An Entrepreneurial Capstone Design Option: U of I MechSE Innovation Trophy Competition

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This paper provides an overview of the University of Illinois Mechanical Science and Engineering Department's optional Innovation Trophy entrepreneurial capstone (senior) design competition, which is aimed to help students launch companies with mechanical design ideas that have societal impact. Over the past five years, four companies have resulted from or are on the verge of emerging from this competition. The competition utilizes the existing senior design structure and facilities with some modifications. An Innovation Trophy Committee evaluates projects, oversees the competition, and ensures that the projects meet senior design course requirements. Students compete for their own senior design project in the pre-senior design phase. The winners pursue their own senior design project that must involve designing, building, testing, and include a business plan. In the post senior design phase winning teams receive a $2,000 budget and space to continue pursuing their designs. Many lessons were learned, including the need to incorporate entrepreneurship in the formative curriculum, encourage the students to pursue their ideas early on, and be selective in the projects that proceed to the senior design phase. There are a few opportunities for future improvement including further incorporation of entrepreneurial experiences in the coursework, allowing students to enter the senior design phase in both the fall and the spring semester, and utilizing more resources on campus including new facilities and students of other majors.

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Introduction

The University of Illinois (U of I) Department of Mechanical Science and Engineering (MechSE) engages its students in approximately 50 different capstone projects (senior design projects) per year. The senior design projects can be classified into four categories: engineering competitions, industrial projects, humanitarian projects, and entrepreneurial projects. A majority of the projects are one semester projects that are offered in the spring and fall semesters[1]. In 2011 MechSE launched an optional entrepreneurial senior design competition to help foster and nurture entrepreneurship in our undergraduate students. There is a recognition that not all of our graduates will move on to work for industry and academia after graduation, and many will start their own business. Furthermore, it is found that new hi-tech businesses account for the majority of the job creation and economic growth in the U.S.[2] MechSE wanted to give its students a leg-up in starting their own business and competing in bigger competitions like the University of Illinois Cozad New Venture Competition[3] and the Lemelson-MIT student prize[4]. Entrepreneurial senior design competition experiences have been pursued at other universities such as Wichita State Uiversity[5] and the University of Waterloo[6]. However, MechSE pursued a unique model that was relatively easy to implement within the existing infrastructure. The present work will provide an overview of the current University of Illinois MechSE Innovation Trophy Competition, results of the last five years, lessons learned, and future opportunities for improvement of the competition.

MechSE Innovation Trophy Competition Overview

The Innovation Trophy Competition is an entrepreneurial competition open to U of I MechSE students (mechanical engineering and engineering mechanics majors) approaching their senior year. It is a design competition that is structured in phases to allow students to satisfy their senior design course (ME 470) requirement while helping them pursue original ideas that have significant engineering mechanics or mechanical engineering design content, promising commercialization potential, and societal impact

Innovation Trophy Committee

The Innovation Trophy committee that oversees the Innovation Trophy Competition consists of faculty and staff with a background in design and entrepreneurship, which include the Senior Design Project Coordinator (faculty responsible for recruiting and managing projects) and the Senior Design Course coordinator (faculty member responsible for teaching the course). They are responsible for:

- Overseeing the structure and development of the competition

- Soliciting student participation
- Evaluating the proposed entrepreneurial senior design projects for the senior design phase and the post senior design phase.
- Provide guidance to students such as pointing them to resources available and helping them define a proper project scope for the senior design phase.

Pre-Senior Design Phase

Students are encouraged to pursue entrepreneurial design concepts as early as freshman year to prepare for the competition. Every fall there is an Innovation Trophy Competition informational session that provides an overview of the competition and winning student teams of the previous year present their experience and give advice. In the spring semester, juniors are invited to submit a signup form to participate in the competition. Students are encouraged to discuss their ideas with members of the Innovation Trophy Committee, and they are regularly seen doing so. Students are asked to provide the following in their application one month before the end of the spring semester:

- Names of the students in the core team consisting of 3 or 4 MechSE students as well as any extended team members, who may be underclassmen or students that may be from another major.
- A brief description of their project idea that they would like to pursue in the senior design phase.
- A signature of a faculty advisor who is willing to advise the team on their project in the senior design phase.

Participating student teams are then asked to prepare a presentation to convince the Innovation Trophy committee to have the students define their own entrepreneurial senior design project. The presentations include previous research and work completed, commercialization potential, and impact on society. A team will move forward to the senior design phase in the fall if the committee feels that the team shows significant promise in commercializing the design.

Project Scope and Design Constraints

Once the selected teams win their own senior design project they must submit a project description, before the fall semester of their senior year that outlines the scope and constraints involved in the one semester project. Like the industry sponsored design projects, the entrepreneurial design projects must have multiple realistic constraints to satisfy ABET criteria. The ABET Engineering Accreditation Commission (EAC) indicates, under General Criteria 5 Curriculum, that "Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."[6] The constraints may include, but are not limited to, the following constraints outlined in ABET General Criterion 3 Student Outcomes: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political.[7] Furthermore, like the industry sponsored projects, the scope must involve designing, building, and testing prototype(s). In addition to these criteria the entrepreneurial senior design projects require a business plan to be complete by the conclusion of the semester. The project description must be approved by the committee before the semester begins.

Senior Design Phase

In the senior design phase, the Innovation Trophy teams have the same requirements as the industrially sponsored teams. The teams meet with their faculty advisor and teaching assistant once a week to monitor progress, provide technical mentorship, and critique their written and verbal communication skills. Issues related to scope of the project are referred to the senior design coordinators and Innovation Trophy committee. The students are required to deliver preliminary design, mid semester status, and final reports and presentations during the semester in order ensure that they are on track and provide the team with constructive feedback. The Innovation Trophy teams are encouraged to seek guidance from other sources as well. We are fortunate to have the University of Illinois Technology and Entrepreneur Center (TEC) which is very useful in helping the students develop their business model. In addition, we have leveraged our MechSE Alumni who include entrepreneurs and patent lawyers for free business and legal advice. In addition, the University of Illinois Law School can provide free patent application services if selected. Students own intellectually property developed in U of I design courses, such as the present.

In addition to the human resources, MechSE provides the innovation trophy teams a $2,000 budget for project related expenses and access to MechSE space and facilities during the senior design phase. Like the industrial sponsored teams, the teams are given their own workbench and toolbox with basic hand tools in the senior design lab. The senior design lab also contains shared power and hand tools. Furthermore, the students have access to a wide variety of MechSE facilities:

- Innovation Studio that contains:
  - 3-d fused deposition modeling printers
  - Carbon fiber and composite printer
  - Laser cutters
  - Wood working equipment

    - Power and hand tools that can be checked out;
- Mechatronics lab that contains:
    - Electronic equipment
    - Soldering stations
    - Tools to aid in the fabrication of mechatronic devices
- Ford Concurrent Design & Manufacturing Lab that contains:
    - Selective laser sintering machine
    - Fused deposition modeler
    - Objet 3-d printer
    - Stereolithography machine
    - 3-d non-contact scanners
- Students are able to consult with and seek the services of skilled machinists in our machine shop that contains the following:
    - Wire EDMs
    - Water jet cutter
    - CNC mills and lathes
    - Welding.

As a result, the Innovation Trophy teams are able to fabricate virtually everything that they need in-house.

Post Senior Design Phase

After the completion of the senior design phase, the Innovation Trophy teams present their work and business model to the Innovation Trophy committee. If their designs and business models look promising they win the competition and are given an additional $2,000 of in-kind support for machining and fabrication expenses along with continued access to the facilities. Many teams choose to continue receiving course credit for this work by enrolling in an independent study course (ME 497) with their faculty advisor in the subsequent semester. The hopes are that the students will leverage their work to gain additional resources from other sources, such as the Lemelson-MIT Student Prize, Cozad New Venture Competition, and other entrepreneurial competitions.

Funding

The Innovation Trophy Competition was funded by a combination of donations from industrial partners, alumni, and the MechSE department.

Results

Over the last five years there were 19 Innovation Trophy competition applicants. Of these applicants seven student teams advanced to the senior design phase. There were four teams that won the competition and received additional funding. All four teams that won the competition either started a company or are in the process of doing so. The four winning design concepts are:

- Low cost wheelchair lift system for homes
- Self-contained fire suppression system for homes
- Improved touchless faucet
- Low cost bionic hand

Lessons Learned

There were a number of lessons learned from implementation of the Innovation Trophy competition. Firstly, we realized that a majority of the successful teams had devoted significant amounts of time and effort towards realizing their designs ahead of the senior design phase. The senior design phase is just one semester, so teams need to have a very good idea about the direction of their work before the beginning of their senior design semester. Industrial projects typically result from the needs of the sponsor who typically have experience with the problem at hand that can include both design constraints and business model ramifications, and are consequently better defined problems from the beginning. As a result, student teams with industry sponsored projects are typically able to complete the goals of the project within the semester. However, entrepreneurial projects, by their nature, are much more open ended. Therefore, the students will need to come up with virtually everything themselves, which takes more time. Teams that entered the senior design phase without much prior work felt overwhelmed and frustrated at times. The teams that were successful in coming up with a viable design, proof of concept prototype, and business plan either worked a semester ahead of time, or worked on developing their product in one of their previous design courses. This observation spurred MechSE to institute several changes:

- Introduce the Innovation Trophy competition early in the curriculum such as our engineering freshmen orientation (ENG 100) and Computer Aided Design (ME 170) courses.
- Advertise the Innovation Trophy competition in a required seminar course such as our sophomore level undergraduate seminar course (ME 390) that includes lectures from alumni entrepreneurs and pointers from a wining Innovation Trophy team.
- Allow students to obtain course credit for entrepreneurial design work in the sophomore and junior years through courses like our free-form undergraduate open seminar class (ME 199DES).
- Advertise and encourage students to participate in the Innovation Trophy competition in sophomore and junior level design and manufacturing courses (our TAM 302 and ME 270) where they are required to design and build a product.
- The Innovation Trophy committee became more selective in determining the teams allowed to proceed to the senior design phase. Teams now need

to have a convincing preliminary business plan and a proof of concept prototype to proceed to the senior design phase of the competition.

Initially, it was envisioned that several teams each semester would compete to win the competition. However, we have seen that there may not be a large enough pool for this type of competition in a given semester. Instead, the committee serves to determine absolutely who moves onto the senior design phase of the competition and wins the competition regardless of how many teams are competing. In fact, in one year none of the three student teams that applied proceed to the senior design phase. Another observation was that some teams were not able to compete because of the timing of the fall only competition. Students must have taken or be concurrently enrolled in all but two required MechSE courses to enroll in ME 470, since it is intended to be their capstone/senior design experience. Some seniors do not meet this requirement in the fall semester, because students enter the program with varying amounts of credit and do not move through the curriculum as a cohort.

Opportunities for Future Improvement

As a result of the lessons learned in the last five years of the Innovation trophy competition several potential opportunities for improvement were identified:

- Further institutionalize the competition through incorporation of entrepreneurial experiences in prior course work.
- Allow students to enter the senior design phase in either the fall or the spring semester in order to increase the number of eligible students competing.
- Reach out to other units on campus to gain more resources and build more multidisciplinary teams. For example, MechSE plans to:
  - Engage the U of I TEC to further incorporate entrepreneurship in the curricula.
  - Engage the U of I School of Business to incorporate business students into the teams.
  - Engage students in the school of Art and Design to improve esthetics and customer satisfaction.
  - Utilize the facilities of the U of I multidisciplinary Design Center that is scheduled to open in December 2018[8].

Conclusion

In conclusion, Mechanical Science and Engineering Department launched the Innovation Trophy entrepreneurial senior design competition aimed to help students start companies around mechanical design ideas that have societal impact and compete for larger entrepreneurial prizes. Over the past five years, four companies have sprung from or are on the verge of emerging from this competition. The competition utilizes the existing senior design structure with some modifications. An Innovation Trophy committee evaluates projects, oversees the competition, and ensures that the projects meet senior design course requirements. Students compete for their own senior design project in the pre-senior design phase. The winners pursue their own senior design project which must involve designing, building, testing, and developing a business plan. In the post senior design phase winning teams receive a $2,000 budget and space to continue pursuing their designs. Many lessons were learned over the past five years including the need to incorporate entrepreneurship in the formative curriculum, encourage the students to pursue their ideas early on, and be selective in the projects that proceed to the senior design phase. There are a few opportunities for future improvement including further incorporation of entrepreneurial experiences in the formative coursework, allowing students to enter the senior design phase in both the fall and the spring semester, and utilizing more resources on campus including new facilities and students of other majors.

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