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Project-Based Learning: Synthesis of Theory and Practice Through Interdisciplinary Projects

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Abstract: *Project-based learning (PBL) in the field of mechatronics is an effective way to develop practical skills and prepare students for real industrial jobs. This article presents an example of the application of the PBL concept at the Faculty of Technical Sciences Čačak in cooperation with industrial partner Vorwerk. By introducing real industrial projects and technical requirements, students are more involved and motivated. The results highlight PBL as a method that connects academia and industry.Prepares students with essential skills for professional success in the rapidly evolving field of mechatronics. PBL also brings together different departments around a common goal.*

Keywords: *Project-based learning; project-based skills; interdisciplinary, mechatronics.*

1. INTRODUCTION

Project-Based Learning is an educational approach in which students acquire knowledge and skills by working on real industrial projects. This method allows students to actively engage in the learning process, developing critical thinking, problem-solving, and teamwork skills. In the field of Mechatronics, PBL holds particular significance as it enables students to synthesize theoretical knowledge from various domains and apply it in solving complex technical problems. [1]

PBL is based on several key principles: active learning, teamwork, and the application of theoretical knowledge in practice. Active learning involves student engagement through discussions, research, and hands-on activities. Teamwork allows students to develop communication and collaborative skills, while applying theoretical knowledge in real-world situations helps students to better understand and retain the teaching material. [2, 3]

PBL builds on constructivist learning theory, which states that students construct their own knowledge by engaging in the learning process. Additionally, experiential learning theories and interdisciplinary theories play a crucial role in PBL, enabling knowledge from various fields and to solve real-world problems. [4] In PBL, the role of the teacher shifts from traditional lecturer to that of mentor. Teachers help students define project goals, guide them through the problem-solving process, and provide feedback and support throughout the project. [5, 6, 7]

2. METODOLOGY

The projects of the Mechatronics Undergraduate program are of a technical nature based on real industry requirements. Students work in teams of two to four which allows them to develop teamwork and collaboration skills. The projects involve the integration of knowledge from various areas such as introduction to mechatronics, technology re-engineering, CAD/CAM technology, computer systems control, sensors, electronics and work organization.

One of the key elements of the PBL in program is interdisciplinarity. Projects require students to integrate knowledge from different topics and apply it to solve complex techniques. For example, students can use CAD/CAM knowledge to design and produce components, while applying computer and electronic control systems to develop management and control systems.

The projects are carried out over several semesters, allowing students to gradually develop and improve their work. During each semester, students work on aspects of the project with mentoring and support from their mentors/professors. This approach allows students to develop a deep understanding of the material and learn practical skills directly in industry.

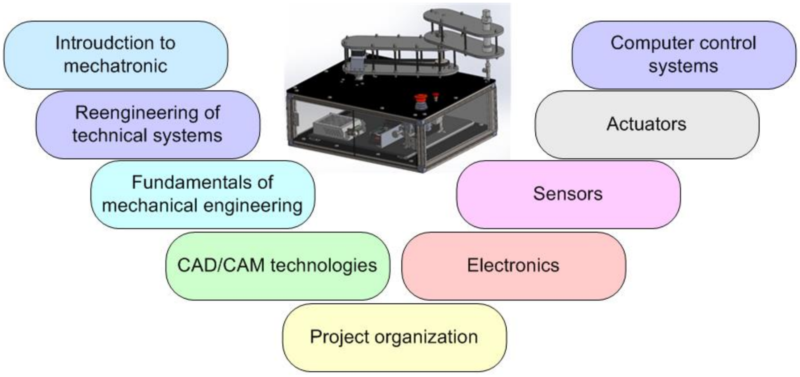

Figure 1. *Interdisciplinarity in PBL*

One of the main benefits of PBL is that students develop practical skills. Working on real-world projects allows students to apply their theoretical knowledge in practice, thus developing essential skills for success in a professional environment. For example, students can use their knowledge to design and test electronic components, while their knowledge of work organization will help to effectively manage projects.

PBL increases the motivation of students by allowing them to work on projects corresponding to their interests and their future career. Students are more motivated when they see that their work has concrete applications growing in front of their eyes. This encourages them to be more involved in the process and give their best.

Working on projects based on real industry demands prepares students for professional challenges. Students gain experience and skills directly for the industry, helping them find employment more easily and adapt quickly to the working environment. In addition, collaboration with industry allows students to create a network of contacts and better understand market needs.

PBL promotes the development of teamwork and communication skills among students. Working in teams of two to four members allow students to develop skills in collaboration, sharing and conflict resolution. Students also learn to communicate effectively their ideas and results, which is a crucial skill in a professional setting.

One of the main challenges of PBL is organization and logistics. Planning and implementing projects require significant resources and time from students and teachers. Teachers must coordinate various subjects and align the project with the curricula, which can be challenging.

Figure 2. *PBL process monitoring*

Evaluation and grading of student projects is a challenge. It is necessary to objectively evaluate the work of each team member. Teachers should develop clear assessment criteria and feedback that will help students improve their knowledge.

Establishing coordination between the different subjects is another challenge. Teachers must align their curricula and methods to allow students to integrate knowledge from various fields and apply it in projects. This requires good communication and collaboration between the teachers.

3. CASE STUDY

One of the successful projects of the Mechatronics program on Faculty of technical science in Čačak involved the use of a planar delta robot for sorting products. A team of students in the course Introduction to Mechatronics first perform research of the current state of the art of technical request. They analyzed in depth the characteristics, costs and design of existing solutions on the market.

Then, through the Fundamentals of mechanical engineering course, they defined the project task with relevant requirements. Based on the task of the project, the team brainstormed and defined several alternative solutions. These solutions were evaluated according to the criteria defined by the courses, resulting in the optimal solution.

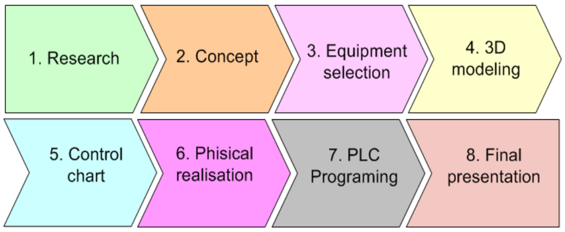

Figure 3. *Phases during the Project*

After finding the optimal solution, the student team developed a detailed 3D model and documentation using CAD/CAM technology. They applied their knowledge of Control Computer Systems and Electronics to develop software and hardware systems.

After detailed hardware development, parts list was created for purchasing of the necessary components. Students are involved in purchasing process. When all the components arrive, they assemble them into a working machine.

The project was successfully realized and presented to industrial partners.

In successful projects, students are actively involved in all stages of the development of the project, with professors as mentors. Students define project objectives, design and test solutions, while teachers provide support, feedback and guide students throughout the process.

Industrial partners often provide feedback on student projects, which helps students improve their skills and better understand market needs. Industry feedback can also contribute to program improvement, allowing teachers to adjust content and teaching methods based on market demands.

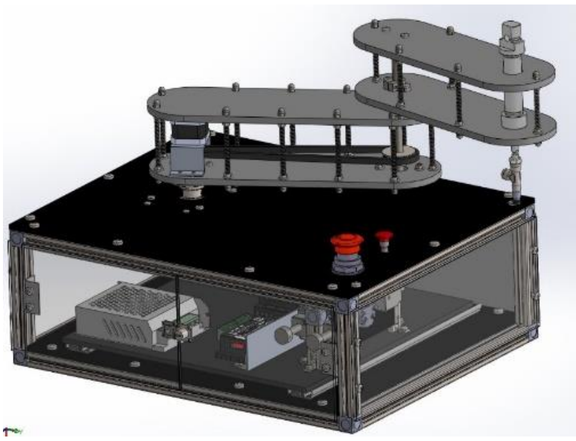

Figure 4. *Detailed 3D model of the Project*

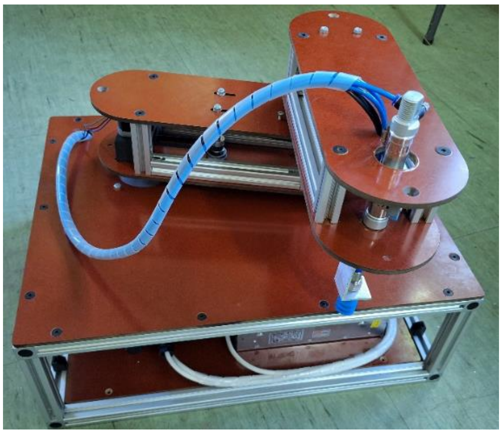

Figure 5. *Physical realization of the Project*

4. CONCLUSION

Project-based learning on the Mechatronics Undergraduate program represents an efficient way to develop practical skills and prepare students for professional challenges. Through practical projects, students cultivate their criticism, their problem-solving abilities, their work and their communication skills. Despite the challenges of organization and evaluation, the benefits of project-oriented learning are clear and significantly improve the quality of education.

Future prospects involve further improving the methodology and strengthening collaboration with industry, which will enable them to acquire even more relevant knowledge and skills.

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