

STARTING AN INDUSTRY-BASED CAPSTONE COURSE

Joseph T Emanuel, Bradley University

BS in Mathematics from the University of New Mexico and MS and PhD degrees in Engineering Psychology from The Ohio State University. Bradley faculty since 1967. Bradley's Putnam Award for Teaching Excellence, Mergen Award for Public Service, Academic Advisor of the Year, Fred Dace Award for Excellence in Teaching. Capstone course coordinator since 1975. Raised more than \$1.2 million in funded capstone projects.

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Abstract

For a department to starting an industry-based capstone design course requires a significant commitment of resources. This paper presents answers to many questions that need to be answered before making such a commitment. The guidelines presented, based on 40 years of industry-based capstone experience can help departments avoid some of the problems.

Introduction

Any department thinking about starting an industry-based capstone course has an almost endless list of questions. This is particularly true if the faculty member responsible for the capstone course is a young faculty member who has limited teaching experience and few industry contacts. The concerns that the faculty member needs to address fall into 3 major categories: obtaining projects, managing the course, and grading. The purpose of this paper is to assist the department that has made the decision to move into industry-based projects, but has no faculty members with experience in this area. A few guidelines that we have found to be valuable are

1. All projects should be on a “for-fee” basis.
2. The faculty should be responsible for finding projects.
3. The faculty should be responsible for forming teams.
4. The faculty is responsible for managing the problem solving process; the student team is responsible for completing the project.
5. Final grades in the course should be assigned individually.

The purpose of a community-based capstone design course is to (1) help the client solve a real problem and (2) to provide a good learning experience for the students. If the first is accomplished, then the second will also be accomplished. The approach should always be one of trying to find a solution for a problem as opposed to trying to find an application for a particular tool. The approach that more closely approximates real world working conditions forces the students to move from symptoms to problem to determining the appropriate tools or techniques to use for developing meaningful alternatives. Departments that opt to use a particular course such a simulation or facility layout are forcing students to find applications for specific tools, thereby limiting their problem solving experiences.

Meaningful projects are those that force the faculty to stretch along with the students. If the faculty member has a well-developed process to guide the students through the semester, then he/she should feel confident in taking on projects for which he does not know the answer at the start of the project. Part of the challenge and excitement for the faculty is to help the students find a solution to the problem and, in doing so, expand his/her own knowledge.

Never be afraid to challenge the students. We have found that student teams consistently provide more for the client than was expected and that the quality of work is at least comparable to that provided by professional consultants.

Obtaining Projects

What type of projects do we need?

The relevant projects will be dependent upon the curriculum. Projects for EE, ME, CE, IE, and MFE curricula will all be looking for different types of projects. At Bradley University, Mechanical Engineering (ME) and Industrial and Manufacturing Engineering and Technology (IMET) utilize the community as their major source of capstone projects. The projects that these departments are seeking differ primarily with respect to focus. ME is looking for projects that will allow the students to develop a product, whether it is a formula car or a shunt for hydrocephalic children, and IMET is looking for projects that emphasis process, such as a facility design and tooling to assemble an F-15 fighter plane. Although potential projects may not fall strictly into one of these two categories, most projects are either predominantly product or predominantly process design. Taking on projects that are out of your department's area of expertise may be interesting, but can also result in disappointing results.

Where can we find projects?

Industry doors tend to be easier to open if the approach is one of identifying ways that the university can help the company, rather than ways the company can help the university. Companies that are interested in hiring graduates usually are interested in identifying the other university resources that might be available to the company. Faculty consulting, undergraduate student cooperative education programs, summer internships, graduate student projects and capstone design projects are all resources that could be of interest to a regional industry.

At the capstone design level, locating projects should be the responsibility of the faculty, not the students. Some faculty awareness of the interests and abilities of the students in the project course can help direct the search for projects. For example, if some students have expressed interest in service industries, then hospital, police and fire departments, post office, the public school system and even doctors' private offices may be logical places to look. If students are more likely to be interested in working on a quality control, facility layout or a manufacturing processes project, then manufacturing facilities are likely to be more fruitful.

The critical factor in obtaining meaningful projects is good industry contacts. The problem is how to develop these contacts. The following are the logical places to look.

1. Companies that would like to hire your graduates

If a company is interested in hiring graduates of your program, then they have problems that your seniors can help them solve. The job of the capstone course coordinator is to talk with such companies and help them identify the type of problem that would be good for a capstone project. These contacts can be made while companies are on campus for job fairs or by the course coordinator visiting the company's site. Often, merely letting your placement office know that you would be interested in speaking with companies while they are on campus will result in the company taking the faculty member to lunch and/or asking for a tour of the department's facilities. Never turn down an opportunity to talk with companies who are visiting campus, even if they are not located close to campus.

2. Departmental Alumni

When looking for projects, the easiest place to start is with departmental alumni, who will understand the types of projects you are seeking and have an interest in the program. These contacts may be developed through telephone calls, personal visits, departmental newsletters, and job fairs. Large manufacturing companies that hire significant numbers of graduates of your program would be a logical starting point.

3. Departmental Advisory Councils

One function of a departmental advisory council is to provide assistance to the department. Asking the individual members to identify potential projects within their organization is one way of providing this assistance. The council member may have needs in their area and can open doors to other areas in their organization that would have potential projects.

4. Faculty members in other departments

One of the organizations that ME uses on a regular basis for projects is a large amusement park located in Florida. This company also has a large park in California that previously employed a member of Bradley's Communications department. This individual was able to use his contacts to open doors that have resulted in Bradley presently being the only undergraduate institution to do projects with this organization. In fact, the company annually has a list of potential projects that exceeds the number of student teams Bradley can provide.

5. Community contacts

People that you know through your work with service organizations, church, or your children's school may be employees of organizations that would be good clients. One project that was followed by three related projects resulted from a letter written to a pediatrician by a parent who was tired of spending time in the doctor's waiting room. The letter let the doctor know that he had a problem and that a team of Industrial Engineering students could help him solve the problem. This project was so successful that the doctor asked a subsequent team to work on another project. At the end of this project, his interaction with professional colleagues resulted in additional projects with them.

6. Current students

Undergraduate or graduate students who work part or full time often are aware of problems within their company that would be good projects. A faculty member's time and effort spent on a site visit with the company can result in a list of several problem areas that might be good design projects.

7. Past clients

This is at the bottom of the list for those departments that are starting community based capstone projects, but moves to the top of the list after the department has established a record of completing projects that provide a value to the client. Some semesters, the list of potential clients contacting us will accommodate all of our project teams.

The bottom line is that the community is full of potential projects; you just have to keep your eyes open and be aggressive to find them.

Pay for Projects

The final question in this section of the paper deals with the first guideline that stated. “All projects should be on a “for-fee” basis.” For some of you, this is the critical (and possibly only) question to be answered in this paper. Why is this important and how do you get clients to pay for projects?

Why is this important?

Both the quality of the problem and the quality of the solution is impacted by the fee paid. If the client is not paying, the project can easily become just a “student project” and moved to the bottom of the company’s priority list. If the client is paying, they want to do everything possible to get value for their money. A fee results in the problems being real issues that the company must address. The fee also encourages the client to make manpower and information resources available as they want to get something out of the project.

How to get clients to pay can be simply answered by stating that you have to do quality work: success breeds success. This will require that you establish a track record of providing value to the company. At Bradley, we performed community-based capstone projects for 6 years before we started asking companies for financial support. The first effort was one of trying to tie the fee to the quality (A, B, C) of the project result, but this was discarded after one semester. Clients stated that they could not determine the quality of the project until they had implemented the solution and evaluated the result. We decided to lower the fee to the B quality level and go with a set fee. Since then the fee has increased by a factor of 4, but is still a great bargain at \$6000 per project. The Dean’s Advisory Council has advised us that we should be charging \$10,000 per project, but we have been reluctant to move to that level as our primary goal is to provide good projects. The \$4000 increment may discourage some potential clients.

The best marketing approach is face-to-face interaction with potential clients. Showing clients examples of written reports from relevant past projects can allow any potential client to gain an understanding of the quality of the final product. If the technology is readably available, showing parts of some of the better presentations is also helpful. A list of past projects, particularly those that would be relevant for this client can help to sell the project for pay concept to a potential client. You also need to be prepared to give potential clients contact names from past projects if they want to make a call to get input from past clients.

Forming Teams and Assigning Projects

Community-based projects offer both the department and the students an opportunity to transition into the work world. In business, a project will be defined and then the team formed to work on it. This sequence is also correct for capstone projects that are community-based. If the team is formed first and then a project assigned to them, the team rarely has the background or the skills to solve the problem. When teams are formed after the project has been secured, efforts can be made to insure that the team will have any specialized skills that will be required. For one of our current projects, the company definitely wanted the team to develop a computer simulation of their production area. When putting the team together, the faculty made sure that at least some of the team members had performed well in the simulation course.

The best size for a team is three members, although some projects can be divided into two components and utilize four people effectively. Allowing students to pick their own projects is not practical as some teams will have more than four members and others will end up with one or two members. At the other extreme, if students are merely assigned to projects, then they are not likely to be excited about the project and may not be committed to the demanding semester-long process. We have developed the following as a compromise approach.

1. From each client, the course coordinator secures a 10-12 minute video that describes the project. Companies that have video production facilities may produce this video themselves. If the company does not have that capability, the course coordinator will videotape a short interview with the client contact and a tour of the facility. Each student in the capstone course views all of the project videos.
2. Each student expresses their project preference by ranking the projects from 1 to n. A student is allowed to have multiple first choices, but may not rank a single project as #1 and all others as #n. Students are also allowed to indicate 1 person they would prefer not to work with and up to three that they would prefer to have on their team.
3. A team of four faculty members who know the students through previous classroom experience assign the students to teams. An effort is made to assign students to their first or second choice while making sure that the team has at least one "leader" and still balancing the teams. The students' expressed preferences are considered, but the faculty does not feel bound by them. In situations where a student may be assigned with someone they did not want as a teammate, the faculty will try to also put someone on the team that was listed as a preferred teammate. In all cases, the intent is to try to form teams that give each team an equal chance of success.
4. Although the faculty expects certain people to emerge as leaders, no team member is designated as the leader. Our experience over the past 40 years has been that the person who becomes the leader is often not the person that the faculty thought would be the leader based on previous projects and classroom performance. Leaders will evolve and may even vary as the project moves through different phases.

Course Management

Each team generates a weekly progress report that goes to the faculty advisors, the industrial contacts, the technical writing instructor and the speech coach. The teams meet with the faculty on a bi-weekly basis to review progress and to discuss current issues confronting the team. Each meeting corresponds to a milestone activity: problem definition, problem analysis, development of alternatives (2 meetings), evaluation of alternatives and recommendations. The team brings a prepared agenda for the meeting together with any tables, charts, graphs or other visual information that will help the faculty understand what the team is trying to communicate. The team is required to put all of their information into Powerpoint. These meetings are scheduled for 1 hour per team. Generally, this is enough time to cover the major issues.

The role of the faculty is not to solve the problem, but rather to manage the problem solving process. As such, the faculty members are responsible for keeping the project on track, however the faculty often are not experts in the technical areas in which the team is working. Therefore,

a technical steering committee, consisting of appropriate members of the client organization, is established. These 3-5 person committees meet with the project team on a regular basis to review progress, provide requested information, and to provide technical expertise.

Course Grading

Although projects are team activities, individual grading is important to prevent the situation where the top student carries the team. If every member contributes equally, then all should receive the same grade. If all do not contribute equally, then the grading system needs to allow for the members of a team to receive different grades. We have developed a grading system that incorporates client, faculty, and team input. The grading system also includes multipliers that allow the faculty to compensate for clients that are more/less corporative, problems that are harder/easier to define, and problems that are harder/easier to solve. All of the details on course grading can be found in Emanuel and Worthington¹.

Additional Resources Needed

In order for students to be able to produce at a professional level, they need office space that goes beyond just a table in the lab. Also, to convince industry to pay for projects, you need to be able to show potential clients the quality of previous projects. The best way to do this is to show them reports from past projects. A well-written report, together with examples of visual material developed for the client presentation, can be good marketing material. Developing a well-written report and a professional quality presentation require some additional resources: a technical writing professional and a speech coach.

Facilities

The ideal arrangement is to give the capstone teams a dedicated office space. We have been able to convert two classrooms into professional quality office space for the teams. Each team has their own cubicle work space complete with two table top computers, one laptop computer, a telephone and a digital camera. In addition, the teams share 3 high speed color printers, a fax machine, a plotter and binding equipment. This professional atmosphere sends a clear message to the teams concerning the expected quality of their output.

Technical Writing

To insure that the reports that go to the client are well-written and complete, we have linked our capstone course with technical writing. All students in the capstone design course must register concurrently with the capstone course for the same section of Technical Writing. This section is designed for our students and all assignments relate to the project. Coverage includes project reports, literature review, content and format for the final proposal. The final report for the capstone design course is also the final proposal for Technical Writing.

Speech Coach

The total package for selling the final recommendations consists of a well written report that contains substantive material plus a professional quality oral presentation. The process that we have developed to help students improve their presentation skills is documented in Emanuel and Kerns². Each project team makes four practice presentations that are critiqued

extensively. The first three are made only to a speech coach and the course coordinator. The team brings black and white printed copies of their slides to each practice session for the speech coach and course coordinator to use for their written comments. Each team will go through their entire presentation and then receive feedback from the speech coach and course coordinator on their verbal skills and on the visual material presented on each slide. The fourth practice session is given to the campus community with all departmental faculty, other students, plus friends and family in attendance. This 20-22 minute presentation is followed by the team answering questions from the audience. The client presentation is usually made within the week following the campus presentation.

Summary

Although using the community as a base for a capstone design course may be as simple as contacting alumni and asking for projects, developing projects that result in a good learning experience for the students requires considerable time and effort. Taking advantage of the experiences of the author and following the guidelines covered in this paper will result in the client receiving value for their time and money and the graduating students being prepared to tackle the problems that their new employers are waiting to present to them.

Bibliography

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