the problem of highly qualified reviewing is substantial. Reviewers are chosen by a lot from the database of specialists. The possibility that the particular reviewer is more demanding that the others, or even that he has some relation to the rivalrous company, and therefore he gives a bad rating to a project, is not negligible. And as the success rate is low, one "unfriendly" review means usually that the project has no chance to be accepted and financed.

In addition, some Czech ministries have their own programmes supporting applied research and development (e.g., the Ministry of Industry and Trade, the Ministry of Culture, the Ministry of Environment). Come collaboration can also be covered by programmes financed from European funds, but the majority of state support of applied research, development and innovation goes through the TA CR. For the better picture, the TA CR budget in 2015 was nearly 3 milliard CZK (about 110 million EUR), and 1 125 904 700 CZK, i.e., more than one third of this budget, was transferred in grants to universities.

5. Conclusion

In the modern world of sophisticated technologies, technical universities with ambitious engineering programmes should play an increasing role. However, the young generation is interested more in soft sciences. The extensive production of "managers for everything" has become a significant characteristic even at some faculties and universities specialising in economics and management, and the labour market sometimes has difficulties in absorbing them. Advanced engineering education needs to arouse more interest of graduates from high schools. Increased research collaboration with industry, leading also to creating more highly qualified and well paid jobs, can help the technical universities to convince potential customers, i.e., young graduates from high schools, about attractiveness and usefulness of engineering.

However, the key importance of academic world is that it is an important factor moving industrial technologies and quality of life forward. It is needless to say, that as the secondary effect it also helps to improve both practical competences of universities and their budget, and contributes to their equipment with modern instrumentation, software and methods.

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The Vital Collaboration of Industry and Academia for the Creation of Interdisciplinary Real World Student Projects

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The global economy in which engineers live is in constant change and evolution. The requirements for engineers today includes not only solid technical knowledge but also require they know how to apply that knowledge to real world problems. For these reasons, engineering education must reach beyond the academic world and draw in industry. The real world experiences that engineering students must have to be effective come from industry and not the more research oriented university environment. This paper reviews what avenues are available to enrich and grow the university/industry relationship and in particular, this paper describes an approach successfully implemented in the U.S. of industry sponsored and driven, final year, interdisciplinary, year long, capstone projects.

Key words: interdisciplinary approach, engineering education, university/industry relationship.

Industry Involvement in Education: There are several avenues for industry and universities to build strong relationships with each other:

1. Industry commercialization of university created technology and intellectual property.
2. Joint research either sponsored by industry or by external organizations such governmental agencies.
3. Participation of industry experts in university curricula as instructors and guest lecturers.
4. Support for updating of laboratories and university resources.
5. Challenging internships for students within the entreprise.
6. Creating projects for students through the curriculum that support the learning process.

In these last two categories, the incorporation of real world projects and experience coming from industry into technical engineering curricula provides a unique and invaluable enhancement to the educational experience. Specifically the inclusion of projects into the curricula supports the pedagogical philosophy of Project Based Learning (PBL). PBL is one of the modern technologies that universities in many parts of the world are adopting to develop engineering graduates capable of being the practical, application oriented, problem solving engineers needed in industry. This pedagogical approach is well established and has been reviewed extensively [1, 2, 3].

PBL is being implemented in a variety of different ways depending on the curriculum and the surrounding economic climate. Essential characteristic of projects within PBL are that the projects are central, not peripheral to the course, they are focused on a driving question, they require transforming acquired knowledge, they are largely student controlled, and finally are real world problems [1]. One of the very successful approaches has been the tackling of projects that have a value to local industry. Industry sponsorship brings industry into the educational process in a vital and important participative way: the projects are real world problems, the mentors from industry are experienced practitioners of engineering and the funding from these projects supports the infrastructure at the university essential for successful projects.

Projects within a PBL program may enter the curriculum at many points but the following three approaches are common: 1) demonstration type competitive projects usually not industry based but created for pedagogical goals to teach and exercise project skills, 2) focused single discipline projects within a specific course and 3) interdisciplinary final year or senior year capstone projects on complex open-ended problems for industry.

The third type of project is discussed in the following sections and demonstrate the vital role that industry should play with their academic colleagues in preparing engineers for the complexity of the real global world.

Industry Driven Inter-disciplinary Final Year Projects: One of the strongest examples of industry projects being both economic engines for regional growth and stimulating experiences for students is the interdisciplinary senior (or final year) capstone project. In many institutions this project brings together and synthesizes the engineering student's entire education by applying it to a complex real world problem. The capstone project, which occurs in the Purdue School of Engineering Technology (SoET) program in the senior and typical fourth year, combines project management, new product development, and interdisciplinary student teams. The project's purpose is to produce engineering graduates who are open to new ideas, comfortable in an environment with diverse disciplines and can mature promising ideas into actual business propositions. Interaction with local industry creates a renewing flow of real projects sponsored by regional industry to create interdisciplinary project for the teams to select and engage with the region.

Common characteristics of a senior capstone project are:

- **Open ended** meaning that the sponsor must not have established an approach and simply needs students to implement it. One of the goals of the project is have the students define the requirements and scope and then deal with ambiguity and the uncertainty coming from having to explore options, select an option based on the best knowledge available at the time and execute the project. This is first course in which no one knows what the correct answer is--- not the professor, not the mentors and themselves. It is up to them to sort these issues out.
- **Complex and Multidisciplinary** requiring team execution and effect interaction across disciplines. In the past the final year projects were individual thesis/projects. However the global world rarely results in an engineer working in isolation and thus an interdisciplinary team experience is an essential part of the project.
- Unfamiliar element requiring the student to act as **self-directed learner.** Just because a particular type of software or technology or sensor was not covered in one of their classes doesn't mean that the student should be able to research the subject, call and talk to experts in the subject including the vendor and use the new element competently.

Capstone projects should allow the students to integrate and synthesize as much of their education as possible. Student teams should tackle real problems in a realistic setting. Commonly accepted project management tools are taught and expected to be applied in the execution of the project. These tools include scope of work, requirement matrices, quantitative down-selection procedures, brainstorming and triage, failure modes and effects analysis, and test planning. The concept of a schedule evolving out of a work plan based on a work breakdown structure and the interdependence of task defined in a gantt chart is developed and applied to their projects. Standard project review processes are imposed moving the projects through six stages and gates: project proposal, conceptual design, preliminary design, critical design review, fabrication and test spanning a full academic year. At each of these gates, presentations are made, a report is written, and the contribution of each member of the team is assessed using a peer to peer evaluation tool. Each team is supported by the course instructor, a faculty mentor and an industry mentor as a minimum remembering that the project is owned, directed, organized and executed by the students. The mentors' role is to guide, not direct. Occasionally intervention by the mentor is needed to correct the trajectory of the project [5].

Pivotal Role of the Industry Sponsor: The first and most important responsibility of the sponsor is to provide project ideas that are valuable to the company while tolerating a certain degree of incompletion. At Purdue University the sponsors are asked to pay a fee for each project. While this fee plays an important role in paying for the infrastructure that allows projects to be successful, a secondary and just as important role that the fee plays is to ensure that the project submitted by the sponsor does indeed have value to them. From the author experience, simply asking for fee of any size drives the generation of projects that are valuable. Frankly speaking, the students and the mentors do not have time to waste on projects that the sponsor does not care about.

With the fee in mind, however, it is important to make clear to the sponsor that perfect results must not be expected. This is a learning exercise. The students are running the project. They must be allowed to make mistakes and recover from the mistakes. Thus the final result may vary and fall short of a finished product or process. These projects are, in fact, the students' projects and, in order to enhance the learning experience, errors are inevitable. Nevertheless the project has a fixed and unyielding termination date, that is, the student's graduation. Extensions are not possible no matter how poor the result. At the end of the semester the project is over and the results are what they are. The university must play the crucial role of managing sponsors expectations, for the students sake as well as for the sponsors sake. Some sponsors are unable to accept that situation and thus are not appropriate participants in this program. Having said all this, it should always be expected that competent technical progress and exploration of potential solutions are made and documented by the students.

Appropriate Project Identification: Given these constraints, what kinds of industry project make good projects? Most real companies have more problems on their development project list than they have resources, skills and talents to pursue. No progress is being made on these often decades old problems and some of the topics, with this lower priority are important and thus can make excellent and challenging senior projects. In order to avoid bureaucratic and something unresolvable issues, projects are deliberately chosen to avoid the need for divulging sensitive company information to the team as well as projects that are intentionally directed as creating new intellectual property and patents. For those projects, the company and the university can engage in contracts and joint research separate from this capstone program as mentioned earlier in this paper.

Some companies have found it very useful to use senior capstone projects as a means of exploring high payoff approaches that would normally be deemed too risky to pursue in a normal company project. Since a senior capstone project is by design not on the company's critical path, these high risk approaches can be explored paving the way for later pursuit by the company if reasonable approaches are revealed during the project.

Several companies have also found a powerful role for senior capstone projects within their personnel development programs. Most industry professional development is focused on project direction and project management. Very little training effort is aimed at developing mentoring skills in the employee. Mentoring is distinctly different from directing. And yet one of the very important roles of a good manager is the mentoring of his subordinates and surrounding colleagues. Playing the role of mentor on a senior capstone project offers promising management candidates an opportunity to develop mentoring skills in a non-threatening activity.

Types of projects that have been undertaken are shown in tab. 1.

As can be seen, the topics range from novel inspection techniques, design and testing of alternative energy technologies, building of manufacturing automation equipment,

In summary, participation in the senior capstone projects offers the following:

- Students experience real world engineering conditions.
- Companies get progress on neglected but important projects.
- Companies and students have an opportunity to evaluate each other as potential new employees.
- Companies get an opportunity to create application, industry ready engineers that meet their needs.

International Cross Cultural Projects: Even though these projects are very challenging, these projects do not give the students the opportunity to understand the complexity of working with people from a different culture, i.e. performing in the global community.

To fill this additional need, the SoET program created an international capstone experience [5]. For the international capstone project, the resources and course content is expanded to include history, languages, psychology and many of the social sciences that naturally fit in and are important for the success of the project.

This international capstone project builds on the existing, industry sponsored, inter-disciplinary capstone team project program but differs in several ways. 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. 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 are approximately ten days long including both weekends. Most of the week involves intense project work. Ideally the first of these trips occurs early in the project and allows for solution conceptualization and for the forming of work assignment and responsibilities. The second trip is usually the integration phase of the final deliverables. Each of the trips has a cultural element – activities that are typical of the host culture. For instance, in the U.S. it has included 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, the students of the host teams are responsible for the logistics and housing of the visiting team. Visiting team members live with the host students instead of hotels or with faculty. This latter feature does not work for all cultures. However, where this hosting feature has been used, the feature is highly popular with the students, 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. In fig. 1 and 2, two of the project completed in 2014-2015 are shown.

In fig. 3, the locations where international project have taken place are highlighted as well as locations presently under development in Australia, South America, and Europe.

Response from Students and Sponsors: The response from industry sponsors is highly positive with over 60% return rate. In some cases, problems that have been in the plants for 30 years finally

Table 1. Final Year Capstone Project completed in 2015-2016 at the Purdue Polytechnic Institute

Sponsor	Topic
General Motors	High speed vision system for chain inspection
Subaru	Solution for Vehicle Transfer Errors
GE Aviation	Automated Poly-Film Remover
GE Aviation	High Accuracy CMC Nozzle Micro-Positioning Fixture
GE Aviation	Portable Wireless marking reader
GE Aviation	Automated EDM Electrode Loader for Turbine Blade Fabrication
GE Aviation	Inspecting Aircraft Engines for Hardware Placement Accuracy
First Build	Gesture control for Venthood with LED lighting
First Build	ADA Compliant Technology Ideas for Appliances
Power Sys	Demonstration of Off-Grid Power System for Parking Lot Lighting
Kimball International	Re-design Tablet table and charging system
Caterpillar	Leak Detection of Diesel Engines
Caterpillar	Assuring Proper Installation of Oil Cooler and Water Manifold
John Deere	Develop an Animated Power Outage Map
John Deere	Develop a camera system to support a kitting station using the Baxter robot
Internafl Idea	Water Flow Controller using the Perfect Gas Law to Control Heating System
Molex	Commercial IR Camera System to Monitor Crop Conditions
Biowall	Automated Plant Health/Water Assessment
Eaton (Forging)	Automated Chute for Hot Part Positioning and Measurement
Eaton (Clutch Assembly)	Line Set Improvement
Eaton (Clutch Assembly)	Large and Small Clutch Spin Box Controls, Data Acquisition and Reporting
Eaton (Hoses and Fittings)	Modification to a Skiving Machine
Eaton (Hoses and Fittings)	Tag Wrapping Machine
Fiat Chrysler Automobiles	Asset Control Utilizing Rfid Tracking Technology
International Projects	
UTEC	House Utilities-lighting and heat for Remote Andean Village
Northrop Grumman UTEC	Access to Internet for Remote Andean Village
GUT/Flextroncs	Automated Inspection of PCB and RF electronics assemblies
GUT	Solar Boat Competition in Amsterdam
Stryker / Netherlands	New Approach to Patient Handling
Lenze Corp	Thermal Management and Health Monitoring of Accuator Drives

Fig. 1. The goal of the Lenze project was to design, build and test a motor system that fit a cylindrical form factor: the original system on the left and the reconfigured system on the right

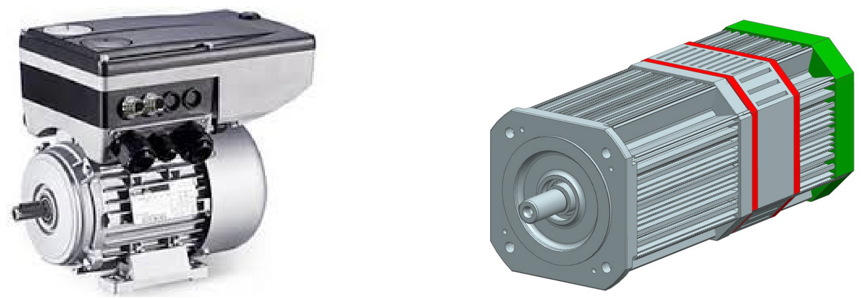


Fig. 2. Clutch Rivet inspection performed using Image Analysis for Eaton Corp

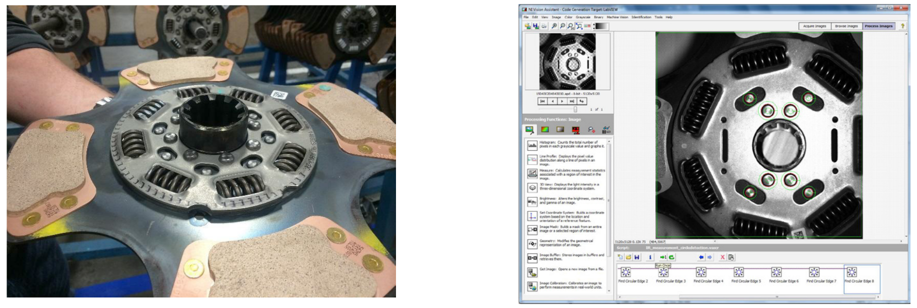
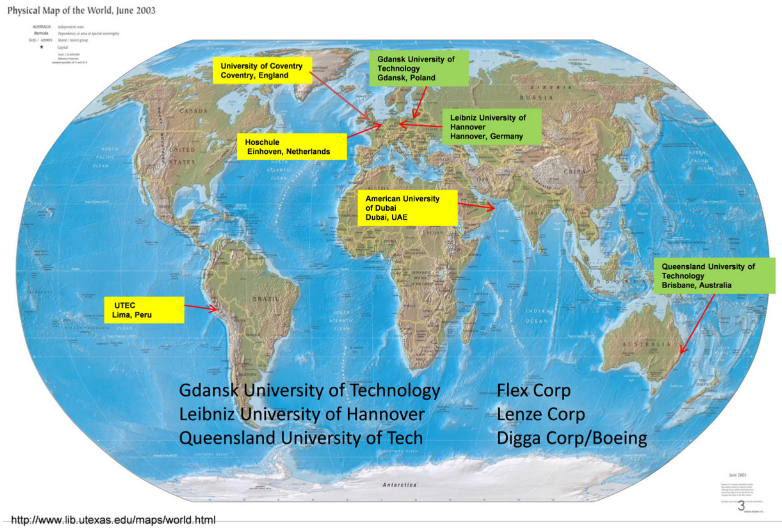


Fig. 3. Location around the world where final year international capstone project have or are taking place. (map taken from www.lib.utexas.edu/mnps/world.html)



got solutions. The feedback from students is highly variable with excellent ratings to poor ratings. After further interviews, the poor ratings stem primarily from the fact that these projects demand a lot of work, more work than the typical course where homework and test results are the measure of success. Furthermore having to work with and depend on team members to perform is a frustration for some students particularly the students who have excelled in the normal course structure and could operate by themselves. The following occurrence is also observed. Students returning back to campus after a few years of experience on the job comment that they did not like the course at the time but, in retrospect, was the best course they had to prepare them for the reality of the workplace. "You were right" is often begrudgingly given.

Conclusion: Industry plays a vital role in producing the type of engineer who performs well in the real world, solving real problems. Projects and internships provided by industry form part of the complete picture needed for this training. International projects add the complexity of different cultures into the challenging dynamics of team projects.

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