# International Student Teams Solving Real Problems for Industry in Senior Capstone Projects

**Sanger,** P. A.
Professor/Director
Purdue University
West Lafayette, IN, USA

Conference Topic: Industry Involvement in EE, The Global Engineer

## INTRODUCTION

Most undergraduate students do not have the opportunity to travel abroad and experience and develop communication skills with others cultures. However in this global world, today's engineer is likely to have to work in global international teams with colleagues from other nationalities. The challenge for many engineering curricula is how to include, in a realistic way, this global dimension.

It is widely acknowledged that senior capstone projects are one of the effective avenues to synthesize an engineer's education. Accreditation bodies including ABET (Accreditation Board for Engineering and Technology) require such an experience in the curriculum. In the School of Engineering Technology, a very successful program of industry funded, senior capstone team projects has initiated and is expanding. In 2013-2014 teams of mechanical engineering technology and electrical and computer engineering technology students are addressing 12 projects on a broad range of topics. Some representative and typical projects that can be accomplished are listed in [1]. It is desirable that next year, when participation in one of these projects becomes a graduation requirement, this program will involve 150 students in 40 projects and continue to grow. This paper describes an expansion of this program to include an international dimension to senior capstone projects that would be open across all of the College of Technology (CoT) and other colleges. As is described below, these projects are primarily sponsored by industry and are fee generating thereby in principle sustainable.

In the Purdue University engineering technology program an international capstone project is being created and introduced in the coming year. This international capstone project builds on the existing, industry sponsored, multi-disciplinary capstone team project that is required of all students. In the international project, half of the team members are students from a non-US university. The full team works on a project proposed by companies with a global footprint in both the U.S. and in proximity to the foreign institution. Most of the global project is carried out using the full range of electronic communication tools such as email, skype, and blogs. In addition two exchange trips are made with team members traveling to their opposite foreign location. Ideally the first trip occurs near the initiation of the project for planning, organizing and conceptualization. One of the challenges is the synchronization of the two curricula and the academic schedules of the two institutions.

## 1.0 SCHOOL OF ENGINEERING TECHNOLOGY INDUSTRY SPONSORED, MULTIDISCIPLINARY SENIOR CAPSTONE TEAM PROJECTS

Senior capstone projects offer an outstanding and unique opportunity to demonstrate the learning outcomes of CoT programs. Upon successful completion of this course, students will have demonstrated the following learning outcomes.

- an ability to function effectively on teams
- an ability to perform successful project planning;
- an ability to integrate concepts from prior coursework in their curriculum;
- an ability to take a project from requirements to final proof of concept;
- an ability to apply creativity in the design of systems, components, or processes;
- an ability to communicate effectively, orally and in written form;
- an appreciation of lifelong and self-directed learning.

In the event that the student becomes a member of an international project, then the tools and skills required in today's multi-national, global environment are experienced in a real world international

setting. The goal is to enhance our students learning experience with real world projects that prepare them to quickly enter the workforce. These projects emulate the real world not only by the subject of the project but by the way the project is conducted.

## 1.1 Type of Projects

In order to satisfy the educational goals of the course, it is desirable that the projects have the following characteristics:

- Be open ended requiring evaluation of multiple solutions
- Be complex and challenging requiring innovation, out of the box thinking,
- Be on subjects just beyond the student's present courses requiring self-directed learning
- Have sufficient scope that would require a team approach
- Be multi-disciplinary—requiring students from more than one discipline for successful completion.

The needs of the project will drive the type of skills and talents needed to be successful. For the College of Technology (CoT), all degree disciplines in CoT are possible resources for projects while students from other areas of Purdue will be invited as needed. These non-CoT disciplines include engineering industrial design and business particularly marketing. For the international capstone project, additional expansion into history, languages, psychology and many of the social sciences naturally fit in and are important for the success of the project. It is important to reiterate here that the project defines the resources needed to be successful and the scope of project can be defined to be as inclusive as meaningful and manageable.

## 1.2 Approach to Project Execution

The execution of this two semester project follows a standard project flow with the project divided up into stages with formal reviews and deliverables required at the end of each phase. The phases are 1) proposal, 2) conceptual design, 3) preliminary design by the end of the first semester, 4) critical design, 5) fabrication and 6) test wrapping up the project in the second semester [1]. Systems engineering and project management tools, such as Gantt charts, schedules, requirement definition and analysis, quantitative analysis of alternatives, failure modes and effects analysis, will be used to carry out and structure the evolution of the project. The product from research is new knowledge and it has been shown that the above process works very well [2].

## 1.3 Involvement of Industry

One of the distinctive elements of this project approach is that industry is required to engage the education process that creates a highly productive engineer. It is desirable that all projects be sponsored by a company or enterprise. Active participation of an industry mentor to assist in the guidance of the project is essential. Participation in a project requires an unrestricted project fee of $6,000 plus reimbursement for unusual travel costs and the providing of project specific materials and outside processing.

Preferred projects are those that are valuable to the company but fall into the "nice to have" category as opposed to projects that are on a critical path defining success for the company. Additionally it is desirable that execution of the project NOT require significant amounts of sensitive or proprietary information and that patents are not likely to be created due to the difficulty of maintaining contact with the students. It should be noted that, in most of the existing programs, the students are expected to pay for any materials needed to complete their project. As a result the scope of their projects must be severely constrained in scope and execution. The support from industry eliminates this cost to the student which contributes to keeping a Purdue education affordable and results in very realistic project execution in scale and complexity.

## 1.4 Scope of the Implementation

When in full implementation, industry sponsored, multidisciplinary student projects can reasonably be sustainable by the fee structure required for participation and could be expanded to all disciplines in the College of Technology. It is envisioned that the structure to be implemented would ALLOW students from all disciplines to participate and get credit toward their degree as appropriate for their program.

One of the biggest obstacles to expansion of the program is in the area of facilities and access to facilities. The hours during which the existing facilities are available will need to be expanded to include evenings until 9pm and 8-12 hours on weekends all the while maintaining a safe and secure environment. Supervision could be provided by graduate students supported by the program. Signup for weekend access could be required. 4-5 graduate students with excellent hands on skills would be needed to cover access availability.

The effective communication of these teams with their mentors and customers is critical. Presently students are not allowed to book conference room with conference phones for weekly meetings and reviews. This policy needs to be reviewed and expanded. Full access with the approval of the mentor or instructor should be allowed.

## 1.5 Personnel

Mentoring teams and overseeing construction activities demand considerable time and a different kind of teaching styles. Some of our faculty members have demonstrated an ability in this new style. However many others are deficient in this area. Mentoring the volume of projects for a CoT wide deployment, which may number in the hundreds, will exceed available time from willing faculty. To supplement faculty resources, the hiring of experienced practicing engineers perhaps from the retired ranks to do only project team mentoring is being pursued. This approach to mentoring resources has been successfully implemented at the University of Arizona [3]. In that case an ample pool of retirees makes this approach possible. Actual experience in managing projects of the senior capstone type and a personal style that lends itself to team mentoring is essential.

# 2.0 INTERNATIONALIZATION OF SENIOR CAPSTONE PROJECTS

More and more companies are engaging in collaborations and projects involving multi-national participants. It is a surprise to many students that many companies with well-known names are foreign owned. Even companies who are U.S. owned are engaging in extensive collaborative efforts with foreign companies. These collaborations are being driven by the global nature of today's economy and all projections indicate that this trend will grow and continue into the foreseeable future. Companies want engineers that are comfortable in these multinational settings and capable of the highest performance with excellent communication and teaming skills in their broadest interpretation.

## 2.1 The Problem of Global Awareness for CoT students

While ABET requirements have recognized the need for these soft skills mentioned above, global awareness and comfort with diverse cultures is often simply talked about and is rarely experienced in real life. Most engineering students have never experienced another culture other than their own. Most US students do not have the resources or the self-confidence to go abroad during their university years. In fact many of our students have not been out of their own state. It is the exception to find engineering students with a useful facility with a language other than English. The goal of this proposal is to create a sustainable global team experience with an opportunity to create an awareness of the issues, challenges and excitement of collaborating on an international scale and fulfilling the shoes of a global engineer [4].

## 2.2 Foundation to Build On

The direction of this portion of the proposal is to take the multidisciplinary senior capstone team projects international and create a model that provides authentic real world international projects that can be replicated. Multidisciplinary student teams would be formed from seniors/final year students from at least two institutions from different nations. The problems would be defined by global companies with footprints in the countries of the institutions. Teams would have faculty mentors from each university and from the company at all locations. The project language must be English. Most of the project would be executed at a distance using internet tools such as skype, blogs, and email. Even communicating using these tools can be challenging when dealing with different cultures. The overall plan includes at least two trips in opposite direction by the teams accompanied by their mentors. These trips would be approximately one week long including both weekends. Most of the week would involve intense project work. Ideally the first of these trips would occur early in the project and would allow for solution conceptualization and for the forming of work assignment and responsibilities. The second trip could be the integration phase of the final deliverables. Each of the trips would also have a cultural element—activities that are typical of the host culture. For instance, in

the U.S. it could include a football game and visit to local tourist attractions or activities such as skiing, hiking, museums etc. depending on the location. To increase the development of solid relationships, it is envisioned that the students of the host teams will be responsible for the logistics and have the visitors live with the host students instead of hotels or with faculty. This latter feature may not work for all cultures and would be arranged appropriately if implemented. The feature reduces the cost to the sponsoring company but most importantly gives the visitors an authentic real cultural experience and improves the building of personal relationships across cultures.

One of the departures from the present senior capstone project program will be in formation of the teams. Presently the Team Builder function of CATME has been found to be very useful especially the customizable criteria recently added [5]. n the present program, the companies are not included in nor have a voice in the selection of team members. In the Global projects, it is envisioned that students will be asked, early in the spring semester, to apply for inclusion in the global projects including an explanation of their interest and why their talents are appropriate to the project. Finalists will be asked to participate in an interview which could include the sponsor if they so desire. Prior to the end of the spring semester, teams would have been formed and communications established that could be carried on during the summer as desired.

One of the challenges of this proposal is the integration of this project with the curriculum for all institutions involved in the team. For practical reasons, starting with only two institutions in a global team is deemed a starting point but not necessarily a hard limitation. Curriculum integration is a challenge and requires willing partners and some flexibility in both timing and learning outcomes for the projects to be undertaken.

One of the exciting aspects of the internationalization of senior projects is the inclusion of other disciplines into the curriculum. During the lecture portions of the courses, broadening activities on the languages, history, business practices and culture of the partner nations are included. During the two visits recreational events and cultural activities will be planned to take advantage of the visit to enhance the experience.

The key to success of this international expansion is industry resources who are specifically trained in transitioning personnel from the US abroad. In addition discussions are underway with companies to provide mentors from the opposite culture for the teams. For example a U.S. ex-patriot in Germany would mentor the German students and a German ex-patriot located in the U.S. would mentor the U.S. team providing first hand mentoring in the real issues of global companies and capitalizing on their expertise.

## 2.3 Status of the International Capstone Projects

Many universities in Europe have indicated that this type of collaboration would fit well with their programs. Initial industry feedback indicates a committed interest to fund projects. The first international project is being launched in the fall of 2014 under the sponsorship of Lenze Corporation, a German firm located in Hanover, Germany with a broad product line in automation and motor controls includes power electronics, gear drives, HMI and motors. The partnering university is the University of Hanover. Students from the mechanical and electrical engineering program will be teaming up with students from mechanical, electrical and computer engineering technology program from the School of Engineering Technology in the Purdue College of Technology. The target of this team is full integration of the power electronics and motor into one compact package. The team will address thermal, electrical, mechanical, vibration and communications issues in a full integrated team approach. One challenge in this type of program is fitting two university schedules together to find appropriate times for travel. In this case the Germany team will travel to the US in early October as their fall period is just beginning which corresponds to the fall break in the states. The US students will travel in the last two weeks in May in what is called a Maymester for the culmination of the project will allowing the project to secure special study abroad funds further reducing the requirements for industry funding.

# 3.0 ASSESSMENT OF GLOBAL COMPETENCIES

Assessing learning outcomes and modification of views regarding diversity and communication are an important part of this initiative. A shortened form of the Miville-Guzman Universality Diversity Scale (MGUDS-S) has been recently shown to be an effective protocol in assessing global competency of

students [6][7]. The MGUDS-S protocol will be used to establish a baseline of attitudes using the full senior capstone class of 120 students. This baseline will be compared to the attitudes of the international team members pre and post. Understandably the statistics in the latter survey will be limiting since the team has only 7 students. However this launch of an international team is just the beginning to be followed in later years with more teams and more nationalities. Setting the protocol for gathering good data for the fully expanded program is the goal.

## 4.0 CONCLUSION

The International capstone project approach builds on a firm foundation of industry sponsored projects at Purdue University. The first trial international project is being launched and will provide realistic global context for a unique educational experience for both U.S. and German students.

## REFERENCES

[1] Sanger, P. A., (2011), Integrating Project Management, Product Design with Industry Sponsored Projects provides Stimulating Senior Capstone Experiences, *International Journal on Engineering Pedagogy*, Vol 1, No 2 (2011).

[2] Yang, B., Sanger, P., and Gardner, P. (2010), Teaching and Learning of Project Management for Engineering and Technology Capstone Research Projects, 2010 ASEE Annual Conference, Louisville, KY, paper 3232.

[3] Private communication, Ara Arabyan, director of the Engineering Clinic, University of Arizona, Tuscon, Arizona, USA.

[4] Jesiek, B., Woo, S.E., and Zhu, Q., (2013), Defining and Assessing Global Engineering Competency: Technical Coordination , Ethics and Engineering Cultures, Proc. Of the Colloquium on International Engineering Education, Lexington, KY (2013)

[5] Layton, R., Loughry, M., and Ohland, M., (2014), Using CATME to Assign Students to Capstone Teams, Proc. of the 2014 Capstone Design Conference, Columbus, OH (2014).

[6] DeTurris, D., Lehr, J., Widmann, J., Laiho, L., Depiero, F., Wood, Z., and Snelling, A., (2014), Comparative Assessment of Scaled Global Engineering Initiatives, Proc. of the 2014 ASEE International Forum, Indianapolis, IN (2014).

[7] Jesiek, B. K., Shen, Y., and Haller, Y., (2012), Cross-Cultural Competence: A Comparative Assessment of Engineering Students*, International Journal of Engineering Education*, Vol 28(1), pp. 144-155.