Benefits of a Project-Based Curriculum: Engineering Employers' Perspectives

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Abstract

As the final phase of a mixed-methods study that explored the impacts of intensive project work on alumni of Worcester Polytechnic Institute (WPI), a technology-focused university featuring a project-based curriculum, an external party conducted in-depth interviews with ten employers of engineering alumni to determine how a project-based curriculum prepares students for the engineering workplace. The employers interviewed ranged from a Fortune 500 multinational conglomerate to a not-for-profit organization and a branch of the U.S. military. This paper discusses qualitative findings from these interviews. All employers interviewed indicated that they regularly and actively seek out graduates from WPI to hire as employees. While employers noted that graduates from WPI possessed especially strong skills in the areas of communication and collaboration—qualities that earlier phases of the study showed were strengthened through participation in project-based learning—not all of the employers were aware that the graduates had participated in project-based learning. Employers who were aware that a project-based curriculum featured prominently at WPI identified experience doing project work—in and of itself—as a reason to hire graduates. They further indicated that a project-based curriculum makes recruitment, training, integration, and advancement of employees easier for employers. Findings of the study overall indicate that a project-based learning curriculum is beneficial not only to the students who participate in it but to the engineering employers who hire them, as well.

Background

Surveys of employers, both in the U.S. and abroad, report the importance of *professional skills* – non-technical abilities such as communication, teamwork, and project management – for successful engagement in the engineering workplace. In a 2013 survey of 318 U.S. employers by Hart Research Associates[1], 93% agreed that "a candidate's demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than the undergraduate major." In a follow-on 2015 study by the same firm, the top five abilities valued by employers were communication, teamwork, ethics, critical thinking, and application of knowledge in real-world settings[2]. Similar results have been reported by studies of engineering employers in Australia, Asia, and the U.K.[3, 4, 5] with each study finding that employers highly value nontechnical professional skills for engineering practice.

Indeed, much of the curricular reform in U.S. engineering education in the early 21st century has focused on more holistically preparing students for the profession of engineering. The professional skills that ABET engineering criteria specify include communication, teamwork, professional and ethical responsibility, and an understanding of the cultural, global, and social contexts in which engineering takes place[6]. In 2005, Shuman et al.[7] described the evolution and importance of professional skills in engineering education, and argued that pedagogies such as global and domestic service-learning and other forms of project-based learning were effective strategies for inculcating those skills in engineering students. The study describes undergraduate

engineering programs around the nation that engage students in community-based problem solving in ways that develop critical thinking, contextual understanding, communication, and collaborative skills.

A recent survey of alumni from WPI found that the alumni attributed a wide range of professional skills and attributes to the intensive project work they had completed at the university[8]. The alumni, who ranged over a span of 38 years' worth of graduates, reported long-term gains in independent learning, problem-solving, project management, leadership, teamwork, oral and written communication, and global awareness as a result of their project work, and also described personal impacts such as character development, self-efficacy, and confidence development.

The curriculum that produced these alumni has, since 1970, required all undergraduates to complete two significant projects, each worth nine credit hours. In the junior year, students complete interdisciplinary research projects, usually for external sponsors, on a topic at the intersection between technology, science, social issues, and human needs. In the senior year, students complete a substantial project in the major, often for external sponsors. Neither project takes the form of a course; each involves small teams of students working independently under faculty guidance to tackle an open-ended, real-world problem. Common learning outcomes for the two projects include research skills, problem solving, communication, and contextual thinking. Over half of WPI's graduates complete at least one of the projects away from the campus, either at an international or domestic site; most of the off-campus projects involve projects for community-based organizations.

In the survey, the alumni of WPI's program attributed elements of career and professional success to their project-based learning experiences[8]. These findings are not surprising, as they are consistent with research that discusses employers' reports of the abilities and skills needed for success in the engineering profession. Furthermore, the study found that female alumni reported more positive impacts than males in 36 of 39 areas, suggesting that project-based learning could also be an effective strategy for attracting and retaining women in engineering[9]. Nonetheless, some engineering educators remain skeptical about project-based and experiential education, and initiatives to substantively engage engineering students in authentic work remain the exception rather than the norm.

The alumni survey examining benefits of a project-based curriculum was the first phase of a mixed-methods study looking at the long-term impacts of that pedagogical approach. In-depth interviews with alumni of WPI's program provided insight into the graduates' experiences, providing examples of how project work, particularly when completed off-campus, helped prepare alumni for professional success[10]. This paper presents findings from the final phase of the study, which involved in-depth interviews with employers of WPI's graduates, and sought to understand the extent to which employers believed that graduates of WPI were prepared for meeting the challenges that existed in their workplaces and the extent to which employers— when they believed students were well-prepared—linked that strong preparation with a project-based curriculum.

Method

Approach: The goal of this phase of the study was to explore employer perceptions of the extent to which they believed that graduates of WPI were prepared for meeting the challenges that existed in their workplaces and the extent to which they—when believing students were well-prepared—linked that strong preparation with a project-based curriculum. To do this in a way that would minimize biasing employers and would maximize the likelihood of capturing both their unique perspectives and unanticipated issues that might emerge, interviews were conducted with employers.

A general interview guide approach was taken to conduct the interviews. While this approach specifies in advance the issues and questions to be discussed, it gives the interviewer freedom to decide on the sequence and wording of the questions during the course of the interview. Advantages to this approach are that it provides a systematic and comprehensive way to collect data while allowing the interview to have a conversational tone and flow[11]. Exceptions to this generally flexible interview approach were as follows: 1) Aside from gathering background and demographic information about the interviewees, the first question that interviewees were always asked was the very broad and general question, "Why do you hire WPI graduates?" and 2) Unless interviewees initiated discussion of WPI's project-based curriculum, they were not asked until the end of the interview to share what they knew about WPI's curriculum or about project work at WPI.

WPI applied for approval from its Institutional Review Board to conduct these interviews, and an exemption was granted.

Interviews were conducted via telephone between August 1, 2013, and July 15, 2014. Each interview lasted approximately 30 minutes. Permission was obtained from the interviewees to audio record the interviews, and they were audio recorded. Audio recordings were created by the external consultant who conducted the interviews, and no one from WPI had access to them.

Instrument: The interview protocol was designed to elicit from employers their perceptions regarding the project-work-related professional skills of graduates from WPI's undergraduate program, both absolutely and relative to graduates from other institutions. A copy of the interview protocol can be found in the appendix.

Recruitment: WPI alumni were not considered for participation in this study. The initial recruitment plan targeted engineering employers of high numbers of WPI engineering graduates. Staff members from WPI's Career Development Center identified such employers for the external consultant and provided contact information for relevant and key individuals. For initial recruitment efforts, the consultant sent appeal letters via e-mail to these individuals. The appeal letters offered a $25 Amazon.com gift card as an incentive for participation and informed potential participants that interviews would be scheduled at time that would be convenient for them.

While the initial plan for this study involved recruiting employers of high numbers of WPI graduates, initial and repeated recruitment efforts via e-mail were minimally successful, so the

external consultant attended a September 2013 career fair that was hosted by WPI where she connected with employers face-to-face. When employers at the career fair were not available for a face-to-face conversation, she provided them with a hard copy letter of introduction and an information request form, which she collected upon leaving the career fair. Following the career fair, recruitment resumed using as the recruitment pool the contacts that had been made at the career fair.

Potential participants were informed that the purpose of the interview was to explore the extent to which graduates from WPI are prepared for meeting the challenges of the 21st century workplace. At no point during recruitment efforts was it revealed to potential participants that WPI was interested in obtaining information regarding their project-based curriculum.

After each employer agreed to participate, after an interview was scheduled, and after informed consent was obtained via an online form, the interviewee was sent a copy of the interview protocol that omitted questions that were related to WPI's project-based curriculum.

Participants: Potential participants were screened for alumni status at WPI, and no alumni were interviewed for this study.

One representative from each of the following employers of engineering alumni of the undergraduate program participated in the study:
1. A large regional utility company in the U.S.
2. One of the world's largest insurance organizations
3. A highly technical program in a branch of the U.S. military
4. A marketing and advertising agency
5. A global diversified technology company
6. An international software company
7. A U.S.-based pipeline and midstream company
8. An international technology and service company
9. A multinational conglomerate corporation
10. A not-for-profit research and development corporation

While all ten employers interviewed indicated that they regularly and actively sought to hire graduates from WPI, the interviewee from the marketing and advertising agency revealed that her agency had never hired a WPI student. She stated that they had made offers to WPI students, but that none had ever been accepted. She indicated that her agency believed that a hire from WPI would be an asset and that the agency was committed to that pursuit. She characterized WPI as a "reach school."

The $25 gift card was accepted by all but one interviewee, whose employer prohibited it.

The amount of time that interviewees indicated they had been familiar with WPI ranged from a couple of years to "30 to 40" years, and it averaged approximately 13 years. Five of the ten interviewees explained that their contact with WPI graduates took place either wholly or primarily in the pre-hire phase while the other five indicated that they also had contact with graduates after they were hired in some capacity or another (either through an internship, co-op,

or full time position). Of the ten interviewees, six were female and four were male; seven were aware of WPI's project-based learning curriculum to one degree or another, one was vaguely aware that WPI students completed some type of project work, and two were not aware that WPI had a project-based learning curriculum or that WPI students completed any type of project work.

Analyses: Data were analyzed initially using a case analysis, and this was followed by a cross-case analysis. The cross case analysis identified patterns in the data through an inductive search using an iterative process that involved multiple listenings of interview recordings and multiple close readings of notes and quotations.

Results

What employers are looking for: While the employers were never asked directly to identify the qualities they were looking for in prospective employees, they spontaneously revealed a number of skills and abilities that their companies desired employees to have. Aside from a solid base of technical knowledge, employers indicated that the following professional skills were of significant importance for their employees: ability to apply technical knowledge, ability to solve problems, leadership capability, strong communication skills (including presentation skills and interpersonal communication skills), ability to be self-directed and self-motivated, and ability to effectively collaborate with others and work on a team.

The ability to effectively collaborate with others was a skill that employers especially prized because, they indicated, it was integral to the nature and success of their work. That collaboration was deeply ingrained in their day-to-day successful functioning was made clear through comments they made, such as: "It's very rare that you're doing things on your own," "Everyone works on a team. … It is *crucial* that you can work collaboratively," "It's rare—it almost never happens—where someone's working on a project completely by themselves, because … with systems engineering it tends to be … a complex set of problems where you need to collaborate with others," and "At this company, even when you're working independently, you're working in groups."

Project-based learning prepares students well for the engineering workplace: All employers who were interviewed—whether or not they knew that WPI had a project-based learning curriculum—indicated that WPI students were well-prepared for their workplaces. Employers who were aware that a project-based learning curriculum was in place made causal links between the project-based learning curriculum and student success in the engineering workplace, overtly stating that the project-based learning curriculum was responsible for creating individuals who were well-prepared for the workplace. Following are some of the comments they made that highlighted the impact of a project-based curriculum on skill in particular domains, verbal communication, collaboration with others, and problem solving. One employer who spoke to the contributions of a project-based curriculum to skill in students' chosen fields of study stated, "They have students that are highly motivated, and typically they have some type of practical hands-on experience … that adds to their level of knowledge and proficiency in various electrical engineering and computer science disciplines."

Other comments spoke to the positive impact of a project-based learning curriculum on communication abilities:

> We have found that WPI students do very well. … In their junior and senior years where they're doing those project-based … courses and classes where they're having to work with teams, they end up being very good as a result of being able to work in that environment—being able to communicate and to articulate … their point of view and what they think is appropriate, having to work through the compromises, all of that. I think … as a result of that type of class work and preparation, they're … better … prepared from a soft skills perspective than [students from] some of their peer universities.

and

> Clearly, they're more comfortable being able to articulate their thoughts and ideas. And as opposed to just blurting stuff out, they're thoughtful about it and able to …present their ideas clear[ly] and concisely. That isn't always the case with new[ly hired] students. … And they're also, I think, a bit more willing to listen and collaborate as a result of it because they had to do it on their teams.

Here is a comment in which an employer highlighted the benefits of a project-based learning curriculum on teamwork, interpersonal skills, and problem solving:

> There's a lot of good maturity … from the [WPI] candidates. They've had a lot of exposure to a lot of different things: The coursework, obviously, you know, good, standard engineering coursework, but also, like I said, working with teams, working with conflict resolution within teams … problem solving. A lot of those skills have kind of been able to be seen and translate well as opposed to someone who's just reading a textbook and … doing problems by themselves, solely—that doesn't translate well to what we do. Having that real hands-on experience that WPI gives its candidates really works well for us.

And employers believed that a project-based learning curriculum contributed to students' general success. As one explained,

> They worked on things that were real world, so their skills sets—when we looked at them—really had a place in our organization. … I think coming out of a college like WPI where there are opportunities to perform in teams sets them up for success because they've already kind of experienced it.

Employers perceive particular value in project experiences that are long-term, substantive, and authentic: Employers conveyed that they had experiences working with potential candidates from other institutions who may have completed projects that were different in nature from those required through WPI. They indicated that not all projects conferred the same benefits on students and that projects were more beneficial to students and to employers if the projects were longer in duration, had a non-trivial scope, involved working with industry to solve problems that truly existed in the world and were not merely exercises, and required students to act in a self-directed fashion. Quotations from several employers summarized these opinions well. Here is how one employer explained how a project that was large in size benefited students, especially with regard to the interview process:

We look at concrete examples of what they've done. … Those [required projects] … give … WPI students a leg up … compared to other students' colleges that don't have that experience because [while] sometimes you have a class-based project, that's very small. These [required projects] are on a much larger scale … so candidates [who have completed those projects] are really able to give a lot of examples because the projects are so broad.

Another employer explained the differences between substantial and less substantial projects:
When you look at resumes [from students from] other colleges, they would have like one or two internships, but they weren't really meaty or have a lot of … strong skills sets or … some of the internships that [non- WPI] students would get really were not long enough even [to] offer enough of … the technical work that a … [WPI-required project] had to offer. … The students not only had to work with a company and, you know, develop something, but then they had to present it, and that was an impressive piece to a hiring manager or myself. So their resumes had really strong skills sets that other students might not have gotten.

Here is how one employer explained that student projects that were conducted in the context of industry were especially helpful because those projects gave students real world experience:
I think that many institutions do some sort of a project-based senior-level— sometimes junior-, sometimes even at the freshman level—[work], but I think that with the way that WPI's is structured and with the focus on working with industry and doing those types of things, I just think they're better prepared for the real world 'cause at some universities it's more of a theoretical, you know … it's almost like a case study, where, you know, [students are] kind of [directed to], "Combine everything that you've learned and go design this plant to do this" … but it's not like, "Here's a real live problem we need to go solve."

Another employer highlighted the usefulness to him of having potential employees who have demonstrated that they can take responsibility for directing their own project work:
I have a personal bias towards people that have executed an independent project that have kind of worked through doing work on their own that haven't been given a homework assignment but have basically created their own homework and then executed on it [because] to some extent, that's what we do in the work world.

From a management perspective, a project-based learning curriculum is an asset to employers:
A project-based learning curriculum makes recruitment, training, integration, and advancement of employees easier for employers. Every employer who had been aware that WPI had a project-based learning curriculum or required students to complete at least one project or team-based activity identified experience doing project work—in and of itself—as a reason to hire graduates. Their positions were reflected in the statement of one employer who said that completing a project in the context of a project-based learning curriculum was a "significant benefit" to his company. Another gave a fuller explanation, saying,
We really like … the project-based team programs…. A lot of [my company's] engineering projects are team-based projects and work … and leadership, so a lot

of the school work translates really well into what we're looking for for candidates.

Employers indicated that, in effect, they used project work as a proxy for the skills that they were seeking, such as collaborating with others, effectively solving problems, and ability to demonstrate leadership. One employer described how candidates were asked if they had worked on a project or on a team, and, if so, what their role was and how they managed difficult situations while working with others. She explained that "those answers … tell us how they'll fit with … working on a team." She further indicated that those at her company knew so much about the significant project work and problem solving requirements at WPI, that those who interviewed WPI students more or less "knew they could work collaboratively." Another employer stated that even if WPI students did not have previous leadership experience, they were still targets for leadership positions in her company because through their project-based work on teams "they know what's required, so they're more comfortable stepping up at this point."

Stating that employers used project work as a proxy is not meant to imply that they did not use due diligence in interviewing candidates for positions. They indicated that they did, in fact, thoroughly review and interview candidates. What their knowledge about the project-based learning curriculum did help them to do, though, was to add efficiencies to their recruitment processes. The project work served as an indicator that they were likely to find highly qualified candidates who had extensive and relevant experience that they could mine during the interview process. An illustration of this is seen through the recruitment approach of one employer, which had selected WPI as the sole school from which it recruited in the entire northeast region of the U.S. As the interviewee explained, "It's worked well, so we haven't really had a need to start to look out for more schools to add to our repertoire." She further explained the importance of the required projects to their recruiting efforts, saying that the projects

> are always discussed at our interviews, and we kind of delve deeper into what [the students'] experiences were with that, what kind of problems they've had, … how their trouble-shooting was, how … was their team dynamics, you know, were they the leader, were they the background, you know, how did they work out any problems. So we get very, very concrete examples, and … at WPI because they already have those programs set forth, it's a very easy translation into what we do because a lot [of what we do] is very similar—it's a very team-based project experience.

Employers conveyed that they rely on the project-based learning curriculum not only to streamline their recruiting efforts, but to serve as a source of much-needed training to their new hires, as well. One employer explained it like this:

> We provide training, but we can't provide training for someone who's completely new to … the working world and teamwork world, so kind of having those built-in experiences … makes it easier for us to get someone up and running.

Another employer's comment implied that the project work not only helped new hires to adjust to the culture, mindset, and demands of his company, but admitted that it made work easier for those responsible for training and supervising the new hires as well:

I really feel like that [project work i]s a really good way to get people into the mode of thinking … that we look for here. Also, kinda—to be perfectly honest with you—it reduces the workload requirement and the management requirement of management, and it also gets all the … employees at a level of autonomy that's just wonderful.

This same employer explained that "on the by and large," WPI students begin working at his company ready to do the kind of work that was expected of them and that this was a considerable benefit to his company. When asked to elaborate on why it was such a benefit, he explained that in the short term employees were autonomous more quickly than they would be otherwise and that that, then, created opportunities to work on specialized development of the employee. Regarding immediate benefits, he stated it like this:

When I can get someone in who doesn't need to be hand held in how they go about executing our project but to some extent someone else has already show[n] them "here are the pitfalls at doing a project, here's how you have to attack it, here's how you have to do requirements, here's how you have to look at how … the engineering process on a project is done" … that's a real big help.

And he described the longer-term benefits of employee integration and advancement to both his company and the employee:

When I don't have to spend time kind of working through the engineering process and how one approaches project management and things of that nature, I can instead dive into, for example, the nitty-gritty technical aspects or how to navigate the political waters of a company or how to work with vendors or things … they wouldn't have necessarily had a chance to do [as a student]. It really helps me get them to another level more quickly.

One employer highlighted the immediate benefits to an employer of having students complete a required project of significant scope in the context of a project-based curriculum by explaining the needs of new hires when they do not have such an experience:

You'd be very surprised at how many other places I've been where people will actually get to the point where they're at or near graduation and … are very sharp students … but they haven't necessarily done any really big projects in which they weren't being assisted by their professors or a TA on a really regular basis, and it shows, because when they're hired … there's a certain amount of spoon feeding they're expecting because they haven't done anything different.

Discussion

The employers participating in this study expressed the desire to hire graduates who, in addition to being technically competent, are adept collaborators, communicators, and problem-solvers. Those sentiments are consistent with employer surveys calling for broad skills and abilities in areas related to teamwork, communication, and application of knowledge in real-world settings. The employers reported that a project-based curriculum succeeds at instilling those skills and abilities in graduates. In particular, they believed that having completed substantive project work

in authentic settings prepares graduates well for success in the workplace, corroborating the findings of a recent study of alumni[8] from WPI's project-based curriculum.

Employers described access to graduates from the project-based curriculum as an asset for their organizations in that it streamlined recruiting efforts, reduced the need for employee training, and made it more likely that the employees would succeed in the workplace. In that sense, hiring such graduates could be viewed as a way to reduce not just the effort to train and prepare them as employees, but also the effort and level of uncertainty associated with the hiring process. Indeed, some employers considered successful engagement with a project-based curriculum as a proxy for the skills and abilities they were seeking.

Engineering education, of course, has a broader and more complex mission than preparing graduates to suit the needs of engineering employers. Some students aspire to full-time graduate study, while others seek employment in sectors other than engineering. According to the U.S. Census Bureau, in 2012 only 50% of U.S. engineering graduates were working in STEM fields[12], underscoring the need for broad preparation. Furthermore, undergraduate programs in any area should aspire to prepare students not just for participation in the economy, but also for satisfying, meaningful lives. Much is at stake during the undergraduate years, particularly in preparation for a profession such as engineering that does not require an advanced degree for professional practice.

Nonetheless, preparation for the workplace is a key consideration for most students in pursuing higher education, regardless of field. In a 2012 national study of incoming college freshmen, employability was cited by 87.9% as a "very important reason" for attending college[13]. Furthermore, as articulated in *Educating the Engineer of 2020*[14], the dynamics of technological advance and globalization make clear the need to prepare engineering students for more than the first job – not only for their own sake, but for the sake of the U.S. economy. That study called for undergraduate engineering programs to emphasize abilities such as real-world problem solving and teamwork – abilities that the employers in this study identified as resulting from of a project-based curriculum.

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Appendix: Employer Interview Protocol
1. Very briefly, would you please tell me a bit about what <company> does? Do you do any international work?
2. What is your current position?
3. How does your current position relate to hiring (or supervision)?
4. How long have you been in a position that has involved hiring (or supervision)?
5. How long have you been familiar with WPI and students from WPI?
6. Why do you hire WPI graduates?
    <Explore surprises. Probe for absolute and relative assessments. Probe for examples.>
7. Tell me about their professional behavior.
    <Probe for absolute and relative assessments. Probe for examples.>
8. Tell me about their ability to collaborate effectively.
    <Probe for absolute and relative assessments. Probe for examples.>
9. Tell me about their critical thinking skills.
    <Probe for absolute and relative assessments. Probe for examples.>
10. Tell me about their creative and interdisciplinary problem solving skills.
    <Probe for absolute and relative assessments. Probe for examples.>
11. Tell me about their communication abilities.
    <Probe for absolute and relative assessments. Probe for examples.>
12. Tell me about their leadership skills.
    <Probe for absolute and relative assessments. Probe for examples.>
13. Tell me about their integration of a macro perspective into professional work. To what extent do they show consideration for issues that extend beyond technology and into the areas of society and ethics?
    <Probe for absolute and relative assessments. Probe for examples.>
14. Tell me about their ability to apply technical knowledge to addressing problems in the workplace.
    <Probe for absolute and relative assessments. Probe for examples.>
15. Tell me a little bit, specifically, about the women that you hire from WPI.
    <Probe for absolute and relative assessments. Probe for examples.>

16. Explore what kinds of international work the employer does and ask how WPI alumni tend to work in cross-cultural situations.
    <Probe for absolute and relative assessments. Probe for examples.>
17. Do you have any ideas about why WPI graduates leave WPI with <whatever it is they say WPI grads have>?
18. Please tell me what you know about the WPI curriculum.
19. If they don't bring up project work: Please tell me what you know about project work at WPI.