The Interdisciplinary Engineering Design Program at the University of Arizona

Ara Arabyan
University of Arizona

The evolution, structure, organization, and finances of the interdisciplinary Engineering Design Program at the University of Arizona are described. The program was started in 2001 and has grown to around 370 students over the last 15 years. The students work in interdisciplinary teams on fee-based real-life projects, with more than 70% funded by corporations and public agencies. The teams are guided by paid professional mentors through industry-standard design processes. The program is financially self-sufficient with only one faculty member paid by the university. Extensive use is made of marketing tools and custom-built software to automate the various aspects of the management of the program.

Keywords: interdisciplinary, capstone, design, engineering

Corresponding Author: Ara Arabyan, arabyan@email.arizona.edu

Introduction

The two-semester interdisciplinary engineering capstone design sequence (Cross-disciplinary Design) at the University of Arizona started 2001 with around 35 students and a few industry-sponsored projects. The course was initially introduced as an optional substitute for the required senior capstone courses offered by individual engineering departments. The course quickly became popular with the students because of its interdisciplinary nature and the involvement of industry and has since grown to around 370 students (in 2015-16) with 70 projects mostly sponsored by industry. The course has now become the required senior capstone course for most departments in the College of Engineering at the University in view of its advantages over single-major capstone courses. The course has also spawned a self-sufficient program (Engineering Design Program) that currently employs more than 15

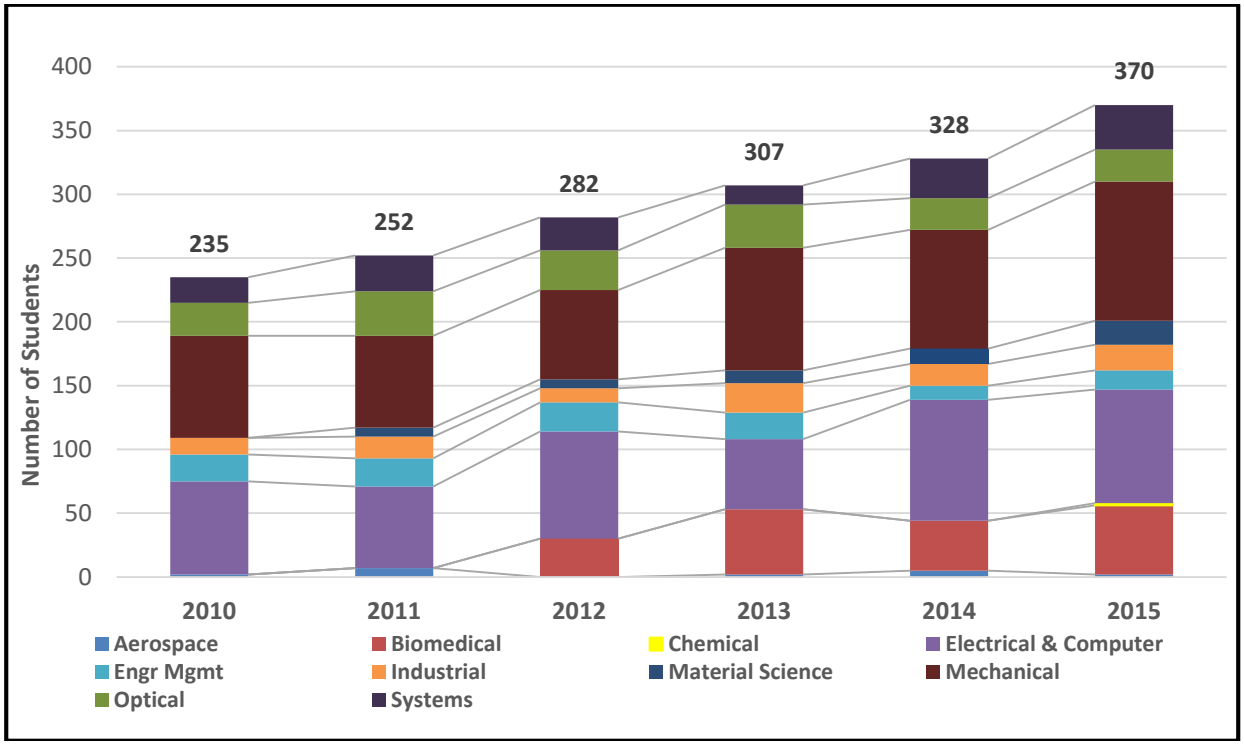

Figure 1. The growth of student enrollment and the distribution of majors in the Cross-disciplinary Design sequence of the College of Engineering at the University of Arizona for academic years 2010-11 through 2015-16 (based on Fall census)

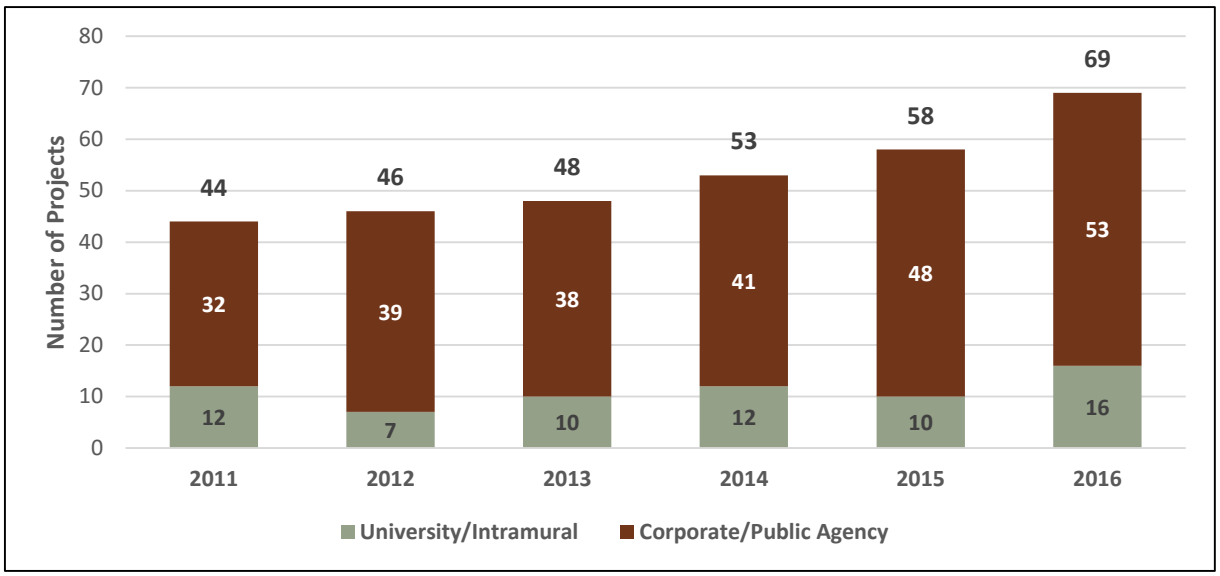

Figure 2. The growth and distribution of projects in the Cross-disciplinary Design sequence of the College of Engineering at the University of Arizona for academic years 2010-11 through 2015-16

professionals in various capacities. This paper describes the evolution, organization, makeup, and accomplishments of this course and the program over the past six years.

Evolution of program

By around 2005, the program had achieved critical mass with over 200 students enrolled and 35 to 40 mostly industry-sponsored projects. Decisions by the largest departments in the College of Engineering (especially Mechanical Engineering and Electrical and Computer Engineering) to participate in the program and to make the interdisciplinary sequence their required capstone sequence played a major role in expanding the scope of the program. The decisions of these departments were driven by cost considerations as well as the positive feedback received from their students who were participating in this optional sequence until then. With growth in the overall student population and decisions by other departments to join (notably Optical Sciences and the rapidly growing Biomedical Engineering program), the number of students in the course has grown steadily in the last six years. Fig. 1 charts this growth and depicts the relative sizes of the different majors participating in the program.

The students enrolled in the program are organized into interdisciplinary teams of five to six students and the teams are assigned to the available projects in each year based on a number of factors. The assignment process is performed by a custom-written optimization software that is explained later in this paper. The fee-based projects are sponsored by large and small companies (mostly in Arizona), faculty, inventors, entrepreneurs, and student clubs. The growth in the number projects available to the students has paralleled the growth in student enrollment as shown in Fig. 2. As depicted by the figure, industry-sponsored projects constitute more than 70 percent of the projects assigned to student teams in the course. The projects for the academic year 2015-16 can be viewed at http:// http://engineeringclinic.arizona.edu/current-projects-and-sponsors. News about the status of selected current projects can be viewed at http://engineeringclinic.arizona.edu/blog-1.

Feedback from past corporate project sponsors suggests that the program serves as an important recruitment channel for engineering graduates. As might be expected, some of the biggest industry sponsors of projects are large employers who hire many engineering graduates of the University of Arizona. However, most sponsors are medium-sized and small companies headquartered in and around Tucson and Phoenix. For the smaller companies, the program not only serves as a focused recruiting channel but also provides opportunities to test out-of-the-box ideas at low cost. Fig. 3 provides an overview of the distribution of industry-sponsored projects among individual companies in the last six years. In the figure, only the top corporate sponsors are listed by name and the remaining companies are lumped together under "Other." The chart does not include projects sponsored by non-corporate entities.

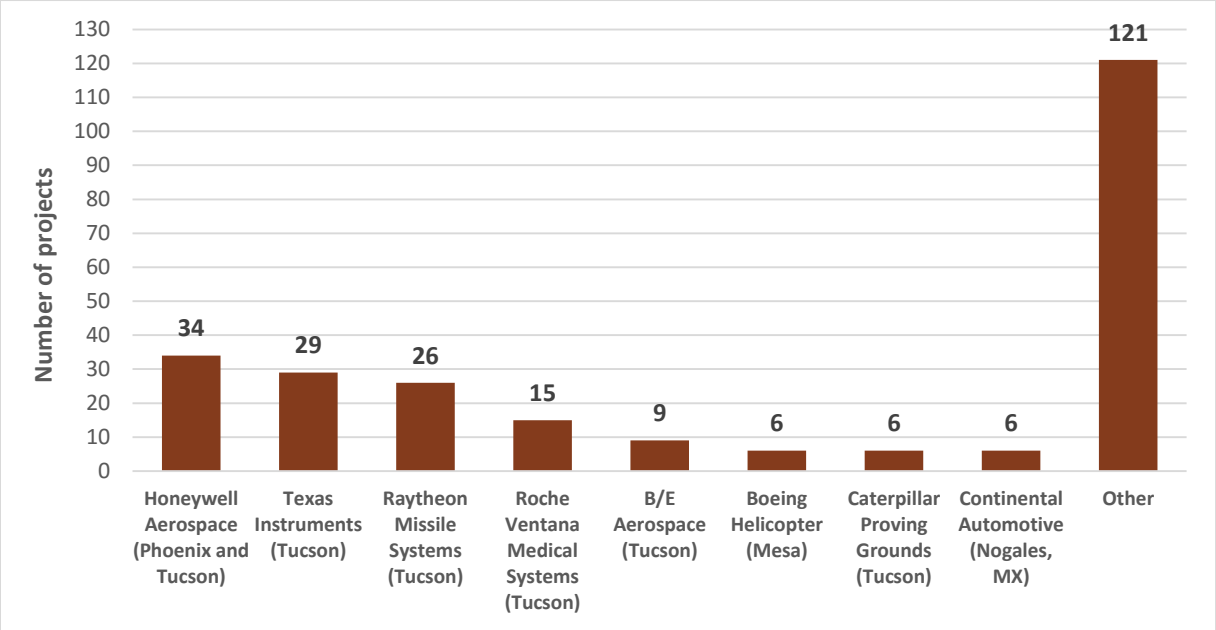

Figure 3. Number of projects sponsored by the eight leading corporate sponsors and other corporate sponsors in the academic years 2010-11 through 2015-16; the "Other" category consists of mostly small companies that have sponsored only one project in the six-year span

The industrial sectors of the project sponsors range from aerospace, electronics, and energy to consumer products, medical devices, and environmental management. This breadth of specialization is also reflected in the subject areas of the projects, which require the skills of all majors participating in the program. In some cases, students required to take capstone courses in departments that do not participate in the program take this course sequence as a technical elective in order to participate in interdisciplinary teams working on real-life projects.

Structure of the course

The course extends over two semesters and follows a timeline that roughly parallels industry-standard design processes in the sequence of its phases (e.g. preliminary and critical design reviews, build and test procedures). This timeline was developed over many years with feedback from project sponsors. The different phases of the project timeline are interspersed with lectures and academic materials on the design process, project management, teaming skills, and written and oral presentation skills. The lectures are given by qualified faculty or industry professionals. These academic lectures are augmented with seminars by guest lecturers on relevant topics ranging from patents and intellectual property to starting small businesses and seeking government grants.

The course culminates in a major event called "Engineering Design Day," where teams in the interdisciplinary course as well as in the single-discipline capstone courses showcase their work to the public and professional judges. The judges are recruited largely from the corporate sponsors of the projects and rate the projects in terms of innovation, completion, and presentation. The judges also select the winners of around 25 corporate-sponsored prizes totaling more than $20,000 for different attributes. The awards and other information about Design Day can be viewed at the website of the program at http://engineeringclinic.arizona.edu under the "Design Day" tab. The program also prints and distributes a booklet each year. The booklet for Design Day 2015 can be viewed or downloaded from http://issuu.com/azengineering/docs/edd_2015_book_press.

All grades in the course are based on the quality of deliverables such as reports and presentations, team participation, and the ratings of external judges. Portions of the student grades are based on sponsor input on some deliverables and the ratings of judges on Design Day.

Organization and management of the course

The program and the course are run by one faculty member, 11 professional mentors, and more than a half

dozen support staff (purchasing, billing, shop assistants, marketing, event organization personnel). The course is also assisted by various faculty from the College of Engineering (in topics related to project management, the design process, and communication skills). The distribution of the costs of the program are shown in Fig. 4. Personnel expenses include the fees paid to the professional mentors.

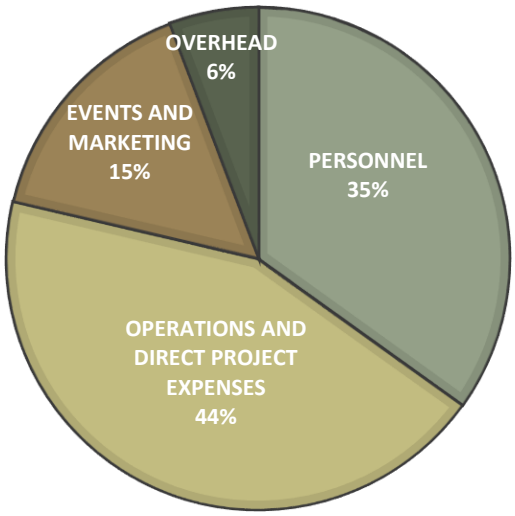

Figure 4. Distribution of the main expenditures of the Cross-disciplinary Design sequence of the College of Engineering at the University of Arizona (for a total projected budget of approximately $640,000 for 2015-16)

The University of Arizona engineering capstone design program differs from its peers in other universities across the nation in that it uses paid professional mentors to advise and manage the student teams as opposed to faculty. The mentors hired for this program are all current or former practicing engineers with many years of design and project management experience in various industries ranging from electronics to aerospace and energy. This model was adopted for a number of reasons.

- Most engineering faculty at the University of Arizona have little experience in professional practice and are unfamiliar with industry-standard design processes. The professional mentors have been able to bridge this gap and pass on their experience to the students.
- University faculty are also not always available to spend time with the student teams because of their busy research and teaching schedules. Professional mentors are paid specifically to spend their time with students.
- Professional mentors have proved to be better (compared to faculty) in driving projects to completion even in the presence of mishaps and uncertainty.
- Professional mentors also appear to be better placed in communicating with their sponsor mentors in terms of project requirements and practical concerns. As a result, they have been much more effective in advising their teams in their communications with sponsors.

Typically, each professional mentor advises six teams and additional mentors are hired as the number projects grows. Profiles of current professional mentors can be viewed at http://engineeringclinic.arizona.edu/blog-1.

Use of marketing and organization software

Extensive use is made of a marketing website (http://engineeringclinic.arizona.edu/) and custom-developed software in the backend of this website to organize and to run various aspects of the program (e.g. solicitations for projects, awards, and judges; team and mentor assignments; organization of Design Day; etc). Large databases of past and present sponsors are maintained and constant communication with current and potential sponsors are maintained through newsletters (e.g. http://www.engr.arizona.edu/undergrad/senior_design).

One particular piece of custom-developed software is an optimization package that assigns student teams to projects based on student preferences and sponsor needs. The LINGO-based software makes assignments using student votes and databases in which sponsor preferences are listed. More detail about the internal workings of the software can be found in Lopes et al (2008)[1].

Conclusions

The Engineering Design Program at the University of Arizona has grown substantially in the past 15 years. The model of interdisciplinary teams advised by professional mentors has been successful both academically and financially. The model may serve as an exemplar for other similar programs across the nation. Compared to other programs at peer institutions, the Arizona program is especially strong in organization and marketing and the number projects it manages but additional work is required to expand the space of its sponsors beyond its region and across the nation.

References

1. Lopes, L., Aronson, M., Carstensen, G., Smith, G. (2008). Optimization support for senior design project assignments. *Interfaces* 38(6):448-464. http://dx.doi.org/10.1287/inte.1080.0373.