Industry-Based Projects in Academia - What Works and What Doesn't

John Lamancusa, Allen Soyster, Robert George
Penn State/Northeastern University/DuPont

Abstract
In June of 1994, three universities and a national laboratory (Penn State, the University of Washington, the University of Puerto Rico-Mayaguez, Sandia Labs) formed a partnership, under the auspices of the Technology Reinvestment Program (TRP) of the Advanced Research Projects Agency (ARPA). This partnership focused on injecting a stronger manufacturing emphasis into the engineering curriculum, with a strong industry connection. Now after three years, each of the three universities have in place formal minors and options in design and manufacturing as well as new laboratories known as Learning Factories [1]. A cornerstone of this project has been the growing interest and support of local industry to participate in the development of these programs, particularly in the area of senior design projects. Currently, nearly 100 companies are supporting senior projects for students in these programs at the three universities. Such projects require major commitment of resources for planning and execution from both the universities and the companies. This paper describes some of the processes, some of the successes and some of the failures in this effort.
Acknowledgement: This project was funded by TRP Project #3018, NSF Award #DMI-9413880.

Our goal: students interacting with industry sponsors
as the result of senior design projects

I. Introduction

Our university graduates approximately 240 Mechanical and 150 Industrial Engineering B.S. degrees each year. Every ME student, and approximately one-third of the IE students take a "capstone design" class in their senior year. Each department has its own class for its own students. The IE class was a true industry projects class. This was run in an almost military fashion by a faculty member (since retired) with considerable industry experience who did not care about student teaching evaluations, but who knew what students really needed to learn. His favorite saying was: "an early stumble saves a later fall". The personal qualities and charisma of the instructor, including sheer determination, industry connections, extensive time commitment and constant supervision of the students all but guaranteed a successful outcome. For a number of reasons, including the retirement of this faculty member, the course can no longer be taught in this style.

In the Mechanical Engineering class, each instructor would concoct a common "open-ended design" project to meet ABET requirements. These projects were typically something the instructor was familiar with or already knew how to solve. Examples included football throwing machines and recycling machines to sort glass by color. There was no interaction with industry and students worked only with peers in their same department.

Beginning in the fall of 1995, our existing senior design classes were modified to utilize projects supplied by industry. Efforts were also begun to form interdisciplinary project teams of students from ME, IE and EE departments. This was part of a new initiative at Penn State, the University of Puerto Rico-Mayaguez, University of Washington and Sandia National Laboratories, called the Manufacturing Engineering Education Partnership (MEEP). The mission of MEEP is to integrate design, manufacturing and business realities into the engineering curriculum. The initiative was supported by a Technology Reinvestment Program grant from the Advanced Research Projects Agency (ARPA). The key elements in this program were: a new practice based curriculum in Product Realization; and the building of a new facility, the Learning Factory, to provide students with modern equipment for creating, designing, prototyping, producing and testing new products. The Learning Factory [1] is the laboratory used by all of our senior design projects courses.

A board of industry advisors was formed to provide strategic guidance and student projects for the senior design classes. In three semesters, 65 projects have been completed. Over 300 students have been involved from Mechanical, Industrial, Electrical, Aerospace, and Chemical Engineering departments.

In this paper, the reader will be provided with viewpoints on industry-based projects from three different perspectives: an industry person who supplies projects and wants to hire qualified engineers, a professor who teaches the course, and the department head who supervises the process.

II. Industry Perspective:

A. Overview

Why does industry want to participate in the education of today's engineers? There is not a manufacturer in the United States today that doesn't feel battered by competition and a changing marketplace. Unless you are a business producing 6% more with 3% less resources each year, you are not performing adequately to keep up with your competition or to satisfy your owners on Wall Street. To accomplish this in the manufacturing arena you must provide solutions faster, cheaper and of a higher quality than you did in the past. The life blood of U.S. manufacturing is the engineering talent that is emerging from our Universities. If these engineers are not ready to contribute better than earlier generations, then our companies will not be competitive and, in large part, have not been. Since 1980, the number of Fortune 500 employees in the state of Pennsylvania decreased by more than 50%. Some of those jobs went to smaller companies that had less overhead and could manufacture at a lower cost, but most of them were lost to global competition. This applies not only to blue collar jobs. One can hire an engineer in New Delhi with a masters degree, to design a product or write software, for $10,000 annual salary who is competitive with a U.S. counterpart with salary exceeding $35,000 per year.

A goal of the MEEP program is to create an alternative core curriculum in undergraduate engineering focused on manufacturing. The sponsor, ARPA, had an objective to strengthen the manufacturing skills of the engineering work force that will design and produce products in a "lean production" environment. This partnership of academia, industry and government has come together to address a basic survival issue for our quality of life in this country; a competitive defense manufacturing base and the creation of wealth through manufacturing. With some few exceptions (airplanes, drugs and software come to mind) we are second class citizens in producing everything from automobiles to televisions. The urgency of meeting this challenge stimulated much of the enthusiasm from the participants and contributed in no small way to the success of this program.

B. Industry-based Projects in Academe

Today's Engineer cannot be working on yesterday's problems with yesterday's tools. They have to understand how to work in cross functional teams, to be self starters and to see the business value of their work. They need to be solving real world problems that translate into real world business improvements. One of the major accomplishments of the MEEP partnership has been to institutionalize a process that brought industry projects into the classroom. Students are now able to apply their skills to the new problems of the marketplace and, at the same time, industry benefits from their work. A number of best practices were found as we developed the process to deliver projects that meet the needs of both industry and academia. Some of these are enumerated below:

1) Responsibility for Projects

New projects and project sponsors are constantly needed and a significant effort is required to achieve this. We believe that this is a joint industry and University leadership issue. The University must make the acquisition of projects a priority. Department heads are in a position to facilitate the process, but it is Industry's responsibility to understand what a good project is (from the University's standpoint) and how to get those projects into the system.

2) <u>Design Teams</u>
We want proactive teams that will keep pushing for what they want. Many student teams tend toward waiting to be told what to do and how to do it. More teams need to follow the example of one team of student chemical engineers who took charge of their project and convinced Allen Bradley to teach them how to program the controllers for their project. Both university and industry must maintain a level of urgency that requires the teams to meet aggressive milestones and goals.

3) <u>Liaison with Projects</u>
It is imperative that there is a point person from the University to lead the development of project proposals. Even when the same company is presenting a project, it is usually a different engineer who leads the engagement. They must be coached on their role and shown how to be both a supervisor and a resource to their student team.

4) <u>Rigor and Relevance</u>
The objective of both parties is to develop a project that has the relevance of the work place and the rigor of an academic challenge. Projects should use all the skills of the student and require concrete, measurable outcomes.

C. The Learning Factory (Laboratory Facilities for Projects)

As much as we like to espouse the virtual organization, it is healthy to have a dedicated space to focus the activities of the work. The Learning Factory is more than a lab. It is the intersection of industry and the classroom. Here is where technology is applied to the design of real world problems that will be translated into industry solutions for the marketplace. As with any robust design, the Learning Factory has the potential to provide value well beyond the students' project. By the Teach, Learn, Teach Principle, the developments that emerge from the Learning Factory floor provide world class engineering education which can be taken back to industry for development and commercialization. It is this win-win relationship that generates the energy for the partnership.

D. Rewards and Recognition

At the strategic and leadership level of the University, the Department Heads and Deans see the value of a program featuring industry-based projects and partnership. However, young faculty believe that this is not the way to get ahead in the promotion and tenure process. There is a high risk perceived for volunteering for industry projects. The traditional pathway to success for today's young faculty is through research and scholarly publications. Fewer and fewer faculty have any prior industry experience. Developing partnerships with industry takes time. A $1500 student design project can take just as much time and effort to procure and execute as a $50,000 NSF grant. The only potential reward in the traditional sense is if a student project can be expanded into a funded research project. These forces tend to push the faculty inward, focusing on the traditional duties that have long dominated the University. The change agents who are developing these new programs may not be recognized and rewarded by current university rewards systems.

E. Principles of the Partnership

There are a number of principles of partnership that industry finds useful in participating in this program. Our Industry Advisory Board attempts to make it easy for a company to participate, and painless for them to exit from the relationship. We work towards a win-win situation with projects, training, technology transfer and access to the best students and teachers. We keep the members up to date with good documentation of our communications. Finally, we encourage patience in the participating industries as we attempt to instill a greater sense of urgency within the University.

III. A Department Head's View

Projects from industry can be the most important and satisfying part of an undergraduate engineering student's academic career. Of the literally hundreds of such projects with which this department head has been involved, the students' evaluation of their importance in their education is an almost universal A+. The industry involvement makes a real difference: like the difference between practice and "playing in a real game." It is an opportunity to innovate and design. Most importantly, there is a "customer" and someone who really cares - the sponsor. In many cases, such projects provide a pathway from the classroom into a productive job.

This writer remembers his own undergraduate experiences with an "industry project" (several decades ago). The project involved the design of an inspection station for an automated line in the production of cigars. Soon after the Surgeon General declared that "cigarette smoking could be harmful to your health," sales of low cost cigars exploded. A local cigar company near my school was ramping-up their production and needed some new methods to ensure the appropriate quality level. My team was charged with "somehow" developing a 100% inspection process for cigars arriving on a high-speed conveyor. The first issue we confronted was determining what was a good cigar and what was not." We expected to see detailed specifications, pictures, examples, etc. To our chagrin, no such specifications existed. The specifications existed only in the minds of three or four inspectors who had worked there for years (ISO 9000 would not come for another 30 years). Moreover, these inspectors were not delighted with the idea of sharing their experience and knowledge with a bunch of "college boys". As one would surmise, our project experience involved learning about real-world things beyond just the inspection station. To be sure, we designed and prototyped a new workstation, but the involvement with the labor, management and plant floor protocols was an education in itself, one that was largely absent from our formal education.

This example is important because such an experience is so routine. All student teams, who have completed industrially-sponsored senior projects, testify to the dual benefit of completing a real project and learning about the people, systems and processes which surround their activities. This past semester, I remember asking a student at the completion of his project the following question: "What was the most surprising thing you learned?" He said, "It takes six weeks to order and receive a part! In fact, it took three times as long to do anything than I ever expected." This is a valuable lesson for any student.

If industrially-sponsored projects are so important and well-received by the engineering students, it must be that the majority of the 70 thousand B.S. engineering graduates per year in this country benefit from such an opportunity. Not so! Although there does not seem to be any national data on this issue, we estimate that far less than half the B.S. engineering graduates are so involved. Why is this so? We believe that there are three important impediments for including industry-sponsored projects as an integral part of an engineering curriculum. These impediments fall in three general categories:

1) Lack of enthusiasm/support from faculty;
2) Uncertain sources of present and future industry sponsors; and
3) A scarcity of space and facilities on campus to house the projects.

The relative importance of these three impediments clearly depends upon the nature of the institution itself. An institution heavily involved with research activities will find that lack of faculty support will be the most important impediment. A university located "in the middle of nowhere" may find generating nearby sponsors a difficult challenge. Even though projects are generated from industry, there must be lab space and technical support on campus to implement the projects. If there is insufficient laboratory space, it is difficult for students to develop appropriate models, mock-ups, software, tools and computer visualization. Most likely, all schools face some elements in all three of these categories.

At a school with high research expectations of its faculty, the most significant impediment is most likely the lack of enthusiasm among faculty for supervising such a course. The typical industry-sponsored senior design project course may have 25-30 students with six or eight projects. Such a course poses some significant challenges for both novice and experienced faculty. There is usually only a minimal amount of formal lecture. The majority of the faculty's time would be involved with one-on-one meetings with teams and team members. The faculty member will need to visit the individual plant sites and monitor the progress of each of his sponsored teams. The whole course, by its nature, is unstructured and the project outcomes are uncertain. Some of the projects may not work out as originally projected. There can be personality problems and lack of uniform commitment among the team members. This is very different from teaching Solid Mechanics or Thermodynamics. For an individual who has never managed nor had responsibility for the success of others in a workplace outside the classroom, the direction and management of student teams can be a real challenge.

What kind of engineering faculty member can actually be successful at this? Certainly, if a faculty member has had extensive industrial experience, a good deal of insight can be provided to the students as he/she reflects on their own experiences. Similarly, issues dealing with project and time management are most easily related by a faculty member who has had some personal experiences. But, in reality, these are operational details which can be overcome through training and experience. A bigger issue deals with motivation and rewards. How does the faculty perceive such an assignment helping his/her promotion or tenure or annual evaluation? For such courses to be successful in a research focused institution, it is absolutely necessary that the administration and senior faculty uniformly endorse the importance and necessity of these activities as part of the undergraduate program. Without such support, such a course will not likely be successful.

Where do projects come from semester after semester? Is the sourcing issue a faculty or administrative responsibility? What financial responsibilities rest with a sponsoring company for student travel, tools and/or materials? It has been our experience that the sourcing of projects should be led by the administration of the program (in contrast with the individual faculty). There are several reasons for this. If industrial projects are a required part of one's curriculum, then more than one faculty must be involved and course direction and oversight is shared among several faculty. Hence, the responsibility of an individual faculty is intermittent. But, contact and on-going relationships with sponsoring companies needs to be regular and routine. Potential projects need to be assessed and reviewed well before the beginning of the semester. In essence, the university needs to have one or more individuals who are assigned to the sponsoring company. A sponsoring company is both a "supplier and customer." As a supplier, the company assigns their own internal management team and finances all the out-of-pocket costs. They are also our customer. There is an expectation that the students will be giving a "best-effort" and that a real benefit may accrue to the sponsor, although no guarantee is or should ever be made. Inevitably, the faculty member who supervises the industry projects course develops some personal relationships with the company personnel. Such relationships are important for encouraging subsequent projects in future semesters. Nonetheless, our experience strongly suggests that the ultimate responsibility for project acquisition should rest with the college administration.

Interestingly, the most obvious need for a design projects course, i.e. space and facilities, we mention last. It is probably the least important issue for determining whether and how to proceed with an industry-based design course. The reason for this is simple. Every engineering college maintains some laboratories, technicians and support staff. The issue, then, is how such resources can be shared and made available for a stream of projects which can have very different requirements from one semester to another. In fact, our experience is that the quality of the technical support personnel is more important than the quality of the space/machines/etc. The students often lack basic experience in processes such as machining and joining. Here is an opportunity for students to receive hands-on instruction about such processes and learn (or learn to appreciate) the various skill sets required. The technical support person is the critical resource. Faculty often do not have the time (nor the skill) to assist students in their actual mock-ups and fabrications. A good technician is indispensable.

IV. Faculty Perspective:

A. Course Philosophy

The purpose of this course is to help students transition from their academic experiences to a successful career in industry. This course offers students the opportunity to apply the engineering fundamentals that they have worked so hard for the last 3½ years to learn. The thing they lack most is confidence, confidence that their basic training in subjects like Thermodynamics, Statics, Dynamics, Fluids, or Materials can be used to solve real problems that do not appear in the back of the book. These aspiring engineers also need to acquire other, non-technical, but extremely important skills. Schedules, deliverables, project management, team skills, deadlines, budgets, design reviews, marketing presentations, and making decisions on things which cannot be calculated by equations, are just some of the features that students never see in their other courses.

The role of the instructor, and the skills required for this class are different from the typical lecture-oriented class. Industry experience, particularly in a design or product development capacity is a definite asset. While the course does require some lectures, the chief role of the instructor is an unstructured one. The instructor primarily serves in many non-traditional roles:

- as a coach and consultant - to guide students in their project and point them in the right direction;
- as facilitator - to provide resources so they can get the job done; and
- as manager - to "crack the whip" at the right time to make sure that they are meeting their obligations to the sponsor.

B. Course Format and Operation:

On the first day of class, students are given a packet of one page descriptions for all the different projects which are being offered. Students are given a profile test to determine their preferred role in a team setting (Carlson Learning Product's "Innovate with C.A.R.E Profile"). Typically 20-30 industry projects are offered each semester. A luncheon is held during the first week for all the students and industry sponsors. The students get to meet their industry sponsors, ask questions about the project, and in the process learn a bit about networking, dressing professionally and which fork to use for their salad. The students bid on the projects on which they would like to work. The instructors from all the participating senior design classes (currently IE and ME departments) then meet to form project teams based on student preferences. Every attempt is made to satisfy the students' first or second choice, while also trying to avoid the embarrassment of telling a sponsor that "no one chose your project". Where needed, students are traded among the ME and IE courses to form interdisciplinary teams. Efforts are underway to include the Electrical Engineering department in the "draft".

The students are informed of their project teams assignment and report to their designated sections at the beginning of the second week. A typical section contains a maximum of 30 students. A teaching assistant is shared between two sections. For the remainder of the semester (15 total weeks long), the students are given a set of milestones and deliverables to fulfill. These milestones can vary depending on the actual project and the instructor's practices, but a typical set of milestones is shown in Table 1.

Table 1. Typical Course Milestones

Task	**Completed**
Team Formation	Week 2
Contact Sponsor	Week 2-3
Visit Sponsor	Week 3
Project Proposal to Sponsor	Week 6
Proposal Presentation at Sponsor	Week 7
Preliminary Poster Session	Week 9
Design Review at Sponsor	Week 10-12
Prototype Hardware	Week 12
Final Project Presentation	Week 15

Lectures are given approximately once per week during the first half of the semester on basic tools and skills which the students may need for their projects. Covered topics include: the design process, design for manufacture, project management (PERT, Gantt), optimization methods, decision tools (QFD, FMEA, Taguchi), communication skills, intellectual property and patents, and ethics. The lectures become less frequent during the latter half of the semester to allow students more time to work on their projects. A second course meeting each week is generally devoted to an individual staff meeting between each group, the instructor and the teaching assistant to review their progress. Each group is required to submit a brief weekly progress report to the instructor and by fax to their sponsor.

Students use the Learning Factory to design, manufacture and test their prototypes. Training courses are offered to teach basic manufacturing shop skills. These courses are voluntary (but highly encouraged). Current offerings include: Safety, Machining, Welding and CAD. The appropriate courses must be completed before students can use the equipment in the Learning Factory.

The semester culminates in a "Project Showcase". This consists of a lunch and project presentations in a trade show style format. Students, industry sponsors, faculty, parents and local news media attend and are treated to professional presentations and demonstrations. Graduate student projects as well as freshman design projects are also displayed. Freshman students are also invited to give them an idea of what they will be doing in a few years. Industry sponsors then fill out an evaluation of their project team, which helps to determine the overall grade.

C. The "Ideal" Project and Sponsor

A critical element in determining the success or failure of a project is the level of commitment of the industrial sponsor. The ideal project is driven by a real need, but is not in a corporation's critical path. No guarantee can be made that the students will solve the problem, but they will give it their best effort. The ideal sponsor is one who does not demand success, but is delighted when it happens. The ideal sponsor is located within a two hour drive and uses e-mail to expedite communications with the student group. He or she is willing to spend time with the students, provides tours of the plant, makes the students defend their work in a design review, reviews reports, provides technical information, serves as a mentor, and takes them out for pizza at the end of the semester.

The best sponsors take the attitude that they are helping to educate the students, by providing an experience that they know will be beneficial to the student's careers. Some sponsors provide projects as a way of obtaining engineering assistance, or to identify new talent to hire. Many of them are Penn State alumni who want to give something back to their alma mater. Some do it either because they had a similar course when they were students; or because they did not, and they wish they had. Whatever their reason, they are all appreciated. The bottom line is that the students get a wonderful educational experience.

D. Financial Management

Initially no fee was charged to the sponsoring companies, thinking that this would stimulate participation. However, it was found that if no money is involved, the effort is not taken seriously. If a company is not willing to pay a small fee, they will be less willing to provide the time of an engineer to oversee the effort. If a fee is involved, companies take a more active role, requiring regular progress reports, providing needed information or equipment, attending design review meetings, and in general, acting like customers who want something for their money. Currently, a $1500 project fee is requested. Of this money, half is a basic allowance, available to the students to pay for basic expenses associated with the project, such as project supplies, tools, presentation materials, travel expenses to visit their sponsor, etc. The remainder partially supports the operations of the Learning Factory, covering the cost of "expendable" items like aluminum bar stock, shop rags, first aid supplies, broken taps, and part-time help to supervise the facility and run training courses.

E. Things that Worked Well

A number of things which worked very well should be emphasized:

1. *Industry Projects* - Having students work on real problems is a tremendous improvement over the way we used to do things
2. *Interdisciplinary Teams* - Putting students from multiple departments together on the same team has many positive effects. It teaches students to respect and value the capabilities of other disciplines. In a homogeneous group, everyone has had the same classes and has the same basic skills. In mixed teams, students learn a lot from each other and bring different but complementary skills to bear on the problem at hand. Lastly, it is representative of the working environment they will face in industry.
3. *Competition* - Competition is a way of life in industry. When two or more student groups work on the same project, a natural competition results. The sponsor benefits from this competition. Each group will generally explore different avenues and design alternatives and the odds of success increase dramatically as a result.
4. *Communication* - Communication is the key to successfully obtaining and executing projects. A synopsis of each completed project is listed on our web site so that prospective sponsors can see the types of projects which are possible. A pamphlet containing project submission information (shown in the Appendix) has been extremely helpful in generating projects and answering routine questions. Sponsors will soon be able to submit their project descriptions electronically (using a form on our web site).

F. Problems Encountered

A number of difficulties and growing pains were encountered including:

1. *Obtaining a steady supply of industry sponsored projects* - This takes constant cultivation, and the dedication of a number of faculty to achieve. An information packet describing the attributes of a successful project was developed which is of great assistance. This information is included as an Appendix. Industry must provide financial support for the projects as well as making someone available who can give the students the guidance and mentoring they need.
2. *Physical Proximity* - Ideally, students should visit the sponsor many times during the semester. .It is far easier to execute a project when the sponsor is located within an easy driving distance.
3. *Communication* - Regular and meaningful communication between students and industry sponsors is critical. The use of fax, e-mail, the web, audio or video conferencing must be encouraged to minimize the need for face to face meetings. Projects fail chiefly because of lack of communication.

4. *Faculty Buy-In* - The new course structure requires considerable cooperation among faculty and acceptance of a more common course format than they are accustomed to. The idea of dealing closely with multiple industrial clients, of supervising students on projects for which the faculty may have no specific expertise, and dealing with issues like sponsors who never return phone calls and group members who don't pull their weight, can be disconcerting.
5. *Institutional Boundaries* - Trading students between different departments to form interdisciplinary teams requires some bureaucratic maneuvering such as scheduling courses at the same time, and allowing another department's capstone course to be an acceptable substitute. Students can also be frightened by the uncertainty of working with and being graded by people outside their department.
6. *Time Constraints*- A recurring feedback from industry sponsors is the one semester project duration. It is difficult to complete all aspects of a design project in 15 weeks. At the end of the semester, good things are just starting to happen, then it ends. While it is good for students to get used to demanding schedules and aggressive design cycles, a second semester would be helpful in translating these new designs to useful hardware on the factory floor. Keeping project teams together for two semesters would be a problem. Attention would also, have to be paid to managing the projects well so that the students did not procrastinate for the first semester, thinking they had plenty of time later. A longer project duration, and commensurately higher expectations of results would also enable us to ask for more substantial project fees.

References

[1] *The Learning Factory - A new approach to integrating design and manufacturing into engineering curricula*, J.S. Lamancusa, J.E. Jorgensen, J.L. Zayas-Castro, J. Ratner, 1995 ASEE Conference Proceedings, June 25-28. 1995, Anaheim, CA, pp 2262-2269.

Biographical Sketches of Authors:

The industry viewpoint of this paper is provided by **Mr. Robert George**. Mr. George directs the DuPont Benchmarking Centre in Wilmington Delaware and for the past three years has lead the Industry Advisory Board for the Penn State Manufacturing Engineering Partnership (MEEP). He is currently benchmarking the various manufacturing engineering education coalitions.

The faculty perspective is provided by **Dr. John S. Lamancusa**. He is a co-principal investigator for the MEEP project and the Director of the Learning Factory. Dr. Lamancusa is one of the brave few in the department who regularly teach the capstone course. He also coordinates the acquisition of industrial projects for all the sections.

Representing the administration view is **Dr. Allen L. Soyster**. Dr. Soyster, formerly the Head of Industrial and Manufacturing Engineering at Penn State is now Dean of Engineering at Northeastern University. He also has served as the Principal Investigator for the ARPA/TRP project titled *the Manufacturing Engineering Education Partnership*.

Appendix: Informational Packet on Sponsoring Senior Design Projects

Sponsoring A Successful Industry-Based Student Design Project

MOTIVATION

Industry based design projects provide students with the opportunity to apply their technical knowledge to an actual engineering problem. The experience helps the students begin to bridge the gap between their academic and professional careers by exposing them to the technical demands and professional expectations of practicing engineers.

BENEFITS TO INDUSTRY PARTICIPANTS

The collaboration on a project with Penn State students and faculty has several direct benefits to the industry sponsor:

1. Students can provide direct project engineering support.
2. Companies can examine the students' performance for future employment consideration.
3. Student teams may generate a variety of ideas with possible applicability beyond the project's scope.
4. More mature and better prepared engineering graduates.

PROJECT EXPECTATIONS AND DELIVERABLES

Each project will typically involve a team of 3-5 students over a 15 week semester. Considering that they will also be taking other courses at the same time, this equates to approximately 400 person hours of effort devoted to the project. Results from student teams are very dependent on the nature of the project, the innate team capabilities, the amount of industrial interaction, and many other variables. Often, a project results in a very direct benefit to the sponsor. Since project success depends on many factors, the sponsor should not expect that directly usable results will be in place at the end of the semester. However, student teams can often produce ideas and preliminary engineering designs worthy of further development. Deliverables to the industrial sponsor may take the form of the following:

1. Reports, Feasibility Studies, Design Analyses
2. Engineering Drawings
3. Prototype hardware
4. Computer programs and data
5. Presentations, videos and/or demonstrations

SPONSOR REQUIREMENTS

To develop a successful industry based student design project dictates that the sponsoring organization assign a motivated individual to oversee and interact with the students throughout the project duration. A minimum commitment of 1-2 hours/week as well as attendance at a luncheon on campus at the beginning and end of semester is required. The industrial monitor serves the following functions:

1. Provides a conduit for project specific information to students.
2. Facilitates the students' education about the sponsor's industry.
3. Meets with the students regularly (at the industrial site, at University Park or via telecommunication).
4. Reviews several reports to provide feedback from the industry point of view (i.e., project proposal, regular progress reports, design analysis, final report)
5. Provides a project evaluation which is used to determine the students' final grade

PROJECT ATTRIBUTES

Projects are typically assigned in the senior year in the student's capstone design course. The projects need to have a strong design component with well defined and clear objectives. For example, the redesign or modification of an existing item or process usually works well. This provides the students with an initial starting point and allows them to remain focused. The required project work must be sufficiently short term such that it may be handled within one semester (15 weeks). Special arrangements can be made for projects of longer duration. Interdisciplinary projects are encouraged since they allow student project teams to be formed with different engineering majors (i.e., multiple person teams may be formed with combinations of mechanical, aerospace, industrial, chemical and electrical engineers).

PROJECT SUBMISSION

Careful consideration and early collaboration between the sponsor and Penn State faculty are crucial to the development and execution of a successful student project. A project submission form is attached. This form should be completed and submitted two weeks before the start of the semester. Students select their project from all the available industry projects, therefore, there is no guarantee that a given project will be chosen.

PROJECT MANAGEMENT

Penn State faculty from the various disciplines represented on a project team will supervise and be responsible for the overall project operation. The industrial monitors serve as consultants to the project team. Typically, two teams will be assigned to work on each project. This encourages competition between teams and greatly enhances the odds that at least one of the teams will achieve a breakthrough result.

FINANCIAL COMMITMENT

The project initiation fee is $1500 per student team (typically 3-5 members). This fee will serve as an "allowance" for the group and is intended to cover basic project expenses such as phone calls, faxes, copy charges, presentation materials, car travel to sponsor location, supplies and construction materials. A portion of this fee is also used to cover the operating costs of the Learning Factory. Should additional resources or equipment be needed to complete the project, students are expected to justify them by written proposal to the sponsor.

INTELLECTUAL PROPERTY ISSUES

The students and university personnel will abide by any proprietary wishes of the company including signing a nondisclosure agreement. All issues related to the ownership of any patent or intellectual property are negotiable.

PROJECT MILESTONES

A typical schedule for a 15 week semester project is shown below. Note that this may change due to specific project requirements.

Task	Completion
Project Presentation and Selection	Week 1
Team Formation	Week 2
Contact Sponsor	Week 2-3
Visit Sponsor	Week 3
Project Proposal to Sponsor	Week 6
Proposal Presentation at Sponsor	Week 7
Design Review	Week 10-12
Prototype Completion	Week 12
Final Project Presentation at Penn State -	Week 15

Senior Project Request Form Date: ____________

Project Title: ____

Sponsoring Company:_________________________________

Technical Contact: ____
Address ____
____
Phone____________Fax___________________ E-mail________________
(Contact person provides information, meets with students, reviews progress reports, arranges plant visits, and assists in overall project grading.)

Overview and Motivation:

Objectives and Deliverables:

Estimated Team Size and Composition: (typically 3-5 persons per group, can mix IE/ME/EE/ChemE students)

Reporting Requirements: (weekly or bi-weekly, one-page fax or E-mail reports are recommended)

Budget: $1500 project fee per group is requested. Students are given a working budget of $500. The remainder covers overhead expenses of the Learning Factory (supplies, teaching assistant wages, etc). Additional funds may be required for specialized equipment or other unique project expenses.

How many groups will you support: (we suggest two)

Proprietary Information and Confidentiality Requirements: