Scalability in an Industry Project Process

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The iProject approach was created at Arizona State University Polytechnic campus as a mechanism to provide industry generated and funded projects, primarily for the projects utilized in the project centered courses. The engineering program housed on the Polytechnic campus has grown from four iProjects in the 2008 capstone course to over 30 projects this year. The process for administering the iProjects faced challenges of scalability both in growth of the program and in the diversity of projects. This paper addresses how the engineering faculty worked with the college to address the challenges faced in scoping and mentoring iProjects for the industry-based capstone experience.

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Introduction

Over the past five years, the Department of Engineering and Computing Systems (ECS) at Arizona State University (ASU) Polytechnic Campus has created an industry engagement capstone project process in response to its teaching mission. This process, known as the *iProject* experience, continues to face complex challenges founded in the need to scale the process both up and out, though substantial changes occurred this past year to improve the process. By "up" we mean the traditional connotation of scalability – to scale up, or grow. The department has experienced strong enrollment growth, leading to increased course offerings, class sizes, and supporting faculty and adjuncts. By "out" we mean addressing breadth or diversity – of the disciplines, of faculty, of types of industry partners, and of the range of stakeholders in the iProject process. This form of scalability complexity is unique to academia and the situated capstone experience at ASU; traditional mechanisms for dealing with scaling "up" may be orthogonal to the needs of scaling "out"; at least in the academic context. This paper highlights many of the challenges faced over the years and describes the processes put in place to help the iProject program meet the needs of all constituents-students, faculty and industry- as the program continues to grow in scale.

Background

ASU's Polytechnic Campus is focused on hands-on applied learning leading to industry prepared graduates. As part of ASU's mission of social embeddedness, all of ASU engages with industry, yet there is a particular focus on this mission at the polytechnic campus. Broadly speaking, the ultimate goal of the department is to construct positive industry relationships that benefit student learning, faculty research, ASU reputation, Arizona's economic growth, and the national economy.

ECS offers several degree programs and continues to evolve its offerings, but for the purposes of this paper we briefly describe similar features of the Bachelors of Science in General Engineering and in Software Engineering. Each program has a project-centered learning experience as the primary vehicle of its professional spine[1] . Engineering students have four years of two-semester design sequence courses that culminates in the senior capstone experience. Software Engineering students participate in the Software Enterprise[2] as part of a project spine[3] that runs from the sophomore year to the senior capstone experience (and into the 1st year of the graduate program). While there are disciplinary differences in project courses, the curricular structure and learning outcomes are quite similar. Students are always engaged in projects; learning outcomes throughout the degree programs fuse technical proficiency with professional skills such as teamwork, communication, and professionalism, and these projects serve as integrative contextualized experiences resulting in students better prepared for industry.

iProject Context and History

Capstone experiences exist academically as a *synthesis* experience for students about to enter the workforce (or graduate school). Secondary goals of the capstone experience include exposing the student to broader industry concerns and experiences. Most schools utilize industry partners in a variety of ways to not only achieve synthesis but to give their students that industry exposure, thus "raising the competitive bar."

We created iProjects as a mechanism to provide industry-sponsored projects, typically as capstone projects but also including other courses within the project spine[4]. Given the project-based program design and the culture of the polytechnic campus, the projects are identified, scoped, and delivered with significant engagement by the program faculty. Our observation of many industry engagement programs is the responsibility is often offloaded to a particular office or faculty member, whose responsibility is to identify and scope projects, then recruit (sell) the projects to faculty and students to execute. In our model, the college oversees industry relationships while project execution, both in terms of project delivery to industry sponsors and learning outcome achievement for students, is the responsibility of unit administering the degree program(s). While this vision provides guiding principles for the iProject program, the rapid growth of the student population combined with the disconnect between scoping of projects vs. faculty mentoring of student projects created concerns among the engineering faculty.

From 2008-2012 the iProject program grew from 4 projects to almost 30 projects, most of which were capstone experiences for students enrolled in the engineering programs. Initially faculty were not involved with project scoping, which created challenges with setting realistic project expectations. iProject sponsors ranged from large established businesses to small companies, startups, and community organizations. The process for upper level program function was directed from the college level, though the faculty mentor executed project implementation. At the college-level the process encompassed the administrative execution of contracts and projects, but the process did not include responsibilities of students, faculty and industry. Because this process was not visible to all stakeholders, it led to uncertainty as we attempted to scale; processes and resource organization were not properly in place to handle the "scale-up" problem – the number of projects and the amount of students executing them, and the breadth of multidisciplinary projects and the sometimes competing (or at least undernourished) stakeholder concerns led to "scale-out" issues.

Structural Solutions

As a result we identified several procedural fixes both administratively and academically, such as better scheduling and expectations along multiple disciplinary capstone courses, but here we focus on larger mechanisms. First, a working group of faculty was formed by the ECS Department Chair to provide recommendations to the iProject program that ranged from project scoping, faculty recognition and workload, student assignments, and budgets. Their suggestions for changes to the broader process were most impactful to the way projects are scoped and run today. Second, in Spring 2013 a "Collaboratory Council" was formed consisting of an iProject program administrator reporting to an Associate Dean, department and program chairs, and faculty from each discipline who were credited service time to assist with project scoping. The result is a collaborative process shown in Figure 1 as the framework under which iProjects are identified, scoped, and implemented today.

Figure 1: Constituents of the iProject Process & Their Responsibilities

The iProject administrator is responsible for industry engagement. Sponsors are identified both at the college and department level (many of our faculty have close ties with industry). The iProject administrator meets with industry partners, discusses the iProject with the program and identifies potential iProjects. Opportunities are added to a pipeline, or list and description of the projects. Most projects tend to fit within the capabilities of the engineering department or there are opportunities for multidisciplinary projects. Projects then move to the Collaboratory Council. This administrative role, currently seated at the college level, could be a full-time job in the near future. The growth of the program and time spent with each sponsor demands the time commitment.

The initial process of scoping starts with the Collaboratory Council, and then quickly moves to the department level for detailed scoping. The Collaboratory Council meets every two weeks, or as needed, to discuss the list of projects, to identify if the project is appropriate for the programs, and finally to determine the best program/department for the project. The department chair then identifies a faculty member with the experience to better scope the project. This

faculty member often meets with the potential industry sponsor (along with iProject administrator) to discuss the project at greater detail and identify the engineering skills needed for the project, e.g. mechanical, electrical or computing. The full scope is then returned to the Collaboratoy for final discussion. The iProject administrator has the responsibility for finalizing contracts with the industry sponsor; this includes a final Statement of Work, the administrative fee, and any NDAs between the university and the company. This process of project scoping starts in the spring semester and continues throughout the summer. We have enough faculty working over the summer to contribute to the Collaboratory Council meetings. Key to the success of faculty scoping is having the department chair, who identifies faculty based on expertise and is aware of their summer schedule.

The department chair and capstone faculty distribute the list of projects and scopes to the faculty prior to the start of the semester, and faculty mentors are identified and finalized at a fall faculty retreat. At the start of the year industry sponsors participate in an iProject Forum, another initiative recommended by the working group, where students have an opportunity to meet with various companies to learn more about the projects. Students provide their top five choices for the project, and then the capstone faculty along with faculty from the Collaboratory place students into teams of four (ideally – due to continued scale-up issues, we had several teams of 5-6 students this year). This year engineering had 26 teams (135 students in the engineering capstone course) and computing had 10 teams (40 students in the software engineering capstone course). The course provides the milestones and some of the larger project management requirements for the projects, and faculty are encouraged to serve as technical mentors to the projects.

As mentioned above, iProject sponsors range from larger companies, such as Honeywell and Dell Corporation, to small start-up companies, such as Joe's BBQ and PreciseMeds. Table 1 below provides a snapshot of iProjects launched in the 2013-14 capstone courses. The larger companies often have engineers that serve as a point of contact for correspondence and meetings, while smaller companies have vested owners who eagerly engage with the student teams. Many of the larger companies return each year with new projects. It should be noted that a handful of projects are received from an RFP sent to faculty, staff and students in the program. These projects proposals are reviewed by a few engineering faculty, and select projects are included in the iProject pool. All iProjects have a faculty project mentor who now select which project they will help manage, versus previous models when faculty were assigned to a project.

While industry sponsors have always been engaged with the student teams, there was no formal requirement, and the faculty project mentors often initiated engagement. A requirement of the engineering capstone course this year includes the initial project scoping meeting, where student teams are required to meet with the sponsor (as possible) to observe and document the customer needs. Near the end of the first semester, teams are required to have a design review with the industry sponsor to finalize concept selection. During the second semester, teams are required to have a second design review to discuss testing protocols for their prototype. Both semesters culminate with a final technical report, which is provided to the industry sponsor. Teams are also required to provide status reports at several time points in each semester. It is worth noting that some industry sponsors meet with their student teams weekly, while others choose to meet two or three times over the course of a semester.

Faculty recognition was an issue that generated the most discussion at a department meeting prior to the formation of the working group. While some faculty volunteered to mentor a project, others were assigned a project. Additionally, it was not clear how the activity of project mentoring was recognized – as service or as teaching. When faculty were surveyed on average hours spent mentoring, 50% of the respondents said 1-5 hours, while 15% said 11-20 hours (this was two years ago before the Collaboratory Council was in place). While the latter amount of time was not encouraged, clearly some faculty members felt the project warranted the time for a successful outcome and feared reprisals if their projects were not considered successful. Working

Table 1: Sample of 2013 iProject Sponsors & Projects

Company	iProject Title	Engineering Skills
Dell Corporation	Algorithm for Optimized Product Packaging	Computing
Dell Corporation	Sustainable Packaging Methods	Mechanical, Manufacturing, Sustainability
Honeywell Corp.	Big Data Analysis to Aerospace Industry	Computing, IT
Honeywell Corp.	Heat Exchanger Optimization	Mechanical, Manufacturing
Joe's Real BBQ	Thermodynamic Properties of a Barbecue Pit	Engineering, Design of Experiments, Instrumentation
PetSmart	Water Remediation in Retail Stores	Environmental
PreciseMeds	Pill Dispenser	Mechanical, Robotics, Electrical
Sandi	Robotic System for Room Mapping	Robotics

group recommendations ranged from adding explicit language to the Promotion and Tenure criteria for iProject mentoring and adding an annual review criteria pertaining to iProjects, to creating a faculty incentivization model.

In response, the department chair recognized mentoring as service to the department and college, and provided faculty development funds to their individual accounts. Project mentoring is also recognized as part of the annual review process. Time commitment has also changed. This academic year faculty mentors committed to weekly hour-long meetings, one design review, and periodic review of student's written work, including Project Status Reports. This reduces service time to 1-2 hours/week, and this time varies based on the needs of the students. This year the capstone course will include a process for collecting feedback from various constituents, including the industry sponsors and participating students.

A fee change was another adjustment implemented this year, and we are in continued conversations about what is appropriate to support a capstone project. There are real costs, where on average teams spend approximately $2K for material costs. These costs are usually associated with projects that are expected to create a physical prototype. Even so, the costs of a "physical build" project can range from a few hundred dollars to several thousand. In contrast, software related or "modeling" projects often do not have high material costs so the expenses for these types of projects follow a different cost structure. To address this, we have added language to our contracts that state if there is a significant increase in the need for material, a bill of material will be provided to the customer for approval and charged to that sponsor. The model for purchasing approval starts with the team and the project mentor granting approval for a purchase request. That request is then approved by the department chair then forwarded to purchasing. The department has an administrator that helps facilitate and track orders for the 36 teams this year. The remaining funds distributed to the department are used for unfunded iProjects, which are often generated by students and faculty, and to provide faculty incentives.

Finally, to accommodate both scale-up issues and students off-cycle (these are usually transfer students, as Poly has a high percentage), the engineering capstone senior design sequence is offered every semester. Far fewer projects are needed in the spring (seven projects launched spring 2014), and some faculty mentor teams in both starting cycles.

Summary and Future Considerations

Changes implemented this year to the iProject process have helped provide better scoping of projects, which result in better experiences for the students as well as the faculty mentor. Transparency of the iProject process, with the involvement of the Collaboratory Council, and the recognition of iProject mentoring in the Annual Review process have alleviated many of the concerns and challenges faculty mentors faced in previous years. And the new fee structure provides more realistic understanding of not only material costs but also project outcomes. This overall model provides an industry-based project as a learning experience for students in senior capstone courses in both engineering and computing.

Of course there are always new challenges. For example in the current year some iProjects have been delayed due to Non-Disclosure Agreements (NDAs) and Intellectual Property (IP) policies. NDAs are necessary from an industry perspective but problematic from a student perspective, as they are required to discuss their work with peers and faculty as part of their academic experience. IP agreements can be tricky, as the rules governing faculty and students differ, and ASU students in general are encouraged to be entrepreneurial. Challenges with scoping and managing student expectations still exist, but we notice both that the number and nature are decreased and manageable. Finally, the structure of our department is changing. Starting in July 2014 ECS will administratively join the Ira A. Fulton Schools of Engineering as the "sixth school." Since college level infrastructure is changing, we are exploring opportunities to facilitate the iProject process within our new school, and across the Fulton Schools (inclusive of a range of engineering disciplinary tracks). All constituents, industry, students and faculty, want to continue the successful iProject model, and with our department chair now serving as the director of the school, we are hopeful we can respond with another year of iProjects with an updated model. Addressing these issues is a continuous improvement process, one of the next major process areas for ECS and the Fulton Schools to work on together. After all, no process is perfect!

References

1. Sheppard, S.D., Macatangay, K., Colby, A., and Sullivan. W.M. *Educating Engineers: Designing for the Future of the Field*, Jossey-Bass, San Francisco, 2008.
2. Gary, K. "The Software Enterprise: Practicing Best Practices in Software Engineering Education," The International Journal of Engineering Education Special Issue on Trends in Software Engineering Education, Volume 24, Number 4, July 2008, pp. 705-716.
3. Gary, K., Lindquist, T., Bansal, S., and Ghazarian, A. "A Project Spine for Software Engineering Curricular Design." Proceedings of the 26th Conference on Software Engineering Education and Training, San Francisco, 2013.
4. Danielson, S., & Roberts, C. A "Successful Engineering Program-Corporate Partnership." 2013 ASEE Annual Conference Proceedings, Atlanta, GA.