Fostering Student Innovators through Small Prototyping Grants - Student Engagement in the Beta Program

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Abstract
The Beta Project was created to inspire and support innovation in engineering students at Portland State University. Each academic term, student teams are invited to submit brief proposals for up to $1000 in funding to purchase materials and equipment for prototype development. Proposals are screened by the Innovation Council, which consists of faculty, staff and community members. If the proposal passes an initial screening, the student team is invited to give a 5-minute presentation, followed by 5 minutes of questions from the Innovation Council. A simple majority vote of Council members decides whether the project is supported. In addition to funding for hardware and supplies, students with winning proposals are provided a faculty mentor and, as needed, access to lab space and other equipment. Since inception the Beta Project has received 259 applications and agreed to fund 124 projects (48%). However, despite impressive results in some projects, several of the approved projects have stalled or been abandoned by the student teams. We summarize the experience with the Beta Project and discuss our current understanding of how to increase student participation and success of projects funded by the program.

Motivation and Origin of the Beta Program
It is commonly believed that engineering students need to develop their creativity as well as their technical knowledge in preparation for profession practice\(^1\)-\(^3\). Given the wide range of social and environmental problems facing humanity, and a business environment that is increasingly competitive, the expectation is that engineers need to be innovative in solving problems and creating new opportunities. As educators, we seek to foster innovation in our students. While many are working toward the same goal, there are a wide range of approaches\(^4\)-\(^8\). Academic publications about student innovation predominantly focus on entrepreneurship education, with little consideration for the origin of the ideas that start-ups commercialize. Instead, innovative ideas are assumed to occur naturally in the individual realm, based on the interests and intrinsic motivations of creative students, community members, or faculty inventors.

In 2010, we began an experiment at Portland State University to encourage students to engage in self-directed innovative projects outside of their engineering course work. The “we” was a group of faculty convened by our Dean, who had secured donations to spur innovation in the College. The Dean called this group of faculty the “Innovation Council” and gave us the task “to create an environment and culture that will inspire young engineers to become true innovators.” The Council created a process to offer small grants that we hoped would encourage and enable student innovators to try out their ideas. Initially we called this program the Innovation Program. A couple of years after the start, the program was renamed as the Beta Project, to emphasize the goal of creating prerelease, or \textit{beta} versions, of their technology projects. As we will discuss later, a case can be made that we also need an \textit{Alpha} Project.
Since its beginning in 2010, the Innovation Council has expanded to include college staff with industrial experience, internship placement, and fabrication support. The Council also has members from the University’s Research Office as well as members from our industrial community. Membership on the Council is voluntary. There is no monetary compensation or release time for faculty. The council has good support from staff in the Dean’s office who manage communication with students and track the budget. Although there is about a dozen individuals on the Council, regular meetings are attended by a half dozen core members who keep the operation going. Given other work responsibilities, the Council operates with minimal administrative overhead, meaning we meet as necessary and aim for an efficient realization of our mission. We keep the process of screening proposals as quick and fair as possible.

When the Council conceived of how students would apply for and gain financial support for implementing their ideas, we wanted to avoid a complicated and difficult process, both for us and for the students. One of the guiding ideas was to emphasize “support over structure”. Since we didn’t know what procedures would work best, we started with a lean process and added rules and constraints as necessary. Another important early decision was to evaluate proposals for the potential for both student learning and innovation. In practice that means the Council might choose to fund a project that we suspect won’t work as planned, but that will give the student team a chance to learn about a technology or process, or that could lead to the solution of a related problem.

The Beta Program aims to inspire and reward innovation in students by helping them try out their ideas without immediate concerns for commercialization. The focus is on technology development and application, and the skill and confidence building that comes from trying to make an idea work. When evaluating any one proposal, this leads to discussions about whether an idea is sufficiently innovative, whether it is even feasible, or whether there is real potential for student learning. We don’t claim to be able answer those questions with high confidence or precision for every project. When in doubt, the potential for student learning is a heavily weighted factor in the selection of a project for funding. In the next section, we describe our current process for selecting projects to support in more detail.

The Beta Program is designed to protect nascent ideas from known “innovation killers”, such as too much structure, heavy-handed judging and mentoring, and early emphasis on business value. Instead, we focus on experiential learning in self-selected projects and emphasize prototyping. Participation in the Innovation Program is voluntary and projects are not explicitly coupled to the coursework of engineering students.

The Beta Program has seen successes and challenges. We have adjusted to improve outreach and streamline the application process. We are currently reflecting on how best to continue. In a companion paper, we examine the Beta Program using the componential model of creativity and innovation. In this paper, we focus on the program implementation and student participation, and we speculate on how to adapt the Beta Program to the evolving environment in our college.
The Beta Program Process

The primary activity for the Innovation Council is the selection of projects to receive funding and other support. The sequence of events for project selection is as follows.

1. The Innovation Council makes a Call for Proposals.
2. Student teams submit short proposals using the template in Appendix A.
3. The Innovation Council reviews the written proposals and selects teams with strong proposals for oral presentations.
4. The student teams selected in step 3 make a private, 5 minute presentations to the Innovation Council, followed by 5 minutes of questions from the Council.
5. The Innovation Council uses a simple majority vote to decide which teams to offer support.

Except for the time between the Call for Proposals and the deadline for proposals, the entire process occurs in the span of one week. After the release of the Call for Proposals, we hold information sessions where student teams can ask questions about the expectations of the Innovation Council, and to get guidance on how to prepare their proposals. Proposals are due at noon on a Friday in the second or third week of the term. The oral presentations and final decisions are made on the following Friday. The tight schedule requires members of the Innovation Council to evaluate proposals quickly.

Step 3 – the written proposal review – begins with a proposal submission deadline of noon on a Friday (typically in the second or third week of the term). Council members rate each proposal on a 1-to-5 scale, though some members use more elaborate subscales to create an overall score. By the Monday following the Friday submission deadline, the scores from individual Council members are forwarded to a member of the Dean’s staff, who tabulates the scores and computes the average score for each proposal. Each Council member also provides written comments on the proposals. On the Tuesday after the submission deadline, Council members meet to discuss each proposal, and determine by a simple majority vote whether to invite each team for an oral presentation. The numerical scores compiled before the meeting are used as guidance, not as a final determinant of whether a team is invited for an oral presentation. After the Tuesday meeting, all student teams are informed of the Council’s decision. The written comments from each of the Council members is combined and, if necessary, edited before the comments are returned to the student teams. Those teams invited for oral presentations are encouraged to use Council feedback to prepare their presentations.

Step 4 – the oral presentation – occurs on the Friday, one week after the submission deadline. The presentations give student teams a chance to respond to comments made on their written presentation. To streamline the face-to-face interaction, no electronic presentations (e.g. PowerPoint) are allowed, but student teams can bring one or two pages of handouts and any physical props that help them describe their project. After the ten-minute meeting with the team (5 minutes of presentation and 5 minutes of questions), the team is excused and the Council prepares for the next presentation. At the end of all presentations, the Council deliberates and by a simple majority vote decides which teams to offer support. A mentor, either from the Council or someone recommended by the Council is assigned to teams who are given Beta Project grants.
Once the teams have approval for funding, they are asked to meet with their mentor to discuss the project plan. Usually the team is asked to get approval for purchases from the mentor. Most purchases of materials and items for their project are made directly by staff of the College. This provides oversight and may yield discounts from suppliers.

Once per year the Innovation Council sponsors an Innovation Showcase. Teams sponsored by the Council are asked to prepare a poster and bring any prototypes or other hardware displays to the event, which is attended by faculty, students, community members and potential donors. The Showcase gives teams a chance to demonstrate their projects, which provides donors a chance to see the outcome from their funding. It also provides an opportunity for interested students to learn about the Beta Project, and, we hope, to become inspired to submit their own proposals.

**History of Beta Project Applications**

In this section, we summarize the quantitative history of the Beta Project. Our University uses the 10-week quarter system, with three quarters (or terms) in the Academic year from September to June. We have three rounds of proposal funding per year, one per term: in Fall (October), Winter (January), and Spring (April). The project was initiated in Fall 2010, and the first round of proposals were accepted in Winter 2011.

Figure 1 shows the history of applications to the Beta Project by term and academic year. In Winter 2011, the first term of the Beta Project, the Council reviewed 40 proposals and approved funding for 23 projects. In Spring 2011, another 18 proposals were submitted and 10 were awarded funding. It appears that there was a pent-up demand for the Beta Program. In addition, the Council did a lot of outreach to students, offering multiple information sessions, visiting classrooms, and encouraging faculty to encourage their students to apply. The overall trend in applications has decreased since that initial round of funding. Since inception, 259 applications have been received, and the Council has agreed to fund 124 projects (48%).

Since 2014, the number of applications has dropped significantly. The Innovation Council is concerned about this trend and is trying to understand and reverse it. We have some conjectures about the downward trend in applications. We have not attempted a systematic survey of student participants to confirm our conjectures.

From talking to students, we have developed hypotheses about the factors affecting student interest and willingness to participate in the Beta Project. The most important limit on student interest is available free time. The Beta Project does not offer credits, and the projects do not overlap with activities in required courses. For students who work, have families, or heavy course loads, the appeal of getting funding, lab space and mentoring to work on a project cannot create more hours in a day.
Related to the lack of free time is the competition for student interest by other project-related activities in the College. In the past three years, two student groups have captured growing interest from the kind of student that would have participated in the Beta Project had those student groups not existed. One group, the Portland State Aerospace Society (PSAS, http://psas.pdx.edu), has many students collaborating to build an open-source rocket to launch satellites. PSAS has good funding, a strong community of technically advanced students, and a very cool end goal. Another group, the Mechanical Engineering Lab Team (MELT, http://psumelt.blogspot.com), is involved in manufacturing projects in the Mechanical Engineering Department. MELT “technicians” are undergraduate students who are trained in the use of laser cutters, 3D printers, CNC milling machines and CNC lathes. In return for more liberal access to those machines, MELT techs are hired as tutors in classes needing instruction or support in manufacturing.

Both PSAS and MELT students have opportunities to do creative engineering work outside of their required classes. When the Beta Project was started in 2010, PSAS was not as large, and MELT did not exist. We hypothesize that part of the decrease in participation in the Beta Project is caused by competition from those groups. Overall, we consider the growing participation by our students in creative projects to be a good outcome, even if that means a loss of monopoly of interest in the Beta Project.
Another new source of competition for student interest is an enlarged and well-equipped makerspace called the Laboratory for Interconnected Devices, or LID (http://psu-epi.github.io). The LID provides access to 3D printers, a laser cutter, small CNC routers for making circuit boards, and a variety of tools for assembling and testing electronic devices. The LID also provides a community gathering space for likeminded students. While it is reasonable to assume that the LID would incubate ideas for Beta Project proposals, the LID also makes it easy for students to do ad-hoc work on independent projects without needing to develop a proposal for Beta Project funding.

Independent of competition from other interesting activities or access to the LID, participation in the Beta Project requires students to conceive and nourish an innovative idea, and develop a credible plan for exploring that idea. In opportunistic and informal conversations with students, we have learned that some students do not see themselves as ready for a proposal to the Beta Project. Some of these students say they don’t have any good ideas. Others say that lack manufacturing experience or confidence to build prototypes. From these discussions, we believe that an intermediate form of low-pressure, project-based training would make it possible for students to gain skills and confidence, so that they would be more likely to develop Beta Project proposals. In other words, we may need an Alpha Project to attract and train students to prepare them for applying to the Beta Project for funding.

**Funding and Completion of Projects**

Table 2 shows the recent history of projects that have been approved for funding from the Beta Project. Complete records from the 2011 and 2012 academic years are not available.

Although the number of applications for funding has decreased since 2014, the success rate of the proposals has increased, especially in 2016 and 2017. During that time, the College hired a part-time adjunct instructor with experience in industrial design to improve outreach and student training on innovation proposals. One outcome of that effort was the more student-friendly application form shown in Appendix A. The form provides more step-by-step guidance to student groups, which has resulted in more complete applications.
Table 2  Projects that were approved for expenditures. Data is shown for years after 2013 when the budget data is more reliable. *Only the year-to-date totals for 2017 are shown since academic year 2017 is underway.

<table>
<thead>
<tr>
<th>Academic Year</th>
<th>Applications</th>
<th>Total Approved</th>
<th>Started</th>
<th>% Started</th>
<th>Average Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>38</td>
<td>13</td>
<td>6</td>
<td>46</td>
<td>$766</td>
</tr>
<tr>
<td>2014</td>
<td>45</td>
<td>20</td>
<td>10</td>
<td>50</td>
<td>$555</td>
</tr>
<tr>
<td>2015</td>
<td>39</td>
<td>11</td>
<td>9</td>
<td>82</td>
<td>$702</td>
</tr>
<tr>
<td>2016</td>
<td>27</td>
<td>16</td>
<td>13</td>
<td>81</td>
<td>$620</td>
</tr>
<tr>
<td>2017*</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>33</td>
<td>$287</td>
</tr>
</tbody>
</table>

The fourth column in Table 2 lists the number of approved projects that incurred expenses against their budgets. The “% Started” column is the ratio of the “Started” column to the “Total Approved” column. We consider those projects to be “started” in the sense that students met with their mentor and gained approval to buy supplies and equipment for their project. Notice that the highest number of started projects was in 2016, a year with fewer applications than any year except 2017, which is still underway. It appears that the better support offered to students by the adjunct instructor in AY 2016 increased the quality of applications as well as the likelihood that students would persist to working on their projects. Unfortunately, the funding for that adjunct position no longer exists and the instructor has moved to another city.

The average expenses in the last column of Table 2 shows that students do not spend the maximum of $1000 available for projects. Many project requests have budgets of less than $1000, and even projects with budgets of $1000 do not manage to spend their entire grant budget. Since on average projects do not spend the $1000 limit, we conclude that $1000 is not an impediment to student participation.

Hidden in the data of Table 2 is the unfortunate fact that several student groups with Beta Project funding simply do not finish their project. We cannot compel students to finish their project since the Beta Project work is completely outside the curriculum. Though the Innovation Council would rather see projects completed, we trust that students learn through even partial completion of their projects. Furthermore, following from our belief in providing “support not structure”, we do not anticipate a good return on any effort to strictly enforce completion of projects.
Some Notable Successes
In this section, we briefly present examples of the kind of student work that is possible with support from the Beta Project.

Alex B.: ACE mobile pollution monitor
Alex developed the ACE, a low-cost, portable, and smartphone-connected set of sensors that measure the exposure of bicyclists to air pollution while cycling in car traffic. The device also tracks the cyclists’ speed, heart rate, and proximity to vehicles. It can be used to identify routes with high versus low exposure to pollutants, as well as providing input to crowdsourcing of pollution maps. The project was awarded an additional $5,000 in funding from the Portland State Cleantech Challenge (https://www.pdx.edu/clean-challenge/), which allowed Alex to develop an improved prototype. Alex used the technology for his Ph.D. dissertation research. He graduated and continues to do research on urban air pollution as a member of the engineering faculty at another institution.

Kristina R. and Nick S.: Dog Safety Harness
This team developed a harness that allows dogs to be clipped into seat belt restraints while they are riding in automobiles. Traditional designs of “seat belts” for dogs aim to protect the lives of drivers and passengers by restraining the dog. In a serious accident, those restraints can do serious harm to the dog. The design created by Kristina and Nick protects the dog’s vulnerable shoulder bones. Kristina had the idea when a friend’s dog died in an accident and she could not find a good seat belt for her own dog. The team received positive feedback that demonstrated that there may be a market, but the team did not pursue these leads very far. A commercially viable solution would require additional expertise to develop a design that is easier and less expensive to manufacture. The project ended with Kristina’s graduation. Kristina found the project very helpful during her job search – all interviewers took great interest in it.

Jeremiah S., Sarmad B., Edgard M. and Evan S: RemZen Sleep mask
This interdisciplinary team developed the RemZen Sleep mask to monitor REM state and other sleep data, log that data, and use the data with an application to coach people into achieving better quality sleep through lifestyle changes. Conventional fitness trackers cannot detect REM sleep. By using lights embedded in the mask that gradually increase in brightness, RemZen also serves as an alarm clock to gently wake the sleeper at an optimal point in their sleep cycle. The idea for RemZen was conceived by Jeremiah S. in an entrepreneurial capstone program (Launch-in-9). The project attracted small angel investments and an equity offer, as well as the attention and support of experts in the medical, technology, and start-up community. It successfully completed a crowdfunding campaign and delivered a first product to the backers. However, it stalled after the founder ran out of funds for living expenses and accepted a full-time, permanent job.

Jon T., Matthew S., Taylor R. and Anne P.: Aquaponic System
This student team developed a self-regulating, closed-loop aquaponic system by combining a fish tank with artificial lighting and growing medium. The system produces
microgreens for salads. The idea was first conceived by mechanical engineering undergraduates for a class project, with no intention to start a business. The team was later joined by a biology major, Anne, who provided knowledge about plant and fish biology. The project was awarded additional prototyping funds by the Portland State Cleantech Challenge. The idea was further refined, resulting in a larger scale system that can fulfill restaurant’s needs for microgreens, while also providing a visually appealing fish tank for guests. The team won the Portland Cleantech Challenge competition finals and split the $25k in prize money. One of their fish tanks was installed in a local restaurant. One team member, Anne, has started a company (Möbius Microfarms, http://www.mobiusmicrofarms.com) to commercialize the solution.

Mark R.: Liquid Wire
The Liquid Wire project received three rounds of Beta Project funding, and has resulted in an electrically conductive gel that can be printed onto fabrics and rubber to make things such as stretch sensors or flexible and stretchable LED light arrays. Initially, Mark became interested in the technology to support robotics. Since then, he has seen additional applications in wearables and printable sensors. The project won second place in the Portland State Cleantech Challenge and has since attracted grant funding for commercialization.

Aimee R., Tom B.: Mushing Cooker
This team created an improved design for a fast-heating, efficient cooker that “mushers” – dog sled drivers – can use in long-distance races such as the 1,000-mile Iditarod. Mushers need cookers for melting snow and thawing food for themselves and their dog teams. The cookers need to be as light and efficient as possible. The design is easy to pack and to operate and heats up twice as fast as traditional cookers. The seeds for the project were an already existing project by civil engineering staff member, Tom B. He encouraged Aimee, who is from Alaska, to take it on and make major improvements. The project is being field-tested. In parallel, a new version for park rangers in Denali National Park is in the works.

Trevor L., Greg M., and Derick T.: Quadcopter Water Sampling
This team developed a UAV-mounted water collection system to improve field water sampling and enhance research capabilities. Rather than having to go out on a lake or river, researchers can fly a drone to get their samples. The project received additional prototype funding as Semi-finalist in the Portland State Cleantech Challenge.

Conclusion
The Beta Project is an on-going experiment to foster student innovation. The impetus was a donation to the College. Our approach arose from a desire to sponsor a culture of creativity and innovation in our students while avoiding cumbersome administrative responsibilities for faculty, or participation requirements that would deter students. We have made progress, but have more work to do.
The biggest challenge is to expand participation, especially of students who are not already inclined to tinker or participate in student groups working on technology development projects. Our primary focus has been to reduce a barrier to experimentation and prototyping by providing funding for materials and components. From talking to students who have not chosen to participate in the Beta Project, we have learned about the need for extracurricular scaffolding events and learning activities so that more students become comfortable submitting proposals. Of course, we also want to have those proposals be of high quality. Therefore, in addition to improving chances that students will become interested and apply, we have to create opportunities for students to learn skills that will enable them to be effective in Beta Projects work.

With the Beta Project funding as bait, we are asking students to engage in activities that are not available elsewhere in the engineering curriculum. For some students, funding is a crucial resource that enables a constructive outlet for their creativity and curiosity. Faculty involved in the Beta Project resonate with this subset of the student population because they share our curiosity and desire to create and experiment. We need to find ways to foster that attitude, to become more accessible, and to build confidence in all students so that they are willing and ready to participate.

References


Enter a short descriptive project name here

**Team**
- **Point-of-contact member:**
  One team member will serve as point-of-contact for all communications. He/she must be a PSU student.
  Click here to enter point of contact.
- **Members:**
  Click here to enter team member.
  Click here to enter team member.
  Click here to enter additional members.
  **Team skills:**
  Explain how your current team has all the skills it needs and if you are still looking for additional team members.
  Click or tap here to enter.

**Project Objectives**
What problem does your innovation solve? Who has this problem? How important is the problem? How will your innovation solve the problem? (e.g. provide cost savings, be accessible to currently underserved users, etc.)
Click here to enter objectives.

**State-of-the-Art**
Explain how people currently solve the problem. What competing solutions and products exist? Provide enough background detail to demonstrate that you have looked into the issue. (Don’t forget to mention solutions that use a different technology or no technology at all).
Click here to enter state-of-the-art.

**Future Output of the Project**
What do you want to deliver (e.g. a model, working prototype, a design, …)? If all goes well, what attributes will your solution have (e.g. what size, cost, speed, etc.)
Click here to enter future output.

**Work Plan and Milestones**
What are the major activities needed for this project and when do you expect to complete them? Provide a high-level schedule.
Click here to enter plan and milestones.

**Resource Needs**
How much money do you request for parts, prototyping material, or supplies? Provide a budget summary. What additional resources do you need (e.g. space, tools, equipment, expertise)?
Click here to enter resource needs.

- Make sure to fill-in all sections.
- Limit document to 3 pages. If needed, you can remove guidelines and team member fields.

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**Figure A1** Revised application form for the Beta Project. Students complete this MS Word template as their application to the first round of project screening.