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Full Court Press as a Come-From-Behind Strategy to Win the Innovation and Entrepreneurship Game: A Case Study at the University of Pittsburgh

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ABSTRACT

This paper reflects on the process followed in the Swanson School of Engineering at the University of Pittsburgh to cultivate an innovative and entrepreneurial culture among students and faculty. As a member of the first cohort of the Pathways program, a strategic process was initiated to unlock the innovation capabilities of students and to feed the demand that early activities suggested existed for more entrepreneurial-focused courses and programs. The plan focused on four inter-related areas of development: people, policies, places, and programs. This paper describes steps undertaken for each key area, as well as why it is believed that each of these areas is necessary for a healthy and sustainable innovation and entrepreneurship culture. Quantified measures of results in each area are presented to describe progress and performance. The near-term mission of the program is to develop a culture in which students learn to create, cultivate, and launch impactful ideas, but the long-term goal is for students to carry those skills with them to realize impactful careers of innovation and entrepreneurship.

Key words: Entrepreneurship, Innovation, Creativity

INTRODUCTION

Cultivating an effective and sustainable innovation and entrepreneurship (I&E) program is a multifaceted challenge involving people, places, policies, and programs, all of which are interdependent and none of which can be neglected. When setting out to create a culture in the Swanson School of Engineering (SSoE) at the University of Pittsburgh that approach was adopted by implementing a "full court press" of development. In basketball, the full court press is a tactic in which a team

applies defensive pressure the entire length of the court. While some teams employ the full court press as a normal strategy, the tactic is often used when a team is behind in the later stages of a game to force turnovers and to wear out the opponent as a means of catching up. In a similar manner, the Swanson School of Engineering considered itself to be somewhat behind compared to other schools in terms of its entrepreneurship culture, so it adopted a full court press strategy – a multi-faceted approach in which all necessary areas of innovation and entrepreneurship were addressed at once. The primary objective in developing the program was to establish critical components in four key areas, including Policies, People, Places, and Programs. This paper provides a brief story of that process, describing efforts in each of the four areas and providing a quantified snapshot of the current status.

COVERING THE FULL COURT – FOUR KEY COMPONENTS OF THE PROGRAM

The Swanson School of Engineering at the University of Pittsburgh has a history of student participation in innovation, with the development of rapid prototyping facilities, creation of an interdisciplinary Product Realization capstone course, and participation in VentureWell (formerly NCIIA) programs throughout the 1990's and early 2000's. The effort to create a more comprehensive program and a culture of innovation and entrepreneurship began in earnest in 2014 with its participation as one of 12 inaugural schools in the Pathways to Innovation Program directed by the NSF-sponsored EpiCenter at Stanford University (Giersch et. al., 2015). Participation in the Pathways program involved a focused effort toward increasing education and opportunities in innovation and entrepreneurship, both in the classroom and through extra-curricular activities. A strategic planning team of faculty representing all departments in the Swanson School of Engineering participated in the effort, and developed a plan of action for the school. It was apparent that much work needed to be done to catch up in the innovation and entrepreneurship game, and most importantly to lay the foundation and to spark a movement toward the type of innovation culture that was a target for the school. The key areas of focus and specific goals were to be

1. Policies – addressing university policies that hindered the current innovation culture. Goal: enable student ownership of IP generated in courses
2. Places – creating spaces for students to engage in design and prototyping. Goal: establish a 4-tiered makerspace structure where the lowest tiers are student managed
3. Programs – establishing curricular and extracurricular programs with which to cultivate the innovation and entrepreneurship process (beyond those that already existed). Goal: transform existing Product Realization Certificate to include innovation and entrepreneurship; increase

participation in the certificate; establish 50% student participation in the program (including makerspaces, curriculum, or extracurricular activities)

4. People – putting into place necessary personnel to support all parts of the program. Goal: create a faculty team to advise the program, including a director; hire adjunct faculty to teach new courses in the certificate; hire staff support

The following sections describe actions taken in each of these areas, along with progress to date.

Policies

During initial meetings of the strategic planning team of faculty involved in the Pathways program there was consensus that a key first step in the process of creating a more entrepreneurial culture was to ensure that students could retain the intellectual property rights for their innovations, thereby incentivizing them to follow through with commercialization or other development outside of the university. This strategy is supported by recent studies of university management of student intellectual property (for example, Barrow et. al., 2014, Duval-Couetil et. al., 2014). The team drafted a proposal to the university administration for a clarification of policy such that students would retain ownership of their inventions whether done in extracurricular activities or as part of a class. The rationale for the request was based on three key reasons: 1) *giving IP ownership to students as a result of their coursework is in line with the Provost's initiative to increase innovation and entrepreneurship across the campus, 2) in an effort to increase innovation and entrepreneurship in the academic environment, there is a trend among universities to provide IP rights to students taking classes, and 3) recent reports indicate that institutions do not gain in the long run by maintaining IP rights of students* (Barrow et. al., 2014, Duval-Couetil et. al., 2014).

Progress toward goal: The goal of enabling student ownership of IP generated in courses has progressed to the university level and changes are underway. Specifically, the expected outcome is that undergraduate and MS students will retain their intellectual property rights in courses they take, in which normal university resources are used and in which no sponsorship is involved that might otherwise restrict ownership (e.g., sponsored research, industry sponsorship). This policy is an important underlying part of the I&E culture, clearing the way for students to be personally motivated to participate in the other aspects of the program described below.

Places

There has been a significant interest in recent years in the importance of physical modeling and communities of practice for engineers (e.g. Forest et. al, 2014, National Research Council 2004). Furthermore, building prototypes is an essential step in the entrepreneurial process – particularly in the case of engineered solutions to problems. In fact, aside from entrepreneurship, many would

argue that building prototypes is essential to the design process itself (e.g., D School Design Thinking Process Guide). Enabling students to engage in the prototype building process requires spaces and equipment – so-called makerspaces – that have become increasingly common in academia (Lightner et. al. 2000, Carlson and Sullivan 2006, Gedde et. al. 2006, Griffin and Cortes 2006).

Prior to the full development of the I&E program in the Swanson School of Engineering, the only dedicated spaces for students to engage in design and prototype fabrication were individual departmental teaching laboratories and a traditional machine shop (i.e., the Swanson Center for Product Innovation) in which students could be trained to work. The machine shop has been effective for a limited number of students, but in general was intimidating for most students and was seen as having a high barrier to entry. The teaching laboratories provided bench space but were very limited in prototyping resources. In addition to these, a student electronics prototyping facility was being developed at the time with specific emphasis on electrical circuits. It was clear to the strategic planning team that new spaces needed to be created. A survey of departments was done to estimate the need. Each department was asked about the estimated usage of maker spaces to meet the following types of needs:

- Low Resolution Prototyping – e.g. cardboard, clay models, and other crafts for first-generation prototypes
- Medium/High Resolution Prototyping – e.g. 3D printing, laser cutting, milling for working prototypes
- Temporary Design Space – for brainstorming and sketching on a white board
- Project/Build Space – temporary or semi-permanent space in which to build prototypes
- Electronics Prototyping – circuit development and microcontroller programming

Responses indicated that such facilities would be useful in courses offered by every department, and could have a reach of more than 3,000 participants each year (where one student in an affected course is considered to be a participant so there will be overlap). The survey did not consider extracurricular activities, which would clearly drive need for the spaces as well.

Considering the survey responses, and informed by workshops in the Pathways program and a Makerspace planning workshop presented by GA Tech (Craig Forest) and VentureWell, a comprehensive plan was created to fill gaps between the existing machine shop and teaching labs with an integrated and tiered set of makerspaces that span a range in resource complexity and prototyping fidelity. In particular, a four-tiered structure in which students can accomplish all of their innovation and fabrication needs was proposed. The general concept was for students to enter the makerspaces on Tier 1 as they begin the conceptual and early prototyping phases of their projects. For these phases, students need white boards and basic craft materials for idea generation and exploration. Once the concept is clearly defined, students often need to create higher-fidelity prototypes by 3D

printing or other rapid prototyping tools. In many cases, prototyping is complete at this stage. For students who require higher fidelity prototypes or full working models (e.g. machined parts from metal or combinations of materials), Tiers 3 and 4 would be made available (with Tier 4 being the current traditional machine shop). In addition to the progression of a project through the spaces, the structure itself invites participation. The fundamental nature of Tier 1 has very low barrier to entry so that inexperienced students can easily participate, moving naturally to more advanced spaces as needs and skills evolve. Table 1 provides a summary of the tiers and their characteristics.

To date significant progress has been made on the development of the proposed makerspaces. Two Tier 1 spaces are currently online, as shown in Fig. 1 (MS1, a low-resolution design and makerspace that is open to all students) and Fig. 2 (a design and low-resolution studio for a new design-thinking course, Art of Making). The Tier 2 space, MS2 (named the "Treehouse" by the students), came online in the fall of 2018, and is shown in Fig. 3. In addition, a digital media lab has been developed in which

Table 1. Proposed Four-Tier Makespace Structure.

Tier 1	
Low Resolution	
Purpose:	Conceptual prototyping and idea generation
Tools:	Craft materials for basic prototyping and ideation
Access:	Daily with 24/7 access for workers, basic safety/operating rules required for membership but the simple tools and materials result in low barriers for students
Oversight:	Student workers and volunteers
Tier 2	
Medium Resolution	
Purpose:	Fundamental prototyping
Tools:	Basic rapid prototyping and digital fabrication tools
Access:	Limited week and weekend hours, gated access
Oversight:	Student workers and staff guidance
Tier 3	
High Resolution	
Purpose:	Detailed, high fidelity prototyping
Tools:	Conventional machining and high fidelity prototyping tools
Access:	Limited hours, gated access, machine sign-in
Oversight:	Student workers and staff
Tier 4	
Highest Resolution	
Purpose:	Detailed, high fidelity prototyping
Tools:	Highest-end and CNC machining
Access:	Limited hours, regular hours with staff on site
Oversight:	Staff

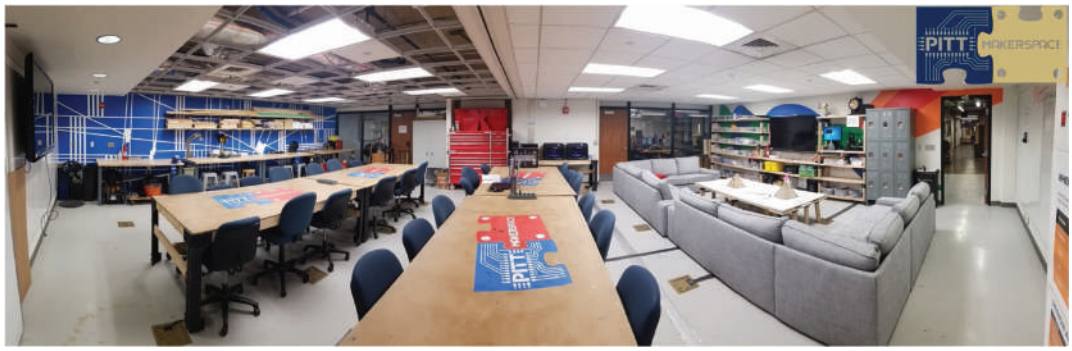

Figure 1. Photograph of the MS1 Makerspace in Benedum Hall.

Figure 2. Photograph of the G34 Art of Making design studio in Benedum Hall.

Figure 3. Photograph of the MS2 Makerspace in Benedum Hall.

Figure 4. Photograph of the Digital Media Lab in Benedum Hall.

students can create, edit, and produce high-quality audio and video products, shown in Fig. 4. The Tier 3 space has been allocated and is scheduled to come online in the spring of 2019. More details of the spaces can be found at www.makers.pitt.edu.

To date, the makerspaces have been heavily used. In the first 20 months since establishment of the MS1 space, over 1,000 students (from all engineering departments and from eight other university departments) have used the spaces, including over 100 student volunteers over that time period (in addition to the ~10 students who make up the management team) who operate the space on a daily basis. The G34 Art of Making studio has hosted multiple courses since its creation (over 120 students per year) who continue to utilize the facility after the course has ended. In the 2017–18 academic year, there were 2,559 recorded sign-ins for the MS1 space, representing 489 individual users (see Fig. 5). This SSoE use makes up approximately 15% of the undergraduate student body.

Progress toward goal: The goal of establishing a 4-tiered structure of makerspaces has partially been met as of this publication date. The first two tiers (low and medium resolution) makerspaces have been established and are now operating on a regular basis with student management and regular operating hours. The third tier is under development and the fourth tier already existed. An additional space, the Digital Media Lab, was created, which was not part of the original goal.

Programs

Programs can be divided into two categories: curricular and extracurricular. The Swanson School of Engineering had activity in each of these areas prior to its full court press in 2014, however since then concerted efforts in both areas have been underway.

Curricular

Related curricular efforts existed in the area of product realization prior to the I&E emphasis in 2014. In fact, the centerpiece was an undergraduate certificate in Product Realization, which drew primarily

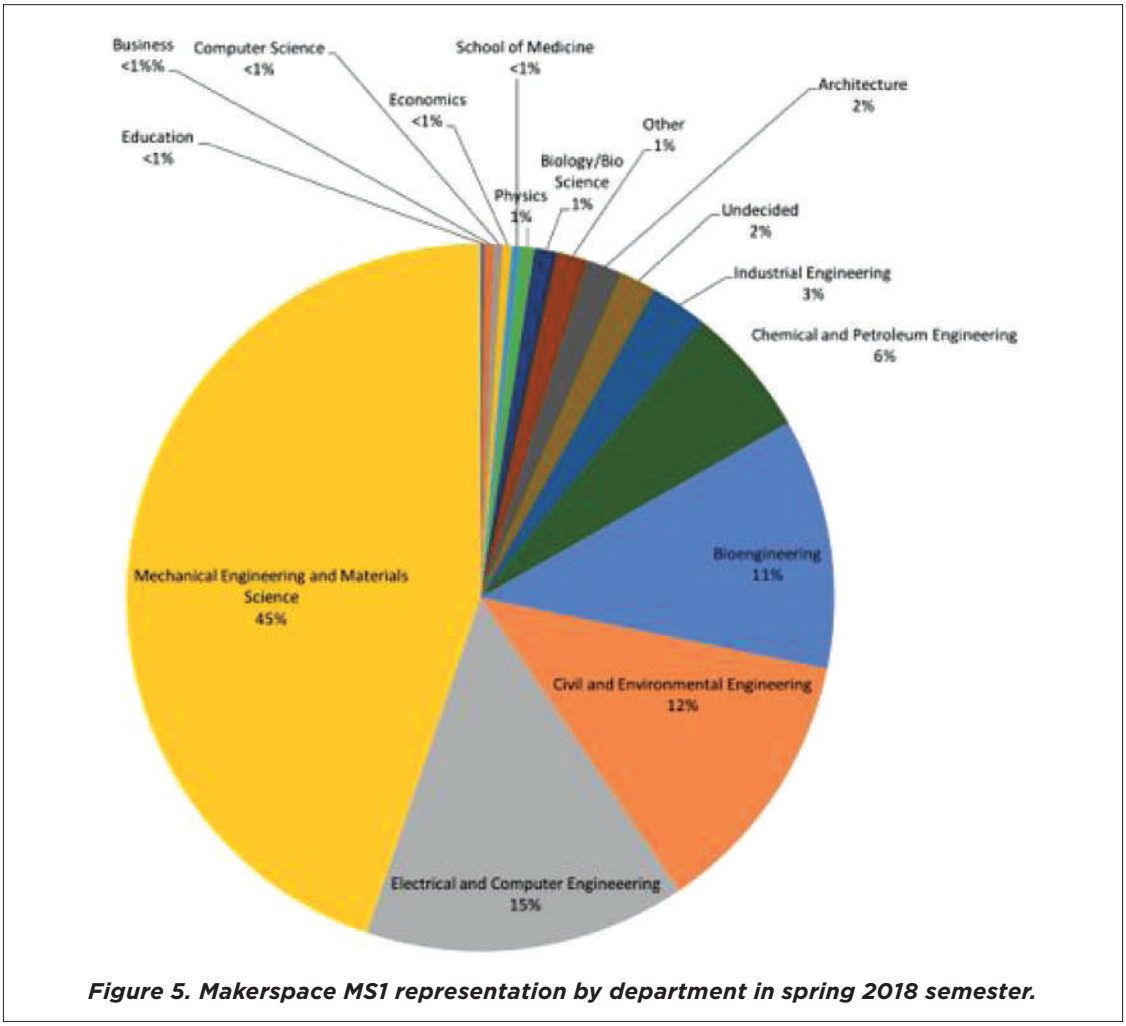

Figure 5. Makerspace MS1 representation by department in spring 2018 semester.

from departmental course offerings (plus two from the College of Business) with a supplemental course in Rapid Prototyping and a capstone Product Realization course. Since 2014 a proposal was submitted to the university to transition the Product Realization certificate to a certificate in Innovation, Product Design, and Entrepreneurship. As the title suggests, the emphasis on product realization has been retained, but a much greater importance has been placed on I&E to reflect the importance of that focus within the school. The new certificate was approved and saw its first graduate in Spring 2017 (along with ten graduates who were completing the old Product Realization certificate, which is now no longer available). To support the new certificate and I&E emphasis, many new course have been created, including:

- Hacking for Defense (offered to graduate and undergraduate students)
- Intrapreneurship: Entrepreneurship within the Corporation

- Lean Launchpad
- Social Entrepreneurship
- Startup Fundamentals
- The Art of Making
- Medical Product Ideation
- Project Based Technology Design
- Chemical Product Prototyping
- Medical Product Development

Details of the certificate program can be found at www.engineering.pitt.edu/IPDEC/.

Additional courses are being considered for future development. In addition to coursework, a new Design Expo – a poster session event to showcase all capstone and other design course projects – was created in the spring of 2015 and has been held each semester since. This event has become very popular with the students as it allows them to exhibit their work to their sponsors, to the local engineering community, and to future employers. Each term approximately 80 capstone and design projects are displayed to equal number of industry based judges, who discuss the projects with student teams and rate their work on a number of attributes to include innovation. Cash prizes are given to departmental teams, as well as an overall Best in Show and People's Choice award.

Extra-Curricular

Extra-curricular innovation-related activities existed at the University of Pittsburgh prior to 2014, however they were limited and without coordination. For example, a student club called Engineers for Sustainable Medical Devices focused on designing and building prototypes in conjunction with faculty from the medical school. Recent efforts have created more options for students, with more integration of the various activities. Examples include:

- The MS1 Makerspace (mentioned above and shown in Figure 1) was designed and created by a team of volunteers that are now simply known as the Makerspace Team. Their group has a hierarchy of leaders who manage four teams (Users, Materials and Equipment, Education and Training, and Sponsorship and Outreach) that oversee all of the daily operations of the space (including coordinating a team of volunteers who staff the facility daily) as well as the long term planning and management.
- Design Hub is a reincarnation of the Engineers for Sustainable Medical Devices club, which was changed to provide a broader range of projects to address design challenges, typically solicited from engineering and medical faculty on campus from all areas, not just the medical front. Design Hub regularly carries out design and prototyping in the makerspaces, and also provides workshops to other students on prototyping skills.

- University Innovation Fellows (UIFs) are undergraduate students who have each made a significant impact on student awareness and participation in innovation and entrepreneurship through events, clubs, and other extracurricular activities on their respective campuses. Nineteen University of Pittsburgh students from across the campus have participated in the UIF program over a five year period.
- Blast Furnace (https://www.innovation.pitt.edu/innovation-institute-programs/blast-furnace/) is a new student accelerator that helps students in their first entrepreneurial process by providing knowledge and skills to get started. The program was created by the Innovation Institute (https://www.innovation.pitt.edu/) at the University of Pittsburgh, and is designed to provide mentorship and an experiential process to undergraduate and graduate students to prepare them for launch of their businesses. Teams of students who have product or business ideas participate in the nine-week program. Engineering students have come to see the Blast Furnace as a natural step in their entrepreneurial process, and there is increasing interaction between Blast Furnace teams (from any part of the campus) and the makerspaces. To date the Blast Furnace has hosted five cohorts involving a total of 300 students on 80 teams, resulting in 26 startups.
- XProjects are team design and prototype projects for internal or external clients. The program was created in the spring of 2017 to provide students with opportunities to learn the tools in the spaces. SSoE I&E staff work with clients to define scopes of work for projects and then form a student team from within the Makerspace community for each project. During these six-week projects, which include a kick-off, weekly design reviews, and a closure meeting, students not only learn fabrication skills but also project management and communication tools while working in interdisciplinary teams. To date, over fifteen XProjects have been completed.

Other I&E extracurricular activities include an I&E Living Learning Community, an annual I&E Bootcamp for students who want a weekend immersion into the process; and numerous workshops held throughout the year in the various makerspaces on a variety of prototyping, innovation, and entrepreneurial topics.

Progress toward goals: the Product Realization Certificate is now the Innovation, Product Design, and Entrepreneurship Certificate, which includes innovation and entrepreneurship content. Participation in the Product Realization Certificate was approximately 2–3 students per year, and that participation has increased by approximately 6 times since the change to the new certificate program. Overall, student participation in all aspects of the I&E program is at approximately 15% of the SSoE student body, although the measures of participation are currently being re-evaluated.

People

An effective program requires the participation of many people. The Swanson School of Engineering has benefited from a committed and active faculty advising team, made up of the original strategic planning team. With the approval of the new certificate, a new program director has been named to administer the academic certificate and to oversee the I&E program as a whole. In addition, the school's administration, including the Dean and the Associate Dean of Academic Affairs, have been fully committed to growing the I&E culture and producing students who create impact. To make the program run on a daily and annual basis, additional people have been added including a Design, Innovation, and Outreach Coordinator who has been instrumental in supporting the increased design and prototyping load in the school, and numerous adjunct faculty who have taught some of the new courses. Finally, as mentioned above, the students have been highly engaged in the program by participating in the breadth of activities and volunteering countless hours to make the workshops, clubs, and makerspaces operate efficiently. This engagement has come through i) an initial call to the student body to participate in design of the makerspaces in 2015 and subsequent student involvement; ii) courses that have specifically incorporated Makerspace use in assignments (e.g. MEMS 0024: Introduction to Mechanical Engineering Design, ENGR 0135: Statics and Mechanics of Materials, and CEE 1618: Design for the Environment), and iii) student-lead workshops on prototyping topics such as basic 3D printing, laser cutting, soldering, programming, and microcontrollers. Enthusiasm and support of students is essential to the continued growth of the I&E program.

Progress toward goals: our faculty team is engaged and providing advice and guidance to the program, a director has been established to oversee the curriculum, extra-curricular activities, and student-managed makerspaces; adjunct faculty have been hired to teach some of the new courses in the certificate and others are taught by tenure-stream and non-tenure-stream full-time faculty; a staff person was hired for the position of Design Innovation, and Outreach Coordinator.

SUMMARY

There are many facets to the development of a culture of innovation and entrepreneurship in an academic environment. When the Swanson School of Engineering set its sights on developing such a culture, the faculty believed that the school needed to address many areas to get the culture to where it needed to be. The planning team took the approach that to be effective, all facets are important and needed to be addressed at once, rather than working on individual parts sequentially, thus the "full court press" approach. It was believed that student enthusiasm was most important

to create a sustainable environment of innovation and entrepreneurship, but this required policy change, the creation of makerspaces, new courses, a new certificate, integrated extracurricular programs, and additional personnel to make it operate effectively. In addition, it was considered to be essential to involve students directly in the development and management of the makerspaces so that they would identify as an inherent part of the process. While much is still planned to be done, these pieces have been put into place and early evidence indicates that the desired culture is being established and is starting to thrive.

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