ENVIHEI

Title of the PBL challenge:
Introduction to various project work forms (PBL, Design Thinking)

Name of the responsible lecturer

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University / Department / Degree program

Silesian University of Technology / Faculty of Transport and Aviation Engineering / Bachelor's Degree in Aerospace Engineering

Course / Subject in which implemented

1st Course / Introduction to various project work forms (PBL, Design Thinking)

Implementation period (dates)

March 6, 2026 – June 26, 2026

Total duration (weeks/hours)

16 weeks / 45 hours

Number of students involved

15 students

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1. Project Design

1.1 Brief description of the project and the challenge proposed

The aim of the course is to familiarize students with the application of Problem-Based Learning, Project-Based Learning, and Design Thinking to solve basic problems related to materials engineering. The aim of the course is to familiarize students with the basic principles of planning and carrying out research projects. As part of the course, students will learn what the Design Thinking methodology and how to use it. Students will also learn about project management methods and how to prepare a research report and presentation. As part of the course, students will learn the basic principles of scientific writing and become familiar with databases and software used to prepare a scientific literature review.

Specific selected topics:

- **Compressors in aircraft engines**: the role of the compressor, operating conditions and causes of compressor degradation, variants – types of compressors – their design, materials used in their construction, protective coatings.
- **Turbines in aircraft engines**: the design and types of turbines, the hot section of an aircraft engine, operating conditions and causes of degradation of turbine components – turbine blades (stationary and rotating), materials used in their construction; protective coatings.
- **Combustion chambers in aeroengines**: their design and types of combustion chambers, operating conditions and causes of combustion chamber degradation, materials used in their construction, protective coatings.

1.2 Expected learning outcomes (academic and transversal competences)

The expected learning outcomes of the course are aligned with the Faculty's established learning outcomes framework and encompass three main areas: knowledge, practical skills, and social competence.

Knowledge

Students are expected to acquire knowledge and understanding of:

- K1A_W2: Research methods, tools, and materials used to carry out simple research projects in the field of materials engineering.

Skills

Students are expected to develop the ability to:

- K1A_U2: Plan and conduct simple experiments in materials engineering.
- K1A_U6: Identify and select appropriate information sources, analyse the information they contain, and actively participate in discussions related to materials engineering projects.
- K1A_U7: Select and apply appropriate techniques, practical skills, and modern research tools used in materials engineering.

Social competences

Students are expected to develop the capacity to:

- K1A_K1: Critically evaluate their own knowledge and the information they receive when addressing problems related to the implementation of research projects in materials engineering.

1.3 Targeted sustainability competences

The course aims to encourage future engineers and designers to integrate principles of sustainable development, green technologies, and social responsibility towards future generations into the design of aircraft engines.

These objectives are aligned with the European Sustainability Competence Framework (GreenComp), particularly the competences of valuing sustainability, supporting fairness, critical thinking, and exploratory thinking. The course seeks to encourage students to consider environmental and societal implications when addressing engineering challenges and to explore more sustainable technological solutions.

The course also contributes to the United Nations Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation and Infrastructure), by promoting sustainable technological innovation, and SDG 12 (Responsible Consumption and Production), by encouraging consideration of resource efficiency and sustainable material use in engineering design.

1.4 Sustainability approach and how it is integrated into the project

Sustainability is integrated into the project through a focus on improving the durability of aircraft engine components, enhancing the efficiency of compressors and turbines, and exploring ways to reduce aircraft exhaust emissions and the associated carbon footprint. These aspects encourage students to consider how advances in materials engineering and aircraft engine design can contribute to more efficient and environmentally sustainable aviation technologies.

1.5 Methodologies and tools used (PBL structure, facilitation techniques, etc.)

The course followed a Problem-Based Learning (PBL) approach, with students organised into small groups of three to five participants. The tutor introduced the fundamental theoretical concepts and provided the necessary background knowledge to support the learning activities. Students then engaged in collaborative group work and individual research to address specific tasks within their assigned projects.

1.6 Organization of the project (group formation, timeline, milestones)

The project was organised into three small working groups, each focusing on a specific engineering challenge. Regular project meetings, generally lasting three hours, were held throughout the course to support project development, monitor progress, and provide opportunities for discussion and feedback.

1.7 Deliverables requested from students (type, format, deadlines)

Students were required to submit two final deliverables:

- Written project report (.doc format).
- Project presentation (.ppt format).

Both deliverables were submitted during the final course meeting, when students also gave an oral presentation of their project work.

1.8 External collaborators involved (mentors, companies, experts…) and their role

The course included meetings with academic experts who provided students with specialised knowledge and insights relevant to their projects. Prof. Bogusław Menadala (SUT) contributed expertise in aircraft jet engine construction, while Dr. Agnieszka Tomaszewska and Dr. Ivona Bednarczyk shared their knowledge and experience in materials science and engineering.

2. Project Evaluation

2.1 Assessment criteria and methods used

The course combined teaching materials, discussions, and distance learning tools to support the teaching and assessment process. The Remote Education Platform (PZE) was used to facilitate communication with students, distribute course materials, and submit assignments for evaluation.

Assessment methods and criteria

Students were required to submit electronic reports, prepared either individually or collaboratively in groups, through the PZE platform. Each report was assessed by the project instructor on a scale of 0–100%, with a minimum score of 50% required to pass. To successfully complete the course, students had to pass all projects undertaken during the semester.

The final course grade was calculated as a weighted average of the assessed course components (seminars and laboratory activities), with significant weight assigned to the final seminar examination.

Course organisation and attendance requirements

Project classes were organised according to the course syllabus and the project schedule established for the semester. The organisation of the classes and participation requirements were explained during the first session. Attendance at project classes was mandatory.

Students who missed a seminar or laboratory session were required to complete an individual make-up assignment specified by the instructor within two weeks of the missed session. The corresponding individual report had to be submitted through the PZE platform for evaluation.

Additional academic provisions

For students transferring from another field of study or university, or resuming their studies at the Silesian University of Technology, differences in study programmes were determined individually, based on the course syllabus and the educational content previously completed.

The course carried a maximum of 4 ECTS credits.

2.2 Evidence of student learning (examples, outputs, results)

All evidence of student learning, including submitted assignments and assessment results, was recorded and stored on the Remote Education Platform (PZE), the Moodle-

based learning management system used by the Silesian University of Technology (SUT), within a dedicated course space for participating students.

3. Reflections and Recommendations

3.1 Main achievements and strengths of the project

The multidisciplinary approach enabled students to explore the project topics from different perspectives, contributing to a more comprehensive understanding of the subjects addressed. The integration of additional knowledge on green technologies and the ENVIHEI approach to raising students' sustainability awareness enriched the traditional project-based learning activities, making the learning experience more engaging and memorable for students

3.2 Challenges faced and how they were addressed

The main challenge was accessing specialised knowledge on aircraft engine design, as much of this information constitutes proprietary know-how held by companies. To address this limitation, an expert was invited to the class to provide additional insights and clarify technical questions raised by the students

3.3 Lessons learned for future implementations

The experience highlighted the value of integrating the ENVIHEI approach into Problem-Based Learning (PBL) activities. Building on this experience, future implementations should continue to incorporate the ENVIHEI approach across all PBL projects, promoting the integration of sustainability considerations into students' learning activities and project development.

4. Supporting Material

4.1 Lecturers' materials and project documentation

Lecturers' materials and project documentation are available in the following link:

https://drive.google.com/drive/folders/12mCY5LNKmbajMXhJ3sDL9Td-GvMEQTOO?usp=drive_link

4.2 Deliverables produced by students, final presentations or pitch materials

An example of deliverables produced by students is available in the following link:

https://drive.google.com/drive/folders/1NtnodqQ5mvXlSPR_m2ybLB6bSSwxy6fU?usp=drive_link

Students' final presentations are available in the following link:

https://drive.google.com/drive/folders/19UAYb_wF0-kVLe50oyEaS5S8s6V5yfPb?usp=drive_link

4.3 Images/videos (with consent)

Photographic and video records were captured with the explicit consent of the participating students, and are available in the following link:

https://drive.google.com/drive/folders/1o-1rhybvATVsyhuvMJnV1-jYRaFJVQNR?usp=drive_link

4.4 Any other relevant material

All the materials, including this report, are available in the following link:

https://drive.google.com/drive/folders/170vjYtsazRE527cd02YZ6IQtmzdeGHg7?usp=drive_link