

# Second-cycle Electronics and Telecommunications Program with Project Based Learning Approach

Ewa Raj, and Krzysztof Tomalczyk

**Abstract**—The paper presents a new second-cycle Electronics and Telecommunications study program that has been running in Lodz University of Technology since 2020. The concept of the program uses the Project Based Learning approach and it is based on three main projects implemented throughout the curriculum. The inspiration was the programs of three foreign universities and extensive research of various groups of stakeholders. The initial evaluation of the program first semester proves high acceptance and satisfaction of the students.

**Keywords**—Project Based Learning; Electronics and Telecommunications; Study program

## I. INTRODUCTION

**E**LECTRONICS belongs to one of the first fields of studies conducted in Lodz University of Technology with full academic credentials since 1992. Act on Higher Education and Science that entered into force in 2005 [1] caused replacement of long-cycle studies with two-cycle studies, while the New Act from 2018 [2] brought us new regulations and requirements regarding the study programs.

Furthermore, new standards for higher education have been recently defined with the introduction of “XXI century competencies” [3], that are not only related to knowledge and abilities resulting from a field of study, but also with a variety of soft skills. According to these requirements all graduates of all fields of study should manifest e.g. critical thinking, creativity, collaboration and problem-solving competencies with consequent character qualities such as: curiosity, initiative, persistence and adaptability. On the other hand, modern teaching methods [3-8] that are oriented on developing XXI century competencies with lifelong learning approach are becoming more and more widespread, available and promising for new generations. Among others, we can mention Problem Based Learning (known as PBL), Project Based Learning (also known as PBL), Design Thinking (DT), Case Teaching (CT), Team Based Learning (TBL), Process Oriented Guided Inquiry Learning (POGIL). The new teaching methods make the learning process more efficient and interesting due to incorporation of many hands-on activities and they benefit at different educational levels [9-11].

The paper presents the concept and implementation of second-cycle Electronic and Telecommunications (E&T) program in Lodz University of Technology. The program has been developed with the Project Based Learning approach and was inspired by similar programs conducted in Olin College of Engineering (USA) [6], Aalborg University (Denmark) [7], and Maastricht University (the Netherlands) [8].

In the American College, projects are the base of the curricula at every semester. It allows to combine interdisciplinary character of conducted courses with better comprehension of the discussed material. The main point of the curricula are year-long projects that are brought and sponsored by external partners. These are the capstone projects during which students must deal with real-life problems while developing engineering solutions.

In the two European universities, more Problem Based Learning approaches are implemented in the programmes. In Denmark, a leading project can be easily distinguished in every semester. Two or three additional courses play supporting role for the main semester project. On contrary, in Maastricht University, in the Science Program, PBL is combined with case study.

Although, there are many differences in practical implementation of PBL, the inquiry based learning results in much better development of “XXI century competencies”. Hence an idea to widely introduce the problem and project based learning approaches to curricula at our universities are a demanded direction of future education changes.

## II. PROGRAM STAKEHOLDERS AND THEIR NEEDS

The work on new second-cycle E&T study program started with the research on expectations of candidates and potential employers, and gathering of academic staff opinions about the ideas of challenges and potential changes. There was a general opinion among all the stakeholders that the introduction of a new E&T program is necessary.

From the socioeconomic environment, 16 companies from the Lodz region, cooperating with our university in the field of electronics and telecommunications have been selected. The profile of the companies is very diverse both in terms of their

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specialization (from equipment-oriented manufacturers to system-oriented service providers) and size (from start-ups to local branches of global corporations). The results of conducted interviews with their representatives regarding the desirable hard and soft skills of their future employees are presented in Fig. 1 and Fig. 2, respectively. The diversity of answers with respect to knowledge and abilities in specific areas of electronics illustrates the variety of profiles of the companies

interviewed. On the other hand, very high demands (essential or useful) with respect to programming skills (both low- and high-level) of electronics engineers are observed through all the interviewed companies. Regarding the soft skills, employers value the most responsibility, commitment, problem-solving and lifelong learning. It is worth to emphasize that none of the interviewees point out any of the listed skills as irrelevant.

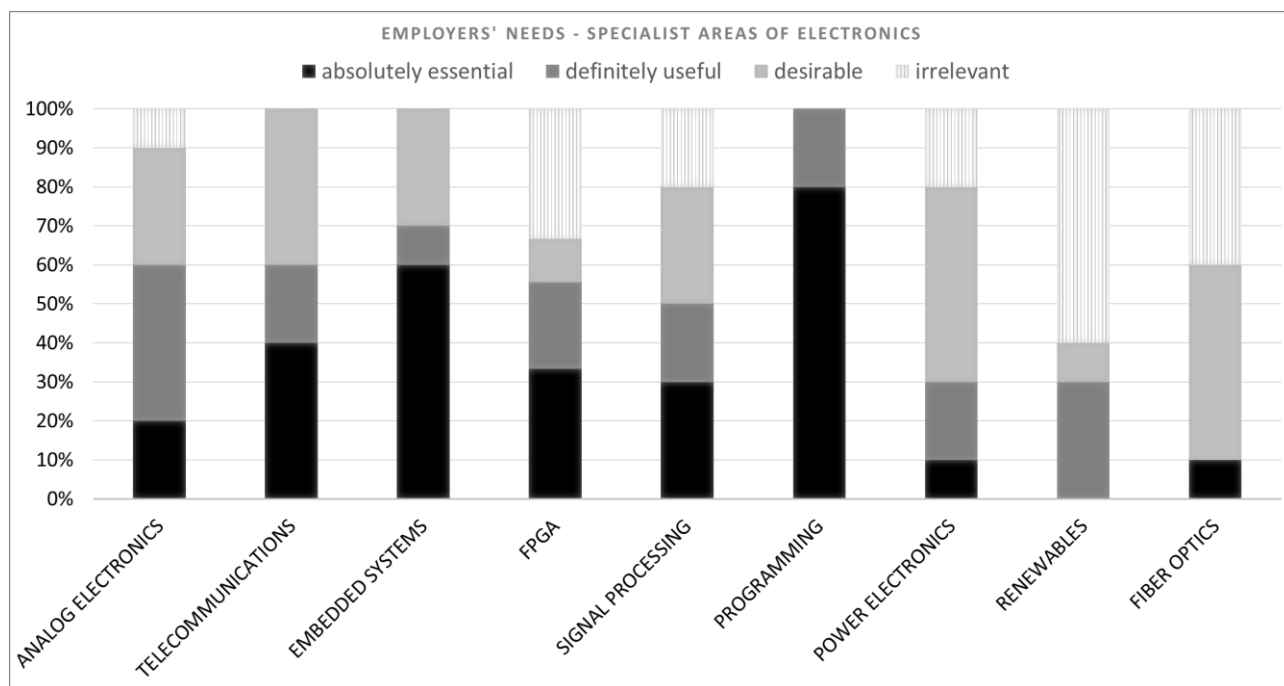


Fig. 1. Results of interviews with employers – hard skill requirements

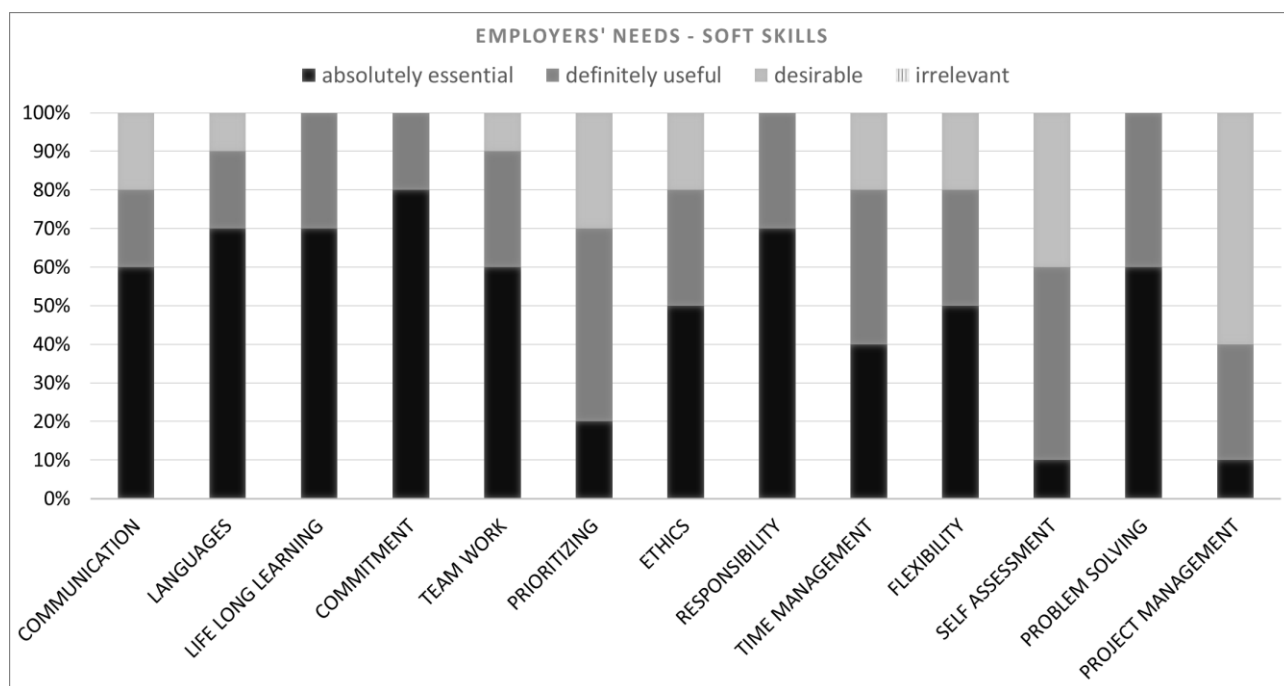


Fig. 2. Results of interviews with employers – soft skill requirements

The second group covered within the stakeholder analysis was 21 students of the second-cycle and 64 students of the first-cycle E&T programs. The main expectations regarding the new program were:

- more practical/experimental activities;
- further personal development in selected areas of electronics or telecommunications;
- program adjusted to the needs and interests;
- higher flexibility of time schedule;
- possibility to connect studying with part-time job.

More detailed analysis of students interests regarding specific areas of electronics and telecommunications is conducted every year during enrolment to the program. The results and their discussion are presented in the next section.

The academic staff of the Faculty of Electrical, Electronic, Computer and Control Engineering was the final group of interviewed stakeholders. Three meetings in the involved teaching units were organized to gather new ideas regarding the program rebuilt. The opinions that were shared were related to the individual courses, higher course selectivity (to allow better program individualization possibility) and more project oriented approach. They all were discussed and the drawn conclusions influenced the final version of the developed program.

### III. NEW SECOND-CYCLE PROGRAM

The developed second-cycle E&T program places great emphasis on practical and applicational skills, flexibility and the possibility of individual development in selected areas of electronics and/or telecommunications. The general concept of the program schematically shown in Fig. 3 is based on three main projects. The first is Autonomous Electronic System (AES) project assigned to the first semester of the curriculum (12 ECTS). The second is Research and Development (R&D) Project carried out in cooperation with the socio-economic environment or with research units or centres in the second and the third semesters (13 ECTS in total). The third and the final one is master thesis (20 ECTS). The first semester project is implemented as a team work of 4 to 5 students. It focuses on an autonomous electronic vehicle design and its main goals are to combine knowledge and skills in the field of electronics (circuits design, microprocessor systems, sensors and activators) and telecommunications (signal processing, wireless communication, or IoT) and to simultaneously develop students' hard and soft skills.

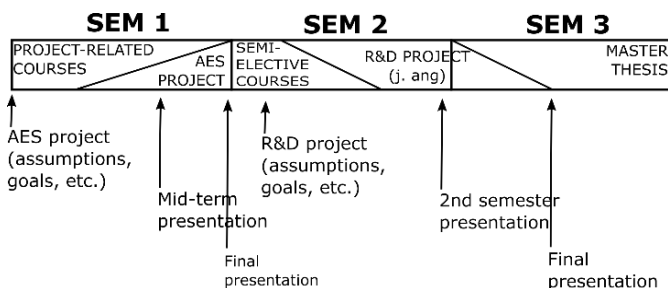


Fig. 3. General outline of the program

The project is accompanied by five project-related courses, the topics and issues of which can be practically used by students within the project:

- Design and Diagnostics of Electronic Systems,
- Microprocessor Systems,
- Wireless Communications,
- Programming in Intelligent Computing.

The Research and Development project is planned as individual or team work in the second and third semester. Students select project topics provided by industrial partners cooperating with the institutes and departments of Lodz University of Technology. Alternatively they can choose research topics offered by the University scientists and join the research teams conducting investigation in the field of electronics or telecommunications at our University. Sample project titles are listed below:

- System for intelligent management of FMC (FPGA Mezzanine Card) modules,
- Gapeau: Enhancing the Sense of Distance to Others with a Head-Mounted Sensor,
- Shape sensing fibre optic sensors – in cooperation with industry partner,
- Saltwater aquarium lighting system – in cooperation with industry partner,
- Investigation of bifacial photovoltaic modules operating in industrial and prosumer installations – in cooperation with industry partner.

The program is concluded with the Master thesis, a project developed individually by each student. These three main projects constitute 50% of the program workload which, together with the other elective courses results in the program's overall selectivity as high as 74%. The presented concept, based on the Project Based Learning method, is part of the Student Centred Pedagogy trend that supports creativity and the idea of lifelong-learning.

### IV. REALISATION AND ENROLMENT

The enrolment to the program is carried out with obligatory interviews that allow to verify candidate readiness from the hard and soft skills point of view to undertake the second-cycle E&T program. Furthermore, the results of the interviews are used to identify potential individual study path of the future students as well as their skill self-assessment. Summary of answers gathered in years 2020-2022 is illustrated in Fig. 4 and in Fig. 5, respectively. Students expect to develop the most in the area of embedded systems and programming, although telecommunications and power electronics is pointed out by about of 60% of candidates. All the potential students assess their skills in different areas at the level of 2.5-3.5 in the scale from 1 to 5. The lowest values are observed for fibre optics and telecommunications. These facts results from candidate's profiles and the type of first-cycle studies completed. Furthermore, there is no exact correlation between candidates' skills and the area they want to develop in. The expectations are more related to the demands of the labour market.

The limit of 30 students is defined for the program, to ensure quality and better contact with the students while monitoring their progress. Despite of supervision also the coordination for AES and R&D projects is provided. Good communication with students and formative assessment with middle presentations help better facilitate teams and individuals and address their needs. The summative assessments at the end of the projects

cover oral exams combined with the project final presentations. During one hour session, student from one team answers challenging questions from examination board consisting of at least five members of academic staff of the Faculty of Electrical, Electronic, Computer, and Control Engineering of Lodz University of Technology.

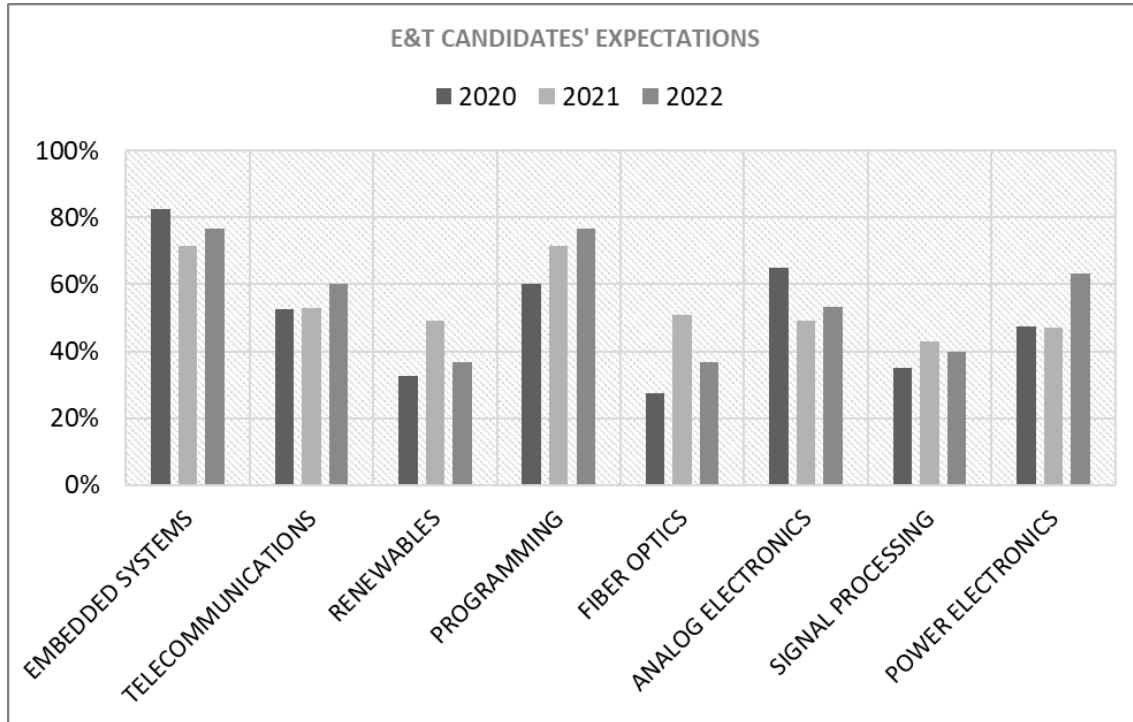


Fig. 4. Candidate expectations gathered in years 2020-2022 during enrolment interviews

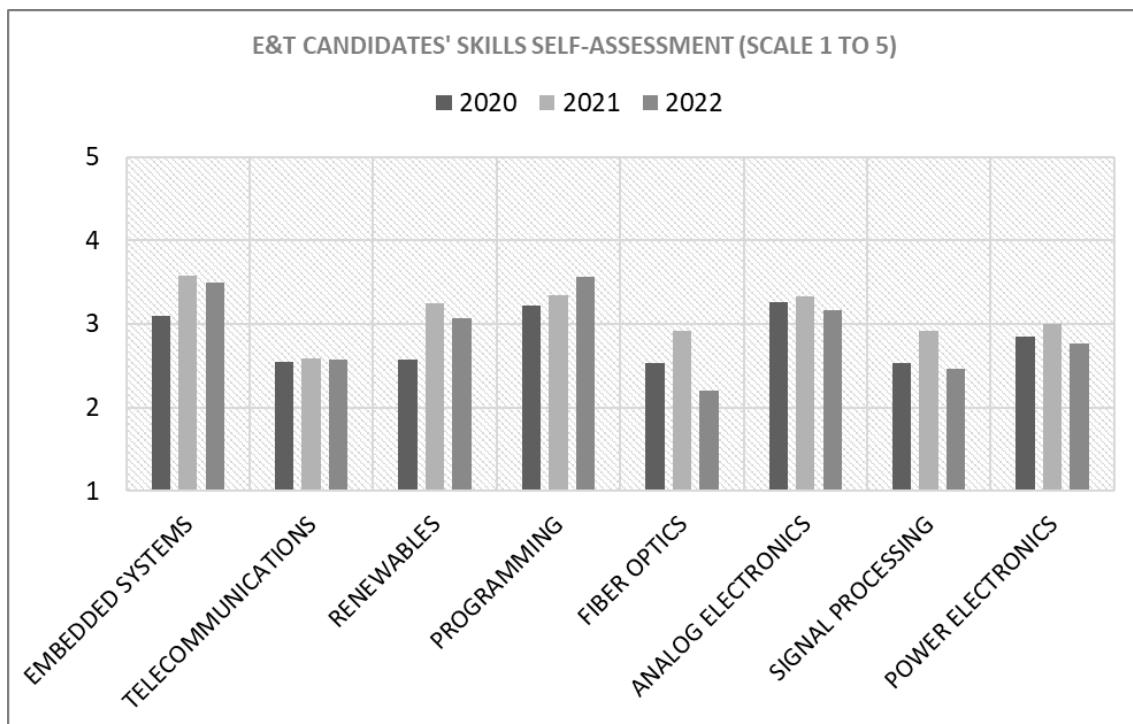


Fig. 5. Candidates' skill self-assessment gathered in years 2020-2022 during enrolment interviews

The program was first run in 2020. During three recruitment processes the number of candidates varied between 51 and 98. The program evaluation has not been finished, yet; although, the first semester for two years have been monitored.

The students were asked to fill in anonymous survey covering four main questions (see Table I and Table II) regarding AES project and project-related courses. Furthermore, the survey was supplemented with additional open questions. The results of AES and project-related courses evaluation conducted by 43 students are shown in Table I and Table II, respectively.

TABLE I  
EVALUATION OF AES PROJECT BY STUDENTS IN YEAR 2020-2021

Question	Result*
1. Have you learned new, interesting things during the course/project?	4.9
2. Do you know where can you apply the acquainted knowledge?	4.6
3. Does the form of conducting the classes encourage you to self-study?	4.5
4. Has the time spent working at home been greater than the number of contact hours with the supervisor?	4.7

\*Scale 1 – 5.

TABLE II  
EVALUATION OF PROJECT-RELATED COURSES BY STUDENTS IN YEAR 2020-2021

Question	Result*
1. Have you learned new, interesting things during the course/project?	4.1-4.3
2. Do you know where can you apply the acquainted knowledge?	4.0-4.6
3. Does the form of conducting the classes encourage you to self-study?	3.9-4.5
4. Has the time spent working at home been greater than the number of contact hours with the supervisor?	2.7-3.6

\*Scale 1 – 5.

For AES course, the grades are very high, both evaluating the project and its realisation and the amount of self-study time. More time spent on self-education based on individual or team work is beneficial, especially because it is the second-cycle program that must prepare students for the third-cycle, as well as develop lifelong-learning competency. Students claim (in the open question section) that the approach allows them to develop hard skill accompanied by team work competences in a very involving way.

In the case of project-related courses, the grades are slightly lower, although the values are kept above 4.0 for three first questions. It is worth to emphasise that the first program run was in 2020 during the pandemic situation. Hence, the average results are affected by online realisation of laboratories. As open questions indicate, students evaluate the best Microprocessors Systems course as the one performing the most supportive role for the main project. Rating of the last question for the courses covering lectures and laboratories, seems to be according to the expectations. Students spent the same amount of time at the university and at home during self-study. So, the courses are well designed.

Furthermore, all the remarks and comments are discussed yearly with the academic staff involved in the implementation of AES project and project-related courses to identify potential aspects for improvement. The level of achievement of the learning outcomes as well as peer assessment are also raised during the meetings.

The second PBL course, Research and Development Project, has not yet been surveyed. As for now, its positive results are visible during final exams (interest and engagement of the students), in the practical implementations of students' solutions in the cooperating companies or scientific presentations of the conducted research at the international conferences [12, 13].

## CONCLUSIONS

To sum up, the new second-cycle Electronic and Telecommunications program was developed and introduced into the educational offer of Lodz University of Technology in 2020. It is based on three main projects realised within the full cycle study implementing Project Based Learning method. The results of the preliminary student evaluation (anonymous survey) of the first semester are very high and promising. The satisfaction of both students and academic staff confirms the efficiency of the new approach.

The students appreciate also high selectivity offered from the second semester. The R&D project has not been surveyed yet, although, the benefits of the approach are visible in the implementation of the developed solution by industrial partners, the high interest of socio-economic environment in further cooperation, and first scientific articles presented and published with students as co-authors.

The full evaluation process is demanded. As it was assumed, it should cover three following program enrolments and must be continued with three-year cycles.

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