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European Project Semester – The Model of International Interdisciplinary Electronics Education

Streszczenie. *Przedstawiony artykuł prezentuje koncepcję, główne założenia oraz efekty i wnioski z wieloletniej realizacji Europejskiego Projektu Semestralnego jako formy edukacji w Politechnice Łódzkiej. Prezentowana analiza dotyczy zarówno aspektów technicznych i wartości merytorycznej oraz osiąganych efektów kształcenia z zakresu elektroniki jak również zagadnień z zakresu interakcji w interdyscyplinarnej, międzynarodowej grupie projektowej. Poniższą analizę przeprowadzono na podstawie siedmioletnich doświadczeń z realizacji zajęć ze strony opiekuna naukowego z dziedziny elektroniki oraz na bazie wieloletnich doświadczeń opiekuna projektu w zakresie organizacyjnym, uzupełnionych analizą statystyczną raportów, ankiet ewaluacyjnych i innych form oceny i monitoringu prac studenckich. Podkreślono pozytywne efekty kształcenia opisywana formą w zakresie elektroniki oraz interdyscyplinarnego rozwoju studenta.* ***(European Project Semester – Model Interdyscyplinarnej Edukacji w Elektronice).***

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Abstract*. The paper describes the concept, main principles, pedagogical effects and material results from the realization of the European Project Semester as an education form, as realized at Lodz University of Technology. This analysis is based on technical aspects and pedagogical outcomes in the field of electronics as well as the challenges and opportunities resulting from the multidisciplinary, international project workgroup environment. All the presented comments, discussions and conclusions are drawn from seven years of technical staff experience and several years of organization team leader experience, supported by the statistical analysis of questionnaires, reports and other forms of students' activity assessment. The positive effects of education in the fields of electronics and multidisciplinary development of students' skills are presented.*

Słowa kluczowe: kształcenie międzynarodowe, nauczanie projektowe, European Project Semester, edukacja interdyscyplinarna.
Keywords: international education, project-based learning, European Project Semester, interdisciplinary education.

1. General Idea and short history of EPS in Lodz University of Technology (TUL)

Dynamically changing global and local environments constitute a real challenge for societies, universities and young university graduates. Not only the scale of the change but also its constant nature and diverse character lead Higher Education (HE) institutions to look for new learning paradigms that will allow young graduates to be successful in an environment of changing job markets, and in their endeavour to support societies with novel engineering solutions. New learning paradigms seem especially important in the field of engineering, as technology itself is an important trigger of fast changes and has a large potential to provide global communities with solutions [1,2].

Towards the end of the 20th century, Lodz University of Technology, together with the Ballerup College in Denmark and Oslo Metropolitan University of Technology, initiated the European Project Semester [3], an educational, one-semester programme whose aim was to motivate young engineers to develop high-level engineering competencies and transversal skills needed to address the challenges of the future. The generic skills include:

a) problem solving,
b) critical thinking,
c) independence in research and decision making,
d) teamwork in an intercultural and interdisciplinary context,
e) proficiency in presenting the results of work in written and spoken forms.

The EPS projects at the early stages of programme development had a more technical and task-based character. In time, EPS has evolved towards more open projects, and socially and human-oriented schemes such as Problem-Based Learning (PBL) [4], Design Thinking (DT), Human Centred Approach [5] and Universal Design. This evolution has enabled EPS to become more holistic in its approach to engineering [6], to integrate more successfully with the socio-economic, intercultural, and ethical contexts of globalized environments in the 21st century, and better address the challenges of current and future trends.

Currently, the EPS network comprises nineteen universities of technology and colleges from twelve European countries, each contributing to the programme with different specificities, but all of them obliged to respect a few fundamental rules. As a rule, EPS is a full 30 ECTS programme and uses English as the language of communication. Students work in interdisciplinary and intercultural teams; depending on the institution, the project itself accounts for from 20 to 25 ECTS, the supporting courses may vary in their content. Everywhere, it is more the students' than the mentors' responsibility to manage the project process, plan and schedule.

At TUL, EPS is hosted at the International Faculty of Engineering that invites academics from other TUL faculties to mentor projects and conduct supporting courses. The 20 ECTS project constitutes the programme core. In addition, students attend a few mandatory courses that help them to be autonomous in team development, effective professional and interpersonal communication, and project execution:

a) Project Management,
b) Innovation Management,
c) Team Building and Communication for Projects
f) Polish Language and Culture.

The project team is mentored by one or two tutors, often representing different disciplines, as well as a Team Building mentor, one person for 3 to 5 teams. In case a project team needs expertise from an additional field, the students have the right to ask for an external expert for consultation. The Team Building and Communication for Projects (TB& CFP) course (c) is evenly spread throughout the semester, as it creates an integrative and peer-learning platform of communication for all the EPS project teams. Its content comprises modules on group dynamics for teams, team building and team management, intercultural communication, writing and presentation skills as well as modules techniques utilized in the approaches used by project teams.

Students work in multicultural teams of 4-5 members on multidisciplinary projects organized around complex contemporary problems that are experienced by companies, institutions, and communities. The projects are conducted in collaboration with companies and are often connected with university research projects.

Students enjoy considerable autonomy in team and project management. They learn how to be independent in research, problem-solving and decision-making. Mentors play the roles of facilitators rather than supervisors of projects: they create the ideal environment for students to make autonomous decisions, and they intervene only at the critical moments

2. The importance of practical project goals

The European Project Semester project is aimed at solving practical technical problems, which generally are at a high level of complexity. To achieve the goal of interdisciplinary cooperation, topics frequently cover many aspects of design, and among others, include the following issues:

a) social research and original problem definition,
b) technical solution of the specified problem aspect,
c) economic analysis,
d) marketing and customer feedback,
e) proper organization, reporting and project presentation.

Many of the above-mentioned issues belong to the framework of Design Thinking methodology [7], and therefore this approach is often deliberately adopted for EPS projects. As a result, the steps of empathy, point of view creation (POV) and idea generation (ideation), listed as point (a), are adopted in project execution. A technical solution of the defined problem, listed as point (b), is practically realized as a formal design, software development, and usually prototype construction. This part usually becomes the main focus of interest for the student group and is often a decisive factor for the solution development, as it is in agreement with the students' main areas of expertise. Frequently, it is discussed with an external expert who is a specialist in the field of the specific solution application (e.g. medical staff, a business expert).

Even though points (c) and (d) are not strictly electronic tasks, they are taken equally seriously since the project should simulate real cooperation in business activity. The outcomes obtained initially constitute the basis for further development and commercialization.

The final aspects of project development (point e) are important for both scientific and academic reporting, and good practice in team organization. It is worth emphasizing that even though the outcome, in the form of a technical solution, is always the pivotal point of interest for the supervisors and evaluators, the structure and course of subjects equally highlight all listed tasks and stages of realization. All these factors are crucial for the student-centred education that supports deep approach to learning, understanding, practical problem-solving [8], and as such is salient for the students' professional careers.

3. Interdisciplinary work as a way of technical problem-solving in electronics

A standard composition of a work group is a team of 4-5 students representing various universities, countries and different education profiles. A project group is usually consolidated around a single purpose, which is frequently reflected in their team name, motto or mission statement and/or visual logo, as presented in Fig 1.

Fig.1. International team „Solar heroes": 5 students from France, Germany, Scotland, Poland and Spain with their supervisors.

A standard team operation plan is divided into several stages with the most important milestones:

a) team constitution,
b) basic knowledge acquirement,
c) definition of the specific problem,
d) design of the theoretical solution, low resolution prototyping,
e) external expert evaluation and consulting,
f) final prototyping and feedback acquisition,
g) official presentation and/or commercialization.

In the first stage, the team organization is arranged with consideration of the task specificity, students' professional abilities and their educational profiles. Less technically oriented profiles e.g., business or management ones, are frequently best suited for team-leading roles, and for work coordination, since they are tightly connected with work scheduling and monitoring and may sometimes be followed collectively in the SCRUM-like organization [9]. A helpful tool for the self-assessment of required competencies is a personal skill profile prepared by each student at the initial stage of the project work and synthesized later in the form of a team SWOT analysis. An example of this process result is briefly presented in Fig 2.

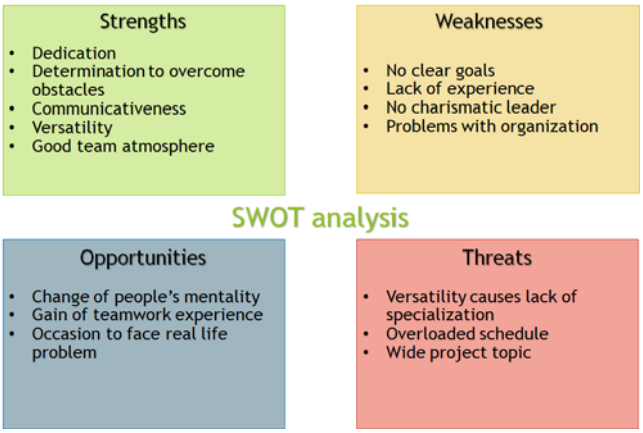

Fig 2. SWOT analysis of the Smart project team, constructed after the initial stage of teamwork. The identified problem was: *How to make citizens partially independent from external energy supply using clean energy production methods.*

Fig.3. A student team visiting the Łódź city center traffic monitoring unit during realization of the EPS project: Energy Effectiveness in Smart Cites.

In the next stage, the basic problem information should be gathered. This step is often realized with the help of literature research, accompanied by laboratory exercises, work visits to companies, and consultations with external experts, as depicted in Fig 3.

At this stage, the mixed technical education profile of the team members with leading electronic specialization is vital for the proper acquisition of background knowledge. Creative cooperation with complementary knowledge exchange is beneficial for designing a solution and for prototyping, which may be an electronic component, software application or a totally new component equipped with mixed systems aimed at new functionalities, as is presented in Fig 4 .

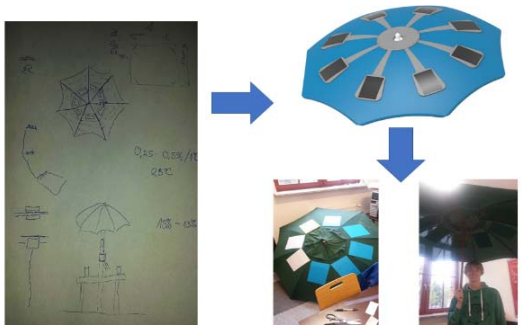

Fig.4. Prototyping of solar outdoor umbrella equipped with PV flexible systems and charge controller for mobile electronic equipment.

Final prototyping is a stage of great importance, as it creates an opportunity for testing multi-disciplinary technical aspects of the solution, as well as receiving feedback from end-users, based on comprehensive interviews, surveys, often organized with the participation of non-engineer team members.

Finally, the reporting and presentation stage is undertaken by the whole team, with beneficial results for complementary transversal skills and abilities.

4. Project outcomes and benefits for students in regard to their future careers

Basic technical outcomes are delivered in the form of a final solution in the field of specific technical disciplines. In the field of electronics, many variants in results may be expected. The main group of solutions comprises designs of new electronic components or equipment, frequently connected with programmable devices. A popular solution is a software application, often constructed in a form dedicated for mobile devices that includes designing programs, demonstrative programs or visual games. Finally, combined electronic systems are developed thanks to the multidisciplinary skills of the design team and based on identified customer needs. Fig 5 presents one of the EPS technical outcomes in the form of new electronic educational equipment.

SoLearn group identified the lack of PV education tools as one of critical problems in photovoltaic development and its popularization process. They designed and manufactured a functional PV off grid demonstrator system with mobile application for an on-line parameters presentation (Fig 5). An attractive and contemporary appearance of the device was achieved by original 3D modelling and printing of the chassis.

The EPS international project-based program creates a very strong platform for developing soft skills, so valued, according to Forbes [10], by employers today: growth mindset, flexibility and adaptability, continuous learning, critical thinking, resilience, curiosity, and a sense of comfort with ambiguity.

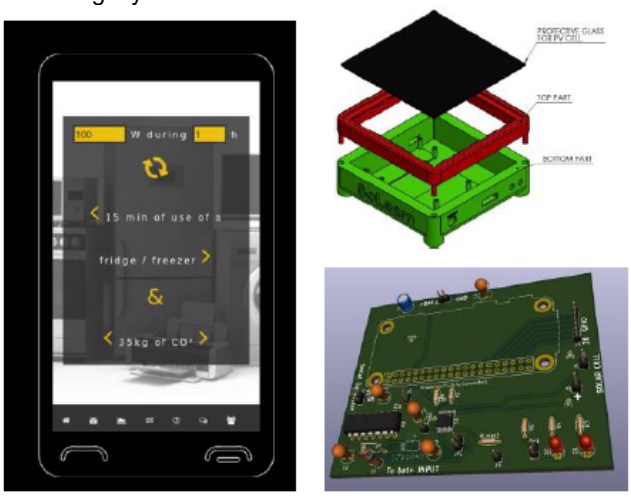

Fig 5. “Novel Methods for Education and Promotion of Photovoltaics”, EPS project outcome in the form of a solar cell operation demonstrator with mobile application for results display

The program, whose main foundation is a group project in an international team, creates an environment that naturally provokes cross-cultural communication, and as such can be more engaging and interesting for students, as it is linked with cultural exploration. However, it may be also challenging and difficult, due to the fact that complex relations between seemingly similar cultures may lead to misunderstandings and conflicts in a team, especially when work accumulates.

The EPS students are supported in their cultural endeavor in an intercultural communication module, part of TB&CFP course, where students are introduced to the concepts of culture and cultural theories of Edgard Schein [11], Geert Hofstede [12], and other scholars, as well as the issue of the impact of diversity on team dynamics. They learn how to be flexible and how to adapt to other cultural modes, not only to survive in a difficult multicultural context, but also to be fully successful while being challenged by the open character of the project, as well as by increased autonomy in decision-making. Independence and autonomy are strengthened by team mentors who do not instruct but facilitate, and refrain from showing students the way to find the right path or solution. [13,14]

The open character of projects, combined with the lack of direct instructions, can be highly frustrating for students. Nevertheless, it might allow for exercising acceptance of ambiguity and uncertainty, and for being able to manifest creativity in problem solving.[15]

Partial results from research on EPS student perceptions conducted between 2015 -2020 show that the students confirmed that the EPS program enabled them to acquire new knowledge, learn teamwork skills, empathy and problem-solving, but also helped them develop creativity and become more autonomous in project execution.

So far, the sample of EPS respondents comprises 61 international students representing European countries including Poland. Specific results of the survey and students’ feedback is presented in Table 1.

The process of reflection was further developed in an essay written individually by every student. The students emphasized the importance of an opportunity to get “new insights into cultural differences” and “develop easiness in communication with different cultures, which may help in a career”,”see other points of view and be more creative”, “develop patience” and “acquire an ability to adapt to lots of

new situations". The students praised empathy as an important aspect of effective communication, which helps them work together as well as "view the problem as it is seen by the end-user. "

Table 1 EPS outcomes in perspective of the students – questionnaire results (years 2015-2020).

No of positive answers [%]	Discussed issue (learning outcome)
91	EPS allowed the students to acquire new knowledge
78	EPS helped the students learn how to solve problems
85	EPS is a good way to develop teamwork skills
81	EPS helped the students to develop empathy
72	EPS helped the students to become more creative

The results are very positive, and demonstrate that project-based education in an international team environment, conducted within the framework of EPS, may be seen as a good way to motivate young people, helping them develop the skills expected from the young graduates by today's employers; but it must be admitted that the research sample is still too small to generalize, and requires further research. The highly international and diverse structure of EPS teams triggers increased exchange of ideas and curiosity, and reveals the need to develop teamwork skills and empathetic communication with a variety of stakeholders. As such, this form of education is an interesting alternative for more traditional learning programs. It is highly valued and very popular amongst students of electronics, as it helps them to cooperate in a modern interdisciplinary and international group, as well as to network with foreign universities and companies.

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