

Mechanical Engineering Students Project-Based Learning in OUAS

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Abstract

Oulu University of Applied Sciences (OUAS) is in the Northern Finland, in the city of Oulu. It has c.a. 9500 students and 500 staff members. The School of Engineering and Natural Resources has c.a. 2400 students, and c.a. 150 staff members, which makes it largest of the Schools of the OUAS. This paper introduces project-based learning approach which is used in the School of Engineering and Natural Resources, Mechanical Engineering department to get local companies to offer project works to mechanical engineering students. The concept is based on organizing a local event or online event for the companies to come to OUAS campus to present their challenges needing engineering students to solve. The companies are then competing, selling or pitching, their problem for engineering students as the engineering students will then individually select the most interesting cases to be solved, and which has linkage to potential summer job and thesis work opportunities if projects are successful. The proposed project topics vary from factory level to single mechanical device building, and industry areas range from high tech industry to healthcare to wood industry, as the application potential of mechanical engineering is wide. The concept has proven to be successful, and it has been established as traditional event with many companies returning to the pitching event annually to get their industry problems solved by group of engineering students.

Keywords: Project-based Learning; Industry Collaboration; Active Learning; Engineering Education; Project based Learning; Project Approaches.

1 Introduction

In Finland, Universities of Applied Sciences (UAS) offer Bachelor of Engineering Education and the curriculums of the engineering degrees are designed to serve the needs of the private and public companies, organizations, and the society. Especially, the engineering degrees are designed from working life perspective to offer as good fit as possible for new engineers to have such a set of skills which are currently needed in the companies. The Oulu University of Applied Sciences (OUAS) mechanical engineering special focus is given to networking and communication skills, as these skills are essential in the current working life. The engineers work is in many cases project based, and these projects are multidisciplinary. The mechanical engineering degree program aims to bridge the transition from studies to industry so that there is easy and fast transition from school to working life.

Learning does not happen, and projects are not completed without feasible target setting. For some motivating target is to just finalize the tasks at hand, but for many, the essential factor for motivation is to acquire skills which have direct linkage to employment after completion of the education (Kekkonen & Juntunen 2019). That gives especially for Universities of Applied Sciences special role to ensure the fit of engineering education curriculum to the needs of the working life. Additionally, engineering education faces many demands as the working life also changes rapidly (Kropsu-Vehkaperä et al. 2013). Project based learning offers flexibility for curriculum design.

Universities of Applied Sciences and the industry have many collaboration programs. For example, the European Union (EU) funded research, development and innovation (RDI) projects offers a great platform for impactful development projects, in which the UAS can develop their activities and laboratories and can via these programs support the deployment of new technologies to companies. Also, the UAS can then offer new engineers with skills on new technology to industry.

1.1 OUAS RDI Program started systematic project-based collaboration with SMEs

One example of successful EU funded program was the OUAS mechanical engineering program called "TEHOJA", which was executed together with the companies during 2016–2020. The program started 2016 with the aim of helping local companies to take into use new automation technologies, which could bring the companies competitive advantages on cost, delivery schedules and product quality. The program focused on finding suitable application environments to collaborative robotics, called 'Cobots', in the local small and medium sized (SME) companies. These 'Cobot' application were piloted during the program in the actual companies. Program main targets was to expand local SMEs knowledge of the collaboration robotics and their application to enhance production, and to train companies' personnel to apply these new collaboration robotics technologies. (Broström, Kaivosoja & Kekkonen, 2019).

Before start of the program the collaboration with local SME's and OUAS mechanical engineering education program was not systematic and one of the issues which needed to be solved was the engagement of the local SME's to start collaboration with OUAS. To resolve this need for systematic and wide collaboration the Mechanical Engineering Pitching Event (MEPE) was established, This MEPE event brings annually local SME's and 3rd year mechanical engineering students together. In this MEPE event the local SMEs are pitching their challenges for the students. Companies are competing to get best students to work on their challenges, so they need to "sell" their challenges to students via pitching type of event, which is known for start-up companies as they sell their business idea to investors. Students will then select their project work topic for the spring semester based on the SME's presentations. This will also give companies participating to MEPE event, a possibility to also get summer trainees for the following summer or thesis workers, as the project work team members will be known by the company, and the students team will know also the companies' processes, products and development opportunities making it easier and faster for the company to employ the students for value adding work in the company.

2 Mechanical Engineering Studies and the Pitching Event (MEPE)

Right from the start Mechanical Engineering studies are aiming to teach students how to master product design and project management activities. First year students are learning basic courses on mathematics and physics but also additionally they have for first year semester course called 'Innovative Product Development'. In this course, the students are leaning the product development process phases, and finally they are designing and building their own product which they have invented. At the end of the course, there is product exhibitions. Some new products have been patented and the licensed, based on their novelty and innovativeness.

During second year of studies the mechanical engineering students are deepening their knowledge on theory and professional understanding on mechanical engineering, these studies will be completed during the third year of studies. Additionally, students have gained practical experience from summer jobs between the semesters. Now the needed basic understanding to take more demanding assignments from the industry (Kekkonen & Juntunen, 2018).

The Mechanical Engineering Pitching Event (MEPE) is organized annually the beginning of Autumn semester, when the new season has just started. The preparatory work has been already started in the spring semester to ensure companies participation to MEPE. In many instances, the closing meeting of the previous projects are best occasions to recruit companies to continue to work with OUAS via MEPE. When companies experience the value of the MEPE it is easier to convince them to continue also in the following year. Naturally also new companies, especially micro companies or SMEs are welcomed to the MEPE, and these companies are search actively to grow the MEPE participant numbers.

At first the companies might experience difficulties in defining their project topics as development resources are scarce especially in small companies (Isoherranen and Ratnayake, 2018). To help companies to define their development project topics the education staff from the School of Engineering and Natural Resources visits the company on site to understand better the company operations and business. Then they can support companies to define their development project topics, which companies are then presenting in the MEPE event. The MEPE event can be virtual event or local event in the OUAS campus. After the pitching, in the following

day students can select the most interesting project topics. The selection is then approved by the education staff via specific interview to ensure the fit and skills of the students for the specific defined project. It is essential the previous studies are completed before entering the project-based learning in actual real-life case company, to ensure that needed background knowledge is enabling successful project completion.

Once the project work has been selected, the students start planning their project planning together with the teachers, and then proceed to kick-off meeting with the companies. After kick-off meeting the actual project plan is made and all the parties need to approve the project plan before start of the project. The project work starts then in the company beginning of the spring semester and is finalized by the end of May. During the spring semester the project execution is followed rigorously to ensure successful development project for company and excellent learning experience for the student.

3 Examples of student projects

1.2 Case 1, Plastic bottle clamp

Head Recycle Systems (HRS) is developing innovative plastic recycling equipment's in Oulu area . This company has participated in 2019 to MEPE for the second time, encouraged by the good experiences of the previous year. They came to event to look for enthusiastic mechanical engineers for a product development project. The project topic focused on development of a new type of mechanical plastic recycling equipment. This project was executed by four mechanical engineering students focused on machine automation and machine building.

The project team was largely given free hands to innovate and develop. Students team was only given certain boundaries to work with but there was plenty of room for creativity and "out of the box" thinking. With the help of this freedom, a new way to construct device, was invented and developed during the project, which will be utilized in the future development of machinery and equipment for HRS client.

The result of the project was a fully functional device that met the client's requirements (see Figures 1 and 2), i.e. the goals of the project were totally achieved. The project team worked as a team systematically and learned many new things in several different sub-areas of product design. Project team describes that the best moment of the project was the completion of the prototype, as well as its initial tests. All the work crystallized into the moment when everyone could see the imprint of their own hands, as well as the realization of common visions and goals. (Heinonen, et al. 2020).



Figure 1. 3D-printed Proof of Concept

Results of this project was a successfully constructed machine with new innovative concepts. All teams engineering students continued cooperation with this company as a Thesis workers. One of the students also got his first job from the HRS company. The projects gave a lot for the students: opportunity to test their engineering skills in real environment. Also, this project helps to get valuable feedback on the content of mechanical engineering courses and their relevance to real working life demands of the companies.

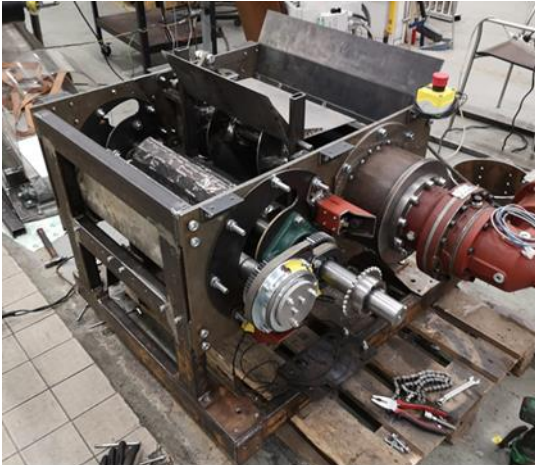


Figure 2. Picture of Working prototype of the product

For the HRS company the result of the project was an innovative prototype, produced with flexibility and at a reasonable cost by the engineering students team. The company was satisfied with the competence, innovation, and cooperation skills of the project team.

1.3 Case 2, 5S implementation in metal workshop

This case project was presented in MEPE in 2019. During 2019 JMC Engine Oy underwent a 5S pilot project for one machine cell. The positive feedback from the operators and improved worksite tidiness was a result of the pilot 5S project. As a result, the company decided to expand this project to cover the whole production site.

The goal of this project was to expand the 5S methodology to the rest of the factory site, promote Lean culture and build a quality and measurement control tool to sustain the changes made within 5S. The aim of the project was to improve job satisfaction, safety, work environment and to eliminate waste from the production. JMC Engine Oy underwent a 5S pilot project for one machine cell. The positive feedback from the operators and improved worksite tidiness was a result of the pilot 5S project (see Figure 3). As a result, the company decided to expand this project to cover the whole production site and also expand understanding of personnel about 5S method with practical training.

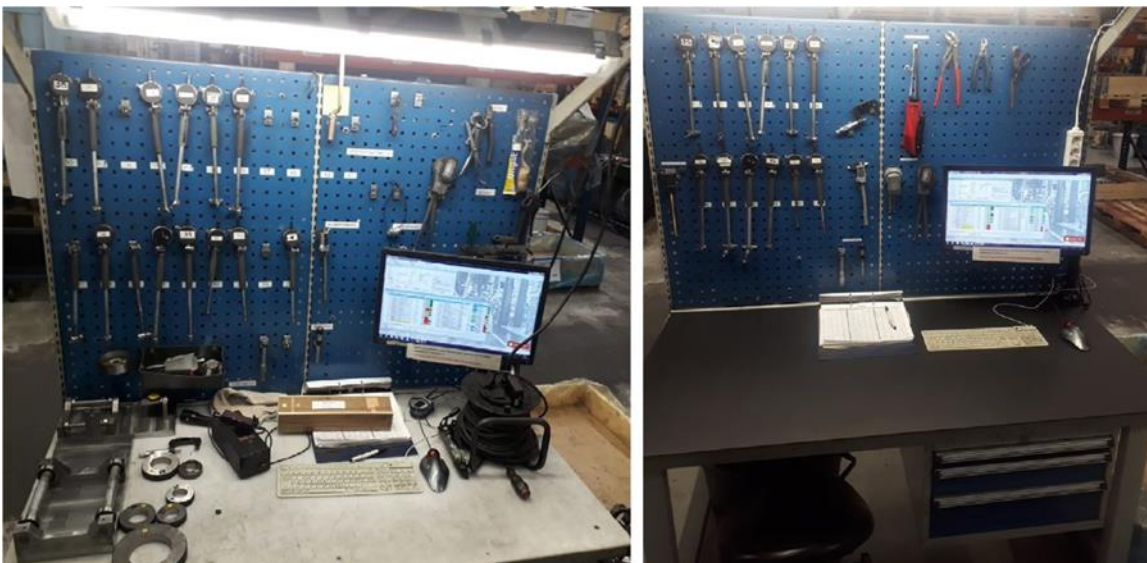


Figure 3. Picture of MCM 510 Workstation before and after the 5S organizing.

In the end of project, the personnel 5S training package was implemented together with the staff of the POTKUA- project. The aim of the training was to teach employees through the 5S theory and practice. At first, theory section was held, where the employees were educated what 5S stands for and what benefits it could

bring. Second part of education was a workshop, where the employees organized their own workstations following the 5S instructions learned from the theory-section.

The student project group thinks that training of the employees is considered the most important milestone of this project. The project members also believe that the training of the employees is a significant promote towards the Lean-culture between employees and to add more “working discipline” at the company. When everyone is trained to the principles of the 5S, everyone knows the rules and what 5S stands for. The project members believe that this also helps to maintain the changes made at the worksite. (Tuomivaara & Laakko, 2020).

2 Legacy of TEHOJA-project

During the TEHOJA project, cooperation was established with 18 different companies in Northern Finland, and as a result of the project, an innovative platform for collaborative robotics was built for Oamk, which enabled the construction of products and applications for companies. Totally, 42 products were developed in the TEHOJA project's product development projects were implemented. The original goal of the project was to implement only 10 pieces of the developed products. Perhaps the most successful robotic projects were carried out for the world’s northernmost ceramics factory, Posio. The factory wanted to participate in the project to promote the ergonomics and resilience and well-being of its employees at work.

As a result of the TEHOJA project, several different projects have started in OAU's mechanical engineering department: Potkua, Roboreel, Roboboost, Roboedu and Kotu projects. The TEHOJA project also contributed to the employment of more than 10 students in local companies, e.g. JMC Engine Oy, Sähkö-Rantek Oy and Pentik Oy.

From 2018, even more local SME’s and all the rest of OUAS’s mechanical engineering departments projects also started to participate in MEPE to deepen cooperation (see Table 1). Like the TEHOJA project, other projects work in cooperation with the business community in the area and implement various projects. Most of the new projects will further enhance the competitiveness of companies, by design new products, increase the efficiency of production mainly via Lean philosophy and the introduction of interoperable robots’ capabilities to the local companies, as in the TEHOJA project. As a conclusion MEPE has widely risen’ SME’s interest to cooperation and awareness of OUAS’s mechanical engineering education in Northern Finland. (Autio, 2020).

Table 1. Number of companies participating in MEPE and project cases between 2016-2020

Year	Companies	Number of project cases
2016	10	10
2017	12	17
2018	22	50
2019	20	53
2020	17	34

4.1 Concept of the MEPE inspires

The implementation of business experiments and the teaching of collaborative robotics, as well as experimentation in companies in the area, have been integrated into basic education thanks to the project. Operations will be continued if there is sufficient demand and need for expertise. The MEPE impacts has also been identified in other OUAS collaboration educational vocational institutions (called 6Aika) as a best practice to follow. They have been told the purpose of the project and the operating principle of the business experiments, but the same operating principles are not possible in all educational institutions, as they are vocational training institutions and do not have the same capabilities as a polytechnic (Autio, 2020).

3 Conclusion

The purpose of this paper was to present the MEPE approach developed by the School of Engineering and Natural Resources at Oulu University of Applied Sciences, in which the needs of local companies for the development of their operations have been harnessed to support the Schools mechanical engineering training.

Ideally, students would look for internships in companies themselves and complete the course very independently. However, the project topics defined in advance by the teaching staff in cooperation with the companies enable the ambitions of both parties to be realized. In teaching practical skills in product development and project management, such a lecture-like, independent way of studying may not produce results when the goal is to train engineers who know practical skills. Thus, there is a need for learning through motivation on a motivating topic and in an environment that matches the work tasks of a graduate mechanical engineer.

The aim of higher education institutions is to train engineers and to develop the professional identity of graduates of the engineering profession through class-room education (science) and the real-life development projects (application). Therefore, as an educator, the School of Engineering and Natural Resources promote our students' self-confidence and thus employment, when the step from student life to working life is not too wide a leap when they have during their study completed real-life industry projects. For many engineering students, this first step in their engineering career and experience working as an engineer can be a project internship or product development course where project topics are mostly given in MEPE and those handle every day, even business-critical challenges for real companies, but tailored to suit graduate engineering engineers. The job of a mechanical engineer is dealing with real world problems and it is best learned by doing, searching or asking for advice from the more experienced, and ultimately through experience. For this reason, each project work and product development course are supervised by an experienced lecturer who has worked in the industry for several years. As an experienced engineering professional, a lecturer can guide, consider potential risks and act as a mentor for engineering students starting their careers and working on a project, both in terms of project management and task development work. When supervising students, lecturers also get to see the activities of local companies and expand their view of the needs of companies and areas for development. This enables the continuous development of educational content and the emergence of new project ideas that would be better able to serve local companies, e.g., providing a low-risk opportunity to test the impact of robotics and other new technologies on a company's production.

This collaboration with companies and integrating their needs into the training of mechanical engineers underscores the fact that the university of applied sciences is a university for working life and industry. By supporting the growth of the professional identity of our engineering students, training them in cooperation with working life and utilizing the know-how of our experienced lecturers in guidance, we strongly contribute to the success of companies in the region by providing experts who meet the needs of the labor market.

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