering Education graduate programs, and an increase in education technology products to meet the needs of the engineering education market, internships in this industry are a great opportunity for students to explore the intersections of their engineering and education experiences. Students who are seeking these roles can use this case study as a model, and the lessons learned as a guideline for future opportunities.

References

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