# DEVELOPMENT OF TECHNOLOGIES AND INNOVATIONS IN A MODERN UNIVERSITY: INTERNATIONAL MULTI-DISCIPLINARY STUDENT TEAMS SOLVING REAL PROBLEMS FOR INDUSTRY[1]

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***Abstract.*** *The industry/business community is demanding graduates who can perform in a real world environment. Industry-derived student projects provide a unique learning opportunity that makes the student's technical knowledge relevant to real problems. International projects where students must work with students from different cultures add the many issues of culture and communication that real global team must face. This paper describes a proven model for incorporating these projects into a university curriculum and merits being at the core of University 3.0.*

***Keywords:*** *international projects, project based learning, engagement, industry/academia collaboration, curriculum transformation*

***Cite as:*** Sanger, Ph. A. (2017). Development of Technologies and Innovations in a Modern University: International Multi-Disciplinary Student Teams Solving Real Problems for Industry. *Vysshee obrazovanie v Rossii* =Higher Education in Russia. No. 11 (217), pp. 49-53.

## Background

The world is constantly changing. In many universities worldwide, the approach to engineering education has been slow to follow. It is no longer sufficient to provide graduates with technical knowledge. The graduates must be able to apply that knowledge and become pro-active problem solvers. Problems in the real world are messy as opposed to the clean, sanitized problems and cases provided in normal university courses. The day is gone when an engineer worked alone on a problem. In today's world, professionals must work in teams, across cultures, across disciplines and with the broad spectrum of human personalities. Instead of looking at this situation as a barrier, today's professional must find ways and approaches to capitalize on this diversity. In order to be successful, today's professional must be an effective communicator, be adept at life-long learning, and be aware of the global context. The demands of this global world require a dramatic transformation in the approach to pedagogy and, in particular, engineering pedagogy.

In response to this demand for pedagogical transformation, the Purdue Polytechnic Institute (PPI) at Purdue University, West Lafayette, Indiana launched a broadly based initiative to transform its approach to engineering education in 2015. This initiative is based on ten elements of transformation:

- Theory based applied learning
- Team project based learning
- Active learning teaching methods
- Integrated in-context curriculum
- Integrated humanities studies
- Competency Credentialing
- Two semester senior (final year) projects
- Industry internships
- Global/cultural immersions
- Faculty/staff to student mentorship.

[1] Presented at the Round Table entitled "Human Resources for Oil, Gas, and Chemical Enterprises: Engineering Pedagogy Development Issues" held at Kazan National Research Technological University, Kazan, Russian Federation on September 7, 2017.

*For the transformation to be successful, a transformation of this scale faces many challenges not least of which is the traditional faculty members themselves. For example, many faculty members have never actually practiced* their profession in the real world having moved from advanced degrees immediately into faculty academic positions. As a result, a transformation like the PPI initiative must overcome the natural inertia of human nature but also address the fears of faculty in moving into the unknown. Each one of the above elements warrants major amplification which is beyond the scope of this paper. The present paper describes only one element: the two semester senior, or final year, capstone project.

### Industry Derived Final year (Capstone) projects

Within the PPI School of Engineering Technology, the concept of project based learning (PBL) is the dominant pedagogical approach. Consistent with this approach, all graduating students must complete a two semester, industry sponsored, senior capstone project in their final year. Capstone projects should allow the students to integrate as much of their disciplinary education as possible. Student teams tackle open-ended real problems in a realistic setting. These problems are actual problems derived from and sponsored by industry. In addition to the course instructor, each team is provided a faculty mentor and an industry mentor to help guide the project. It is important to remember that these projects are the responsibility of the students. The mentors are only guides and coaches and do not direct the project. This condition requires that the choice of projects be appropriate to this variability in results. To satisfy the academic goals of the course, projects must have the following characteristics [1]:

Be open ended requiring evaluation of multiple solutions,

Be complex and challenging requiring innovation, out of the box thinking,

Be on subjects just beyond their present courses, requiring self-directed learning,

*Have sufficient scope that would req* team approach, and

*Be multi-disciplinary — requiring stude from more than one discipline for successf completion. All degree disciplines in the PPI are possible resources for project. These disciplines* include mechanical technology, electrical and computer engineering technology, computer graphics and visualization, computer and information technology, aviation, aeronautical, manufacturing, industrial, and operations and quality assurance to list only a few. Disciplines from other colleges of Purdue University are invited including business and agriculture as examples.

### Sources of Projects

Most companies have more projects on their development list than they have resources to pursue. Some of the topics, with lower priority but still valuable and important, make excellent and challenging capstone projects. Regional industry partners and supporter of the program are invited to examine their development needs and nominate topics that would stimulate the students' learning while providing the company assistance in completing valuable work. Note that these projects are primarily learning experiences and final results are variable and often fall short of full completion.

An American football analogy seems to work here: students delight in taking the ball deep in their own goal line and advance the ball up the field. Touchdowns are not promised but advancement and progress on the problem in a professional manner is. In any case, knowledge about an issue or problem that is important to the company is matured and explored instead of sitting on the shelf while waiting for resources. The team will provide a project document containing the results of two semesters of work which is made available to the sponsor. This document shall include a requirements matrix, conceptual designs considered, a down selection, design documents as appropriate to the discipline, budget, a proof of concept for the project, a test plan and test results.

Of course, the primary motivation for the company is realize work on a problem. However, another benefit is identifying, evaluating and attracting new potential employee to the company. Additionally the company has an opportunity to enhance the education of and formation of the innovative and highly trained workforce needed for vibrant, local economic growth.

**International Capstone Projects**

Most undergraduate students do not have the opportunity to travel abroad and develop skills working 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.

In the PPI, an international version of the capstone project has been created and implemented [2; 3]. This international capstone project builds on the existing, industry sponsored, multi-disciplinary capstone team approach described above. 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. The working language is, by necessity, English. One of the most important aspects of these projects is that there are not two teams working in parallel. There is one team and there exists an interdependency of tasks: they must figure out how to work together to be successful. 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, conceptualization and relationship building. During these trips, the visiting students live with their hosting teammates with total immersion into the local culture.

Many universities in Europe have indicated that this type of collaboration fits well with their programs. The first international project was 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 was the University of Hanover. Since then, ten additional international projects have been completed in Peru, Germany, Denmark, Poland and the Netherlands.

For most of the Purdue students, these projects are their first experience outside the U.S., much less having to work with students from another culture. To help the students navigate this new experience, the class contains extra readings and discussions largely taken from "Where Cultures Collide" which describes many of the areas where culture differences appear and compiles these differences for over 50 countries [4; 5].

### Experience at KNRTU on Project Based Learning

In the fall of 2016, the author spent extended time at Kazan National Research Technological University in Kazan, Tatarstan as a result of an Algarysh grant to introduce and demonstrate project based learning to faculty of the Institute of Additional Professional Education. PBL training and lectures were given to over 50 undergraduate and master students along with faculty from the institute. A full description of the effort is given in [6]. The students also engaged in team projects on self-determined topics. The length of the projects was only six weeks but the expectation was the scope of work defined by the team would be completed. For most of the students, this team project was the first team project that they had experienced. Note that a team project is different than collaborative learning which some of the students had experienced. In additional to traditional project management tools such as Gantt charts and scheduling, several class exercises focused on team dynamics and interpersonal issues such as motivation and leadership. At the end of the projects, the students were required to make a presentation and demonstrate the results of the project to the class and faculty. Overall, the results of the projects were impressive and the student feedback was very favorable [6]. In a related trial outside of the author's direct program, it was found that the training given to students in project management and interpersonal skill had a positive impact on their success and favorable feeling toward the experience [7].

Several faculty members expressed the feeling that Tatarstan industry would not interested in getting involved in this type of student learning experience. In order to explore industry interest, the author approached several companies during the traditional Tatarstan Oil, Gas and Chemical Forum, the largest international event of the Russian oil and gas industry, which opened at the Kazanskaya Yarmarka exhibition center on September 6, 2017. With little difficult, the author was able to identify several companies who would be interested in having students work on projects that the company envisioned to be valuable but were not being pursued due to lack of present resources. While this experiment is limited, the favorable result suggests that this mechanism could be interesting to Tatarstan companies and offers an another pathway for KNRTU to actively engage with the community and be an active part of the economic energy of the region.

### Considerations

As a result of these trials, the author feels that final year, industry derived, multi-disciplinary projects are not only feasible at KNRTU but would enhance the pedagogical approach and the presence of the university in the economic growth of the region. KNRTU students appear to thrive in the team experience if given adequate training and mentorship. While broad implementation of PBL may be too big of a transformational leap for KNRTU at this time, industry and community driven projects could be a vibrant element of the University 3.0 initiative.

### 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(2).
2. Sanger, P.A. (2014) International student teams solving real problems for industry in senior

capstone projects. 2014 SEFI Conference, Birmingham, England.
3. Sanger, P.A. (2015) Filling Cultural Awareness Gaps in International Senior Capstone Projects. 2015 Annual Conference of the Australiasian Society of Engineering Education, Melbourne, Australia.
4. Lewis, R.D. (1996), *When Cultures Collide: Managing Successfully Across Cultures*. Nicholas Brealey Publishing, London.
5. Sanger, P.A., Nguyen, P., Kropiwnicki, J., Mishchenko, E.S. (2015). Cross Cultural Diversity in Engineering Students in America and Europe. 2015 Annual SEFI Conference, Orleans, France.
6. Sanger, P.A., Pavlova, I.V., Shageeva, F.T., Khatsrinova, O.Y., Ivanov, V.G. (2017). Introducing Project Based Learning into Traditional Russian Engineering Education. 2017 International Society of Engineering Pedagogy Annual Conference, Budapest, Hungary.
7. Khasanova, G.F., Sanger, P.A. (2017). Collaborative Project-based Learning in Training of Engineering Students. 2017 International Society of Engineering Pedagogy Annual Conference, Budapest, Hungary.

*The paper was submitted 23.09.17.*
*Accepted for publication 16.10.17.*

## МЕЖДУНАРОДНЫЕ МЕЖДИСЦИПЛИНАРНЫЕ КОМАНДЫ СТУДЕНТОВ В СОВРЕМЕННОМ УНИВЕРСИТЕТЕ: РЕШЕНИЕ РЕАЛЬНЫХ ПРОБЛЕМ ПРОМЫШЛЕННОГО СЕКТОРА

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***Аннотация.*** Секторы промышленности и бизнеса нуждаются в выпускниках, которые смогут эффективно работать на современном производстве. Проекты, которые реализуют студенты по запросу промышленных предприятий, предоставляют уникальную возможность получить технические знания и практический опыт в решении реальных проблем. Международные проекты, где студенты работают с представителями различных культур, дополняют общеобразовательный процесс культурными и коммуникативными задачами, с которыми сталкивается команда в ходе совместной деятельности. В статье описывается апробированная в Университете Пердью модель, позволяющая включать подобные проекты в учебные планы и которую заслуженно можно рассматривать как ключевую для Университета 3.0.

***Ключевые слова:*** международные проекты, проектное обучение, включенность в проект, взаимодействие промышленности и университета, трансформация учебного плана

***Для цитирования:*** Sanger Ph.A. Development of technologies and innovations in a modern university: international multi-disciplinary student teams solving real problems for industry // Высшее образование в России. 2017. № 11 (217). С. 49-53.