

Professional Practice and the Engineering Curriculum

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Abstract

There are elements of professional practice common to the engineering profession in all engineering fields. However, many, if not most, engineering academic curricula allow little or no room for professional practice other than minimal capstone projects. In those that do, the approach is widely scattered. The purpose of this paper is three-fold: (1) To briefly describe a professional practice program (featuring sponsored senior design projects) as adopted by California State University, Los Angeles (CSULA); (2) To discuss difficulties encountered in establishing such programs nationwide; and (3) To highlight the benefits and other facets of the Strategic Corporate Alliance Initiative at CSULA. We believe that first and foremost, a professional practice program will provide students with the experience of working on interdisciplinary team-based projects. (Virtually all engineering graduates entering the professional workplace will work in interdisciplinary teams.) It is vital that the projects be real-world projects suggested and funded by an outside sponsor. Moreover, the team project experience should extend beyond a one or two semester capstone course. Paul Jones and his colleagues at Corporate & University Relations Group have implemented custom Strategic Corporate Alliance Initiatives at CSULA, Arizona State Polytechnic University, and U. C. Santa Cruz that feature adaptations of the Harvey Mudd (HMC) Clinic model. The goal of a professional practice program should be to prepare students for engineering practice in all its aspects: technical and social. Resistance to incorporating professional practice into an existing curriculum takes many forms. This includes a natural resistance to change and inadequate rewards to faculty for teaching and advising team-based projects, especially sponsored senior design (capstone) projects. For those institutions interested in a professional practice program, there are a number of other academic issues to be overcome. For example, there may be concerns about teaching credit for project advising, and course credit for students. Different departments at the same university can differ widely on these issues. Also, some departments will have a one-semester capstone course while for others it might be a one-year course. These complications may preclude carrying out sponsored interdisciplinary projects.

Senior Projects in the CSULA Professional Practice Curriculum

Howe and Wilbarger¹ in their 2005 National Survey of Capstone Courses report that 67% of respondents state that their average direct cost per project is from \$1 to \$1,000, while only 5% reported costs above \$5,000. At CSULA engineering student team budgets

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(supplies, hardware, software, travel etc.) typically exceed well over \$5000, which enables students to solve much more challenging open-ended problems.

The essence of the CSULA Professional Program is a series of sponsored student-team projects. We assert that students perform to their best ability and receive the most educational benefits when they are working with a real customer and are working to meet the needs of the customer. Here we describe the nature of these projects.

Scope of Work: To ensure that each senior design team is engaged in a project that is both challenging, and has a high likelihood of success, it is recommended that the sponsoring organization submit several project ideas to help ensure that a suitable project will result. The design problem should be a real open-ended problem and be important, but not on the critical path for the sponsor. It should be a problem that makes sense for a sponsor to outsource.

A team of four students is assigned to each project, and each student will work, on average, 10 hours per week on the project for the full September – June academic year. The total project effort will be roughly 1200 person hours (30 weeks).

Project Liaison: The liaison is most important. He/she represents the sponsor and ideally should be a stakeholder in the outcome of the project. He/she should be knowledgeable about the needs of the company with respect to the project requirements and often serves as the domain expert for the student team. Additionally, the liaison should understand that his/her organization is supporting students and must be aware of the educational needs of the students, as well as the needs of the company.

The liaison should be able to commit to a conference call with the team each week. He/she should plan to meet with the team multiple times during the academic year and should also plan to host the team for a company site visit early into the project. This is to help students become familiar with the context of their project and to help the team establish a customer relationship with their sponsor.

Program Timeline: The schedule for projects is constrained by the academic calendar. On Senior Project Launch Day all company sponsor liaisons are expected to come to campus and to meet with their respective teams. The purposes of this meeting are to build rapport with the team; to present the problem in greater detail, and to allow for clarification of the requirements and constraints on the solution; to agree to the schedule for the first term, including timing of weekly conference calls; and to provide background on the problem to bring the team up to speed.

The first “student deliverable” is a work statement for the project. This includes the scope of work for the project, and contains a clear statement of the project goal in the students’ words. This work statement should be completed about five weeks after the initial launch date. After review, the sponsor might modify the work statement. The purpose is to arrive at an agreed-on project goal. The remaining three project phases (conceptual design; preliminary/final design; prototype/test) flow from the work statement, and will vary from project to project.

A design review is typically scheduled sometime between December and January and is normally held at the sponsor’s site. The purpose is to agree on the conceptual design of the sponsored project. (Senior technical managers are encouraged to attend.) This is followed by all of the remaining project elements: finalizing the design, prototyping, testing, and data analysis.

The project culminates when all teams present their findings at a celebratory event at the end of the academic year. Students are then expected to deliver a final report, and if relevant, present their results at the sponsor site.

Difficulties in Establishing a Professional Practice Program

Resistance to incorporating professional practice into an existing curriculum takes many forms. There is a prevailing resistance to curriculum reform at all colleges and universities. Furthermore most universities are dominated by research, and may have little interest in a professional practice undergraduate program. For those institutions that are interested, there are still challenges remaining. A primary one is the attitude of the engineering faculty who will set the tone for the professional engineering program and, in the end, will determine its success or failure. The fact that advising student-team projects is a different form of teaching, but is no less important than conventional classroom teaching, is often not recognized.

Academic Issues: There are a number of academic issues involved in introducing professional practice to the engineering curriculum. The first concerns teaching credit for project advising. That is, what course equivalent is given for advising projects in the teaching schedule? At Harvey Mudd College advising two Clinic projects in a semester is deemed to be equivalent to teaching one course (of three) in a semester.

Project advising should be embedded in the teaching schedule, not an add-on. Proper credit should be awarded for this very important type of teaching. One or two people advising 40 projects in a capstone course leads to superficial results.

Ideally, the important task of project advising should be shared by all members of the teaching faculty; not be assigned to a committed few. The same faculty members who teach engineering science should also serve as project advisors. This is part of recognizing the importance of project learning (and professional practice) for faculty and students, as well as the administration. The use of clinical professors with industry experience will often compliment tenured faculty as professional practice instructors and project team advisers.

Another consideration is conflict of interest. Many faculty members may have active consulting practices. Advising of sponsored projects is a source of potential conflict. To some extent, this is a matter of personal integrity. At HMC this has not been a problem. Faculty members have found the two activities to be reinforcing. Many with consulting practices have brought in sponsored projects through their consulting. And consulting has improved faculty skills in managing projects, and interacting with students, as well as bringing real-world experience to campus.

The Strategic Corporate Alliance Initiative at CSULA

The Strategic Corporate Alliance is a partnership between CSULA and strategic corporate partners. CSULA was awarded the prestigious Excellence in Engineering Education Collaboration Award by the Corporate Member Council of the American Society of Engineering Educators at the February 2012 ASEE/CIEC Annual Conference. The Aerospace Corporation, The Boeing Company and Northrop Grumman Corporation were recognized as members of the ASEE Corporate Members Council as founding sponsors/partners of the CSULA College of Engineering, Computer Science, and Technology (ECST) Professional Practice Program.

Invitation to Industry: The College of Engineering, Computer Science, and Technology at California State University, Los Angeles (CSULA), invites your organization to become a member of the CSULA Strategic Corporate Alliance. The purpose of the Strategic Corporate Alliance is to create highly engaging and relevant corporate and university partnerships in order to jointly establish CSULA as a recognized world class provider of professional practice experiences for its engineering and computer science students. The program aims to enhance the recruitment, retention and graduation of high-potential students that are fully prepared to enter the professional workforce.

Description: CSULA is beginning the fifth year of the Strategic Corporate Alliance Initiative. Programs that have been developed and supported through the Strategic Alliance include an award-winning sponsored Professional Practices Program, a sponsored Corporate Scholars Program, and an Executive in Residence Program. Key

programs under development include an enhanced summer transition program for first-year students (STEP-LA), and a curriculum redesign committee that will continue to revise the curriculum to be more hands-on and industry focused.

Members of the Strategic Corporate Alliance Initiative are asked to donate between \$5,000 to \$25,000 to support and enhance current programs, as well as to help launch new and innovative programs that will help students succeed in the Engineering, Computer Science, and Technology professions upon graduation. Members will hold a seat on the Dean's Advisory Board and become a stakeholder in the development of such programs.

CSULA strives to be recognized as one of the leading universities for providing corporate partners/investors with their highest return on investment for sponsored projects, research, student programs, and recruiting. In addition to becoming a strategic alliance partner, one is invited to participate in one or more of the programs offered below by the CSULA College of Engineering, Computer Science, and Technology:

Undergraduate Professional Practice Program: As detailed earlier, the purpose of the Undergraduate Professional Practice Program is to provide students with a capstone experience, in which they apply their theoretical knowledge to real applications. The program exposes students to an industry setting, where students work with a real client (industry partner) to solve a client-defined problem. The result may be a physical prototype, software package, or operational algorithm. Regardless of project type, student teams are expected to meet the needs of their client, and deliver a product at the end of the academic year. Projects involve teams of four or five engineering/computer science, or technology students, and a faculty advisor working on a real customer problem for a full academic year (1200 hours per team minimum). Faculty and staff support the efforts of the student-led professional practice teams that solve the problems for the customer. The sponsor will have full use of the results.

The college launched the Professional Practice Program in 2008 with nine founding corporate partners: The Aerospace Corporation, The Boeing Company, DirecTV, Heateflex, Los Alamos National Laboratory, Northrop Grumman Electronic Systems, Northrop Grumman Integrated Systems, Pratt & Whitney Rocketdyne, and Southern California Edison. In its second and third year, the college welcomed new partners that include: EmCycle, Medtronic MiniMed, Naval Surface Warfare Center-Corona, Space Systems Loral, Southern California Gas Company, Raytheon, and the United Parcel Service (UPS).

Several elements make these projects like an actual work experience. First, the industrial partner specifies the open-ended problem. It is a real problem that needs to be solved.

Second, the team is self-managed by the students. Although there is a faculty advisor and a recognized student team leader, each student has a leadership role and the responsibility to make sure the team functions well. This simulates many work situations. Finally, the industrial liaison is the customer for the team.

The team must react to changing information as the year progresses. The skills of negotiating, project planning; presenting, adjusting to changing conditions, and writing reports, are all needed in the workplace, but often are not sufficiently taught to undergraduate engineers. The Professional Practice project is much more like an industrial experience than any other course situation. Students are exposed to the skills required to be a professional engineer.

The self-sustaining, exemplar Professional Practice Program has allowed the College of Engineering, Computer Science, and Technology at CSULA to join a small but elite group of colleges and universities such as Harvey Mudd and Olin that are recognized leaders in professional practice preparation of graduating engineers. Sponsors are asked to provide funding in the amount of \$25,000 per project and provide a stakeholder liaison to have weekly contacts with the team.

Corporate Scholars Program: The objective of the Corporate Scholars Program is to establish CSULA as the go-to university for recruiting, retaining, and graduating the highest-potential, industry-ready engineering and computer science students. In addition to a focus on women and underrepresented minority students, a distinguishing feature is the extensive involvement of corporations and student organizations in developing a world-class experiential program that compliments the Professional Practice Program described earlier.

As a result, a student council was formed, comprised of students from each Engineering, Computer Science, and Technology discipline. All sponsors are honored at a Corporate Scholars Day/Strategic Alliance meeting. A key element of this day is the one-on-one networking sponsors will have with their scholarship recipients and other scholars within the college. The ECST student council, along with its 23 student organizations, focuses on developing various activities and events in collaboration with their corporate partners. Each year, the ECST student council hosts Engineering Week, ECST Career Fair, and Career-Awareness Day.

Career-Awareness Day presents to minority students a wide array of career possibilities in the engineering, computer science, and technology fields. CSULA is the only minority-serving institution (MSI) in the Western United States, with an ABET accredited engineering program with Hispanics and African Americans constituting about 60% of the enrollment. With that said, we believe that this event and ongoing student activities with partner companies are necessary because role models in the technical fields are not readily accessible to the population of students that served.

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Corporate partners are asked to contribute a minimum of \$5,000 to a scholarship pool and \$2,000 for student organizations to offset the cost of organizing the aforementioned activities, and other student-related activities. Ongoing support of this program ensures that sponsors are engaged with student organizations on campus including SWE, SHESS, NSBE, Tau Beta Pi, etc.

Exceptional benefits begin accruing to corporate sponsors immediately. They have the opportunity to establish relationships with a very bright and motivated contingent of current engineering, computer science, and technology students. Active participation in the ongoing development of this exemplar program will increasingly assure that CSULA will provide an important cost-effective solution for each corporate partner/sponsor in achieving its recruiting goals.

Executives in Residence: The Executives in Residence Program integrates professional employees and retirees from corporations and government into the curriculum at CSULA. Executives in Residence may work full-time or part-time teaching classes, conducting research, and mentoring students. Executives in Residence also mentor graduate and undergraduate Professional Practice projects.

The knowledge executives have in their respective fields through their certification process and their industry experiences, is an invaluable asset to the college and the students. Their participation directly impacts the mission of the College of ECST: which is to provide students with a world class applied Engineering, Computer Science, and Technology experience.

Conclusions

The most meaningful facet of Professional Practice in the Engineering curriculum is the incorporation of outside-sponsored student team projects. We have described one such model for these projects, and some of the difficulties in establishing a professional practice program. In addition, we have outlined an example of a more comprehensive Strategic Corporate Alliance that will help strengthen overall corporate support and further enhance professional practice in the curriculum.

Reference

¹ Susannah Howe and Jessica Wilbarger, Smith College, “2005 National Survey of Engineering Capstone Design Courses”, 2006 ASEE Annual Conference and Exposition.

