PRO HACKIN' project result 6

Showcases of best practices

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1. Introduction

This section aims at providing a general overview of the contents of this document, stemming from the same foundations of the document that presents the guidelines for hackathon implementation as the PRO HACKIN' consortium defined them for the project results #5. This document, in turn, presents the actual implementation of the methodology as it has been adapted by the four PRO HACKIN' consortium partners at their academic institutions, potentially with the involvement of external players, such as companies or other academic partners (e.g. other academic staff from different research units or departments). These examples are provided in order to make explicit the efforts the consortium carried out and show how they fit the PRO HACKIN' methodology to a wider variety of possible applications. This document, therefore, is conceived to provide the reader with first-hand information about the opportunities and the challenges that the implementation of the PRO HACKIN' methodology poses to its expected users, so that its future adaptation to a wider number and variety of university courses (or to company design & development events) becomes easier.

1.1 Hackathon definition and umbrella concept for the Hackathon-like events

A hackathon is a time-limited event, usually lasting between 24 and 48 hours, in which individuals or teams work intensively together to develop innovative solutions to specific challenges. Originally, hackathons focused on programming and software development, but they now encompass a variety of disciplines, including design, business, engineering and social innovation. The term "hackathon" is now used as an umbrella term for similar events such as idea sprints, agile development sessions, designathons and makeathons, all of which share common elements such as problem solving, rapid prototyping and teamwork. A product hackathon is a more focused variant, concentrating on developing or refining a specific product or feature. Unlike traditional hackathons, which may explore a broad range of topics, product hackathons aim to enhance an existing idea or bring a new product iteration to life. The emphasis is on balancing technical innovation with user experience, business value, and product-market fit. These hackathon-like events can focus on different stages of product development, such as ideation, development or hands-on prototyping, and they can be held in person or online. These events might last for some days as well as take place in shorter bursts. Typically, shorter durations are associated to more focused events, whose objectives are fewer (in number) and typically restrained to specific phases of the development process, while maintaining the flexibility and iterative progress central to effective designing. Regardless of format or field, hackathons create an environment that fosters creativity, interdisciplinary collaboration and innovation, making them valuable for educational institutions, businesses and individuals alike.

As mentioned above, hackathon and hackathon-like events are not to be considered synonyms as the latter category covers a wider set of events and initiatives that, in any case, share many common points with each other. However, in the remainder of this document the terms hackathon and hackathon-like events are used interchangeably to ease the reading.

1.2 Target reader of the document

This document targets the needs of different profiles within both the academic and the industrial environments, especially those who might be interested or have a stake in hackathon-like events for two main reasons:

- To facilitate the learning of hackathon-like events participants so that they can acquire both design skills as well as other key skill qualifications that might improve their professional profile
- To speed up the ideation and development process within innovative projects for the (re-)design of products and, more in general, technical/technological solutions aimed at addressing the needs of one or more target users.

These profile, therefore, include both educational staff such as educators, not necessarily restrained to the arena of academic profiles (e.g. high school teachers might be interested too, besides university professors). These profiles, then, also include facilitators and coaches which might provide support to young or adult learners in their practical activities during the hackathons.

Moreover, as the document showcases the examples of implementation in real environments, the expected reader might also be a company manager that aims at getting a preliminary idea of the challenges to face for the implementation of hackathon-like events by means of the PRO HACKIN' methodology together with the benefits this can generate for the staff that participates in these events as well as the results the same can produce in a predefined (and typically shorter compared to traditional initiatives/processes) time frame.

1.3 General requirements for the implementation of Hackathon-like events in regular courses and in collaboration with industrial partners

This document complements the others provided by the PRO HACKIN' consortium and especially the document that covers Project Results #5 (Guidelines for product hackathon realization in various scenarios). Therefore, a detailed set of requirements for the implementation of hackathon-like events is thoroughly accessible in Section 3 of that document. The examples provided hereafter, however, display how the PRO HACKIN' partners considered the opportunities emerging throughout the existing courses they were carrying out at the different institutions and within which they implemented the PRO HACKIN' methodology. The reader will be exposed to the essential conditions for the implementation of hackathon-like events, which include:

- The need to deal with one or more steps of the product development process that can carried out via practical activities (hands-on experiences of active learning);
- The availability of an arena of potential participants with the required essential/basic background knowledge (which they will get enriched by the end of the activities with new elements / skills / competencies);
- The availability of supporting staff, which might support students during the hackathon-like events;
- The possibility to run the activities with small groups of students and enable an appropriate supervision by the coaches during the hackathon-like events;
- Adequate spaces (e.g. rooms) to enable the collaboration among students belonging to the same team, whether this is a virtual space (e.g. enabled via remote collaboration tools) or a real one (a room equipped with tools for live collaboration);
- A timeframe with a duration of not less than 2/3 hours in a row that students can use for the deployment of practical activities;
- The availability of tools for the prototyping of solutions, whether this are formulated as solution concepts (e.g. sketches and/or extremely basic prototypes) or as complete product architecture configured into a specific layout (e.g. represented as a 3D model, digital or tangible).

1.4 Need for adaptation

This document also aims at enabling the reader to familiarize with the PRO HACKIN' methodology and its versatility. In fact, the examples of actual implementation presented in the next subsections are essential to show how the consortium partners adapted the prescriptions of the PRO HACKIN' methodology in a flexible way to the already existing courses they deliver at their own institutions.

A key point that every educator that aims at creating a hackathon-like event must consider is the existence of elements that prevent the direct implementation of the PRO HACKIN' methodology. The PRO HACKIN' consortium already experienced this as the implementation of hackathon-like events into their existing courses had to comply with the existing limitations triggered by the accreditation of university courses within the legal framework of their states, to enable them to award legally valid academic degrees.

These limitations required the academic staff to bend the PRO HACKIN' methodology and its series of events to make it/them compatible with the structures of existing courses, their syllabus and already defined exams rules to evaluate the achievement of intended learning outcomes by the attending students. For this reason, the reader should be aware that this document does not include "as-is" implementation of the PRO HACKIN' methodology, but it works as a compendium of different experiences concerning its adaptation to already existing courses.

On the other hand, other contexts for the implementation of the PRO HACKIN' methodology might generate different types of constraints. For instance, the limited availability of staff holding educational skills in companies might limit the availability of coaches capable of providing methodological guidance during the hackathon-like events. Similarly, and independently from the context of PRO HACKIN' application (whether this happens in academic courses or in companies), the timeframe which is available to the participants for their activities might constitute another important limitation to address. These learning-by doing activities can be distributed in a series of event having the same goal (through a convenient extension of the hackathon-like event into a multitude of short ones) or collapsed into a unique event in case the design challenge/case study at hand makes this possible (e.g. some product design phases might be shortened in duration to enable participants to quickly access the next design stages).

1.5 Structure of document remainder

The remaining part of the document includes two main sections: the next one provides a general summary of the PRO HACKIN consortium's efforts to implement methodology and highlight how all the different initiatives embedded hackathon-like events. Such a section also highlights the commonalities and the differences between these initiatives to provide the reader with a clear overview of how the requirements described above have been satisfied and which additional type of constraints needed to be tackled for adequate implementation.

Then, an additional section presents the different initiatives that every consortium partner independently carried out for the hackathon implementation, organized into a repeatable structure. Each contribution describes the general structure of the course where the PRO HACKIN' methodology was adapted and then implemented for the creation of hackathon-like events. Then, these describe the relevance of the PRO HACKIN' approach to the course and make clear what are the essential elements of the methodology / guidelines (PR5 document) have been used in practice. Each subsection is also enriched with the description of the actual implementation carried out by each partner and a list of the benefits that they observed with reference to more traditional educational approaches.

To provide a more general perspective on the benefits the PRO HACKIN' methodology generated in these different implementations; the concluding section provides a summary of the positive outcomes observed together with a critical analysis of open challenges for their replicability. Additional opportunities for implementation the consortium is already considering are also presented to highlight future opportunities for additional project implementation and the dissemination/adoption of its main findings.

2. Framework of hackathon-like implementations showing the best practices

2.1 Variety of events proposed by the consortium

The implementation of the Pro Hackin' methodology within the already existing body of classes and courses carried out at the different institutions required adequate tailoring activities. This is necessary as the institutions might have already undergone accreditation processes with national bodies which needs to guarantee the compliance of the whole study course with the national laws and regulations to award students with legally valid degrees. As such, the reader should not be surprised by the presence of some differences between the Pro Hackin' methodology and its actual implementation in existing courses.

Table 1: Summary of the Hackathon-like events at the different institutions of the consortium. Partners by row, Hackathon-like events as for the PRO HACKIN' methodology by column.

University	Pro Hackin' Opening Event	Pro Hackin' Product Hackathon 1	Pro Hackin' Product Hackathon 2	Pro Hackin' Product Hackathon 3	Pro Hackin' Closing Event
UNILJ	Introductory presentation on the product development process and the expected activities for each development phase (combination of PH1 objectives)	Exploration of the product area and thorough research for a detailed problem definition.	Concept development and selection (implementation of PH2 objectives)	Design of the embodiment, selection of the final components and their cost.	Final presentation of the results from all phases of product development, virtual or simple 3D-printed prototypes
UNIZAG	-	Product teardown workshop that includes disassembling and analysis of the technical features of real-world products.	Conceptual design workshop during which students are encouraged to develop new conceptual solutions. After the initial selection of the conceptual solution, teams work on its further embodiment. As such, it covers aspects of both PH2 and PH3 events).		
TUW	Presentation of the project assignments by educators. Collection of the relevant standards and design guides by students (combination of PH1 objectives)	-	Conceptional Design and layout of the machine element (Objectives from PH2), starting with initial calculations, hand drawn sketches, progressing towards early cad models.	Embodiment Design (Objectives from PH3), co-development and finalization of 3D cad model and allowed stress calculation from standards.	Closing Event: preparation of production documentation and final presentation of the machine element's 3D Model.
POLIMI	Presentation of the case study by the industrial partner to student teams (it reflects Pro Hackin' kick—off event, but students already know each other)	Definition of a shared vision for the problem and gathering of relevant data (it reflects Pro Hackin' PH1 hackathon as students collect	Shared analysis of LCA results, definition of main problems and formulation of alternative ones. Collaborative generation of multiple directions of solution to address the environmental problems (it reflects part of Pro Hackin' PH2 as it requires student to start from problems and		Presentation of the results of the project (it reflects Pro Hackin' final event as students need to summarize their work collectively in a short presentation)

		data from external sources and contribute to generate a shared understanding of the situation at hand)	identify possible opportunities to develop the product differently)		

Table 1 summarizes the initiatives that the different academic institutions that partner the Pro Hackin' consortium carried out within their academic courses to display how the project methodology can fit many different scenarios of application. More specifically, Table 1 presents the different series of hackathon-like events that the partners carried out and creates a link to the hackathon-like events that characterize the Pro Hackin methodology in order to provide the reader with a general overview of the activities they carried out and facilitate the identification of potential similarities with the needs of third parties who would like to adapt and finalize similar Pro Hackin' methodology implementation in academic courses taking place as part of regular study curriculum.

Additional details about the specific implementation of the Pro Hackin Methodology are detailed in the next section (Actual Hackathon-like implementations)

2.2 Requirements of the PRO HACKIN' methodology and implementation-related constraints

In the introduction of this document, a general set of requirements to consider before the implementation of Hackathon-like events have been presented in brief (full details are available in the other deliverables, mostly PR3 - Manual for hackathon implementation and PR5 – Guidelines for hackathon implementation). The actual implementation of the methodology required its adaptation, as the courses presented in Table 1 took place with significant differences compared to the PRO HACKIN' course and its series of 3 hackathon-like events.

All the above implementations of hackathon-like events in regular courses deal with one or more steps of the product development process. Specifically, these are all requiring, to different extents and in different stages of the design process, the students to carry out practical activities that can foster active learning. It is however necessary to underline that just one out of the 4 implementations of the methodology cover the whole set of PRO HACKIN' hackathon-like events (Ljubljana). The other 3 implementations by the other consortium partners cover a subset of them. None of the implementations regards less than two hackathon-like events.

The next section of this document will also provide details about the implementation of the course into two very different settings, depending on the number of students/participants. None of the implementations dealt with as many participants as in the regular PRO HACKIN implementation (approximately 40 students). Three courses out of four have more than 100 students, while one a smaller number (13 students overall). The relevance to product design and development of the courses in which the hackathon-like events took place, enabled the partners to populate the activities with students already equipped with the required essential/basic background knowledge. These were fit to deal with the essential steps of the product development process and its practical activities, while they also extend their competences and skills through the accompanying lectures they can attend during the semester.

However, the large number of participants in most of the above courses complicated the satisfaction of the requirement concerning the availability of supporting staff, which needs to actively participate in the hackathon-like events to support students during their hands-on activities. The partners dealing with large numbers of students per class successfully managed to tackle the above issue as they split the classroom into subgroups of smaller student size. Within these subgroups, the partners created small teams that are manageable by supervisors, thus reducing the number of coaches that concurrently need to interact with students.

The locations to enable the proficient execution of hackathon-like events had to be properly defined in advance, as a standard classroom conceived for the delivery of traditional ex-cathedra lectures does not enable the required level of interaction among the participants. Some partners shifted the hands-on activities typical of the hackathon into adequate premises which are also potentially equipped to enable students to carry out practical work (e.g. technical laboratories or computer-equipped rooms). The class with few students (13) faces minor limitation despite the location of the hackathon-like events is a room for traditional ex-cathedra lectures. Both the room size (50+ seats) and the essence of the project work, which did not require anything else than a laptop and a shared desk, enabled a versatile use of the space. Students organized their work in the classroom corners, facing each other from two consecutive rows of seats with a flat desk in between. Tools for remote collaboration made it possible for students that had obstacles to physically attend the event, to join from other places (their flats/home or a different university campus).

3. Actual Hackathon-like implementations

3.1 Example of University of Ljubljana, Faculty of Mechanical engineering

3.1.1 What course the implementation took place in

Around 140 students took part in the "Design Methodology" course in the summer semester of the study year 2023/2024 and worked in teams of 2-4 people to develop innovative physical products. The course focused on new product development and guided students through the technical design process. Throughout the semester, teams chose their own design tasks and worked their way from concept to detailed design. The course incorporated a hackathon-like approach, especially in the final days before important deadlines. Students were familiarized with the principles of product hackathons in the lectures and were able to apply them to their project work. In 30 hours of lectures and exercises and 40 hours of independent work, the students gained practical experience in concept creation, the design process and prototyping. The goal of the course was to teach students the importance of user-centred design, ergonomics and technical specifications. By the end of the course, students were able to understand the entire development process, from ideation to prototyping, using creative methods and techniques.

3.1.2 Why are Pro Hackin' methodology and guidelines relevant to this course

Hackathon methodology and guidelines are highly relevant to the "Design Methodology" course because they promote rapid, focused problem-solving, which is crucial in new product development. Hackathons encourage teams to collaborate intensively under time constraints, mirroring real-world scenarios where deadlines drive innovation. By applying hackathon principles, students can learn to efficiently manage the design process, from ideation to prototyping, within limited timeframes. This method fosters creativity, teamwork, and adaptability, which are key skills in engineering and product development. Additionally, the iterative nature of hackathons aligns well with the design cycle, helping students quickly test and refine their ideas based on user feedback and technical specifications. Thus, hackathons enhance students' ability to produce tangible, well-conceived products within the course's structured, hands-on format.

3.1.3 How it was implemented

In the "Design Methodology" course, hackathon methodology was implemented by structuring the project work to simulate a hackathon environment. Students worked in teams throughout the semester to address self-chosen design challenges. The course began with lectures introducing the principles of product hackathons, teaching students how to rapidly prototype and iterate their designs. The semester was divided into two main reporting periods, with teams expected to make significant progress by each deadline. As these deadlines approached, students worked intensively in a hackathon-like mode, focusing on rapid problem-solving and collaboration. The structure encouraged them to apply creative design techniques, quickly generate concepts, and develop prototypes (Figure 1). This approach replicated the fast-paced, deadline-driven nature of hackathons, giving students real-world experience in managing time and resources to bring their designs to completion.

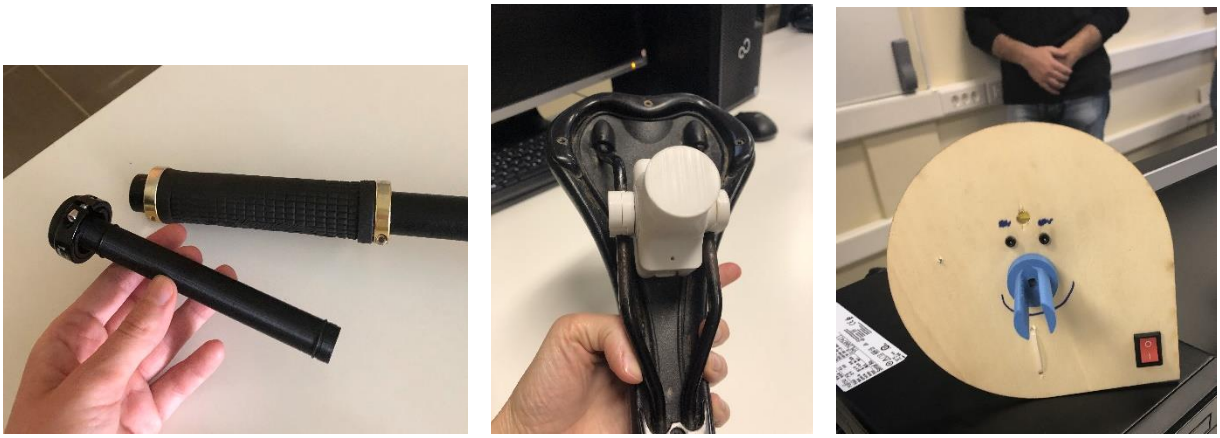

Figure 1: The students' prototypes at the end of the design methodology course

3.1.4 Observed benefits

The implementation of the hackathon methodology in the "Design Methodology" course led to several observed benefits. First, it promoted rapid learning and application of design principles and helped students grasp complex concepts more quickly. The time-limited nature of the hackathon mode improved teamwork, as students had to collaborate efficiently under pressure. This also boosted creativity and problem-solving skills as teams had to quickly develop and refine ideas. The hands-on approach allowed students to better understand the practical aspects of the engineering design process, from concept creation to prototyping. In addition, the focus on user needs and technical specifications helped students to develop user-centred and technically feasible products. Overall, the hackathon-like format provided hands-on experience and improved students' ability to manage projects, meet deadlines and produce tangible results in a limited amount of time.

3.2 Example of University of Zagreb, Faculty of Mechanical engineering and Naval Architecture

3.2.1 What course the implementation took place in

The implementation of hackathon-style events took place as a part of the *Product Development I* course, aimed at providing mechanical engineering students with a comprehensive understanding of product development, engineering innovation, and teamwork. The course aims to introduce these students to the multidisciplinary aspects of product development and engineering innovation. Through a combination of lectures and tutorials, the course covers project planning, product analysis, conceptual design, organisational strategies, and intellectual property management. In this way, the course covers theoretical foundations and practical exercises required to understand engineering design and product development processes. To be more specific, the intended learning outcomes are:

- Analyse user needs for the development of the new mechatronic system
- Compare existing technical solutions and products on the market
- Create functional decomposition of the mechatronics system
- Create technical specifications and the house of quality for the development of the mechatronic system
- Generate and select conceptual solutions for the mechatronic system

This course annually attracts more than 120 students, which are usually divided into groups of 20 students (for tutorials). However, for specific activities within the course and for hackathon-like events, groups are divided even further into teams of 3-4 team members. The traditional course structure consists of 13 weeks (lectures and tutorials) with the exception of one or two events ("hackathon-like" event – 3 hours each).

3.2.2 Why are Pro Hackin' methodology and guidelines relevant to this course

The Pro Hackin' methodology and guidelines are highly relevant to the *Product Development I* course as they emphasise rapid, hands-on problem-solving and practical applications of theoretical knowledge. This methodology aligns with the course's goal of multidisciplinary innovation, allowing students to engage in more "real-world" product development activities within a controlled yet dynamic environment. The introduction of this methodology and guidelines offers new opportunities and frames/structures the tutorials (and included exercises) in a more engaging and dynamic manner.

By integrating short, intensive events into the course—such as the product teardown and conceptual design workshops—the methodology enabled students to experience the pressure and creativity associated with real product development cycles. The hackathon format provided an opportunity for students to apply theoretical concepts in a time-constrained, collaborative setting. As such, this supports competencies related to critical thinking, technical problem-solving and collaboration in team settings.

These events offered hands-on exposure to the specific aspect/phase of the product development lifecycle, making them directly relevant and mapped to the intended learning outcomes of the course.

3.2.3 How it was implemented

The hackathon-style events were integrated into the traditional structure of the course. These workshops were scheduled during the usual timeslots planned for tutorials. To maintain the same ECTS credits, some tutorials were condensed into these hackathon-like events.

Two key workshops were implemented: a *Product Teardown Workshop* (related to the PH1 objectives) and a *Conceptual Design Workshop*.

The *Product Teardown Workshop* allowed students to disassemble and analyse the technical features of real-world products. The products were provided by industrial partners, ensuring that the teardown was relevant to current industry standards. The goal of this workshop was to give students a deep understanding of product functionalities, design constraints, and material properties by engaging them in such a task. The teardown process was collaborative, encouraging teams of 3-4 students to engage with the technical aspects of product disassembly, analysis, and problem-solving within a three-hour timeframe. The teaching staff is involved in providing real-time feedback and guidance.

Figure 2. Product Teardown Workshop

The virtual variant of this workshop (developed in a CAD environment) was perceived as very useful during the period of university renovation when some activities were not performed as traditionally. Later analysis showed that, despite not being carried out in physical laboratories and workshops, this workshop replicated to a major extent activities in physical teardown activities. This allowed students to obtain the learning outcomes, even in such "crisis-like" situations.

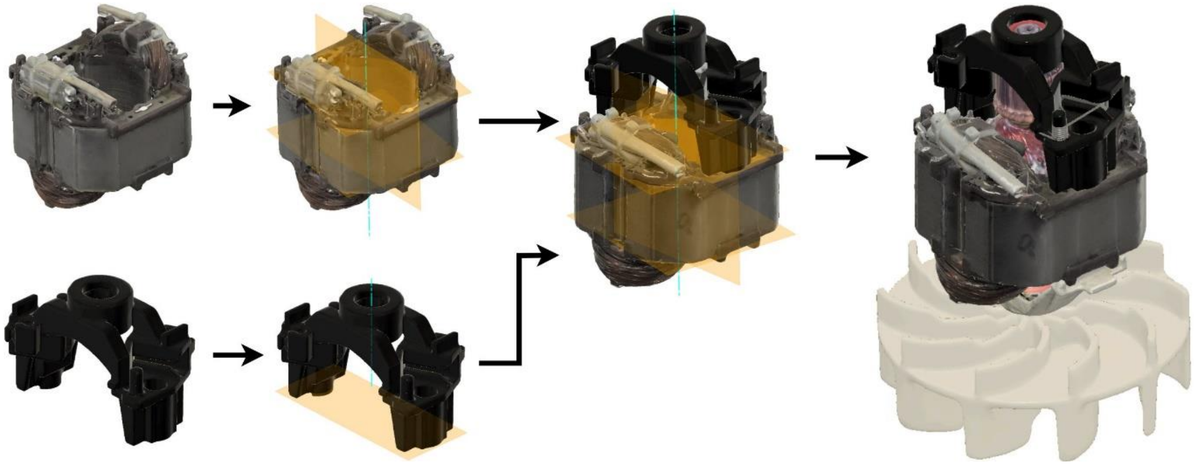

Figure 3. Preparing virtual models for virtual Product Teardown Workshop

Depending on the course circumstances, in some course editions, The *Conceptual Design Workshop* followed. Inspired by design thinking workshops held as a part of the *Innovation Management in Product Development* course at the same Uni (some course leaders), the same workshop concept was reused within the context of this course. This workshop, held in a physical setting, encouraged creative problem-solving and brainstorming within teams, focusing more on the development of technical conceptual solutions. Students were provided with a design task (usually not related to the product teardown), requiring them to explore existing solutions and conceptualise new ones.

3.2.4 Observed benefits

Unlike traditional exercises that focus on theoretical knowledge and pre-defined problem-solving scenarios, these hackathon-style workshops introduce more dynamic, hands-on learning experiences. Students actively engage in product disassembly and conceptual design workshops, fostering critical thinking, collaboration, and creativity.

As such, implementing physical/virtual product teardown and conceptual design workshops significantly enhances the learning experience in the *Product Development I* course (such courses often rely heavily on lectures and theoretical tutorials). The implementation of these hackathon-like events offered several benefits:

- Improved practical skills
- Increased awareness of team collaboration settings in a controlled environment (face-to-face or via online collaboration tools)
- Increased engagement and motivation of participating students (and teaching staff)
- Improved supervision and guidance of students (teaching staff provides real-time guidance, helping students refine their problem-solving approaches)

In addition, the virtual option for product teardown, specifically, offers increased flexibility and scalability, making it more adaptable to contemporary, remote learning environments—something that traditional tutorials often lack. As such, it is suitable for courses with large cohorts or remote learning settings.

3.3 Example of TU Wien, Faculty of Mechanical and Industrial Engineering

3.3.1 What course the implementation took place in

"Machine-Elements Engineering Design Training" (3 ECTS) is a bachelor-level course aimed at mechanical and industrial engineering students. Each academic semester the course facilitates roughly 200 students. Groups of approximately 20 students are guided by an educator, and within these groups, students form teams of 3-4 members. Each team works collaboratively on a practical project, typically focused on designing and developing a two-staged gearbox or a piston compressor within the timeframe of a month. The course is the practical counterpart to an accompanying theoretical lecture and requires students to apply, integrate and consolidate previous knowledge from the domains of mechanics of solid bodies, fundamental principles of engineering design and technical drawing/CAD. Upon completion of the course, students will learn how to:

- Calculate, design and select machine elements (shafts, gears, piston drive components, bearings, housing) to standards and design guidelines.
- Determine the type of lubrication necessary for the system by considering thermal operating conditions.
- Independently organise within the teams and perform the design task for all stages of problem clarification, conceptualization, and virtual prototyping.
- Recognize and evaluate the advantages and disadvantages of the chosen machine elements within the given operational conditions.

3.3.2 Why are Pro Hackin' methodology and guidelines relevant to this course

Previously, the "Machine-Elements Engineering Design Training" course had to be completed independently by each student, which meant a high workload on students and educators. We observed that students worked on their individual assignments in TU Wien's CAD-Lab and, while not mandatory, for the most part, the whole group of students worked there simultaneously, helping each other, sharing information and best practices. Since students were already collaborating intensely and in a short timeframe, it was decided to change the format to group work and implement hackathon like events as gates to finish assignments under tutor supervision and later combine it with design reviews.

The course structure is strongly oriented towards the five major events of the methodology and students are required to work on a project-based assignment similar to the extra-curricular classes held in the scope of Pro Hackin'. Although this version of the course does not involve an industrial partner that initiates a design challenge and facilitates the design reviews, and the work is done mostly in a live setting, rather than remotely.

3.3.3 How it was implemented

The implementation of the Pro Hackin' methodology into the "Machine-Elements Engineering Design Training" course involved restructuring the course into a series of hackathon-like events. This shift transformed the traditional individual work format into a collaborative, team-based approach. The course now follows five key events that centre around student teams working under tutor supervision and are followed up by a design review in a gate like process.

Kick-Off Event: The course begins with a kick-off event, where students are introduced to their assignments and made familiar with the course structure, timeline, and expectations. Teams of 3-4 students are formed, and the project tasks are distributed. The challenge typically involves designing a two-stage gearbox or a piston compressor, and students are guided in organizing their approach to the task.

Following the Kick-Off Event students are expected to collect the respective requirements from standards, review principles of constructive design theory of mechanical components and do desk research on the respective machine elements. Similar to activities from PH1 of the Product Hackathon methodology to establish a shared understanding of the problem and decompose it to create more manageable sub-problems (can be done for individual parts and calculations).

Hackathon like event similar to PH2: The hackathon like event focuses on the initial calculation and layout of the machine elements and the creation of a hand-drawn sketch of the assembly. During this phase, students are expected to apply their theoretical knowledge to generate preliminary designs under tutor supervision.

Hackathon like event similar to PH3: This is followed by the second hackathon, which centres on the detailed planning and the creation of the basic CAD model. At this stage, teams work intensively on finalizing the initial components and preparing for more advanced design tasks.

The final product structure and detailed design is determined before the closing event. Finalizing the CAD design also goes along with finalizing the calculations for the relevant elements, since they are iteratively aligned with the 3D model to meet the required standards.

Closing Event: The course culminates in a closing event, where students are required to verify that a specific component of their design (for example, the input or output shaft of the gearbox) meets global load capacity requirements, especially in areas prone to stress concentration, such as notches on the shaft. After verifying strength and durability, students derive production-ready drawings from their 3D CAD models and the bill of materials.

In addition to submitting their final design, students present their projects in an oral presentation to educators, tutors and peers. This presentation covers the design process, challenges encountered, key decisions made, and the final outcome. The oral presentation provides an opportunity for students to showcase their problem-solving skills, defend their design choices, and receive feedback on both their technical and presentation skills.

3.3.4 Observed benefits

The shift to a hackathon format has yielded several benefits for both students and educators. One significant improvement is the overall quality of submissions. By working in teams and having multiple touchpoints with tutors, students are able to produce more well-rounded and thoroughly designed projects, benefitting from the intense exchange of ideas and knowledge with their peers. The collaborative format has reduced the workload on individual students, making it more manageable and better aligned with the course's 3 ECTS credit allocation. However, it is more challenging to determine whether the intended learning outcomes are met by each individual student, making tutor feedback, which is much more involved during the development process, crucial for evaluating individual performance.

Additionally, the focused, time-constrained nature of the hackathon events ensures that students remain engaged and motivated. These events provide a structured process where each stage acts as a quality gate, ensuring that students achieve tangible progress throughout the course. This structured workflow encourages students to stay on task and continuously refine their designs based on immediate feedback from their educators.

One of the most significant advantages of this format is that working in teams better reflects real-world engineering problems. In professional settings, engineers rarely work in isolation; they collaborate across disciplines, work within teams, and deal with shared CAD environments. In this course, students face similar challenges: coordinating tasks, managing conflicting schedules, and integrating various subsystems into a unified design. Additionally, they must address common real-world issues such as version control, managing changes to the CAD model, and ensuring compatibility between different components and assemblies. This team-based approach provides a more accurate representation of the complexities engineers face in industry, while also enhancing students' problem-solving and communication skills within a collaborative framework.

3.4 Example of Politecnico di Milano, School of Industrial and Information Engineering

3.4.1 What course the implementation took place in

Fifteen students took part in the "Creativity for Sustainable Design" course (3+2 ECTS) in the spring semester and worked in teams of 3-4 people to improve their skills on the identification of environmental problems and the inherent opportunities to develop products which are more eco-friendly and nature compliant. The students have different background as this is an elective course which is accessible from different study courses and integrable to different study plans. The 15 students were composed by Mechanical Engineers, Management Engineers and Industrial Designers, evenly distributed. The course includes practical activities for the development of an LCA study (retrieval of data and creation of product system models and Problem Identification) and the
identification of possible opportunities for sustainable product development (at conceptual level). Throughout the semester, the teams must focus on a case study proposed by an industrial partner, which regards a product that is potentially environmental harmful and that requires redesign to be made more sustainable. The course aims to make students capable of, among the other intended learning outcomes:

1. Creating a Product System model (Process model) for the life cycle of the product (Cradle to Gate/Grave);
2. Analysing the results of an LCA study and evaluate the main problems that trigger the most significant environmental impacts;
3. Generating alternative problems to facilitate the exploration of a wider set of creative ideas.

3.4.2 Why are Pro Hackin' methodology and guidelines relevant to this course

Hackathon methodology and guidelines are highly relevant to the "Design Methodology" course because it has a structure that combines theoretical lectures with practical activities that are carried out in teams. In such activities students are required to:

- search for relevant product data and information individually and in teams;
- communicate with each other and share their findings both internally and with the industrial partner;
- agree, as a team, on the next steps of their workplan together;
- harmonize their findings and generate a shared product model and life-cycle model;
- observe environmental problems from different perspectives;
- generate (directions/opportunities of) solutions to address the environmental problems through product redesign;
- select the most promising directions of solutions to propose to the industrial partner.

For this reasons, part of the practical activities carried out by students during the course appear to be particularly overlapping the purpose of the main phases of the product development process proposed by the Pro Hackin' methodology, which favours an easier adaptation of the same.

Among the above items, the Pro Hackin' methodology appears to be particularly relevant for students learning in order to:

- build a shared understanding of the situation at hand (development of a shared [mental] model of the problem);
- have a clear plan of activities and organization of the work in order to be effective for achieving the goals of product development required by the course/case study topic;
- share/distribute the workload among the different team members for individual activities both during and beyond the duration of the collaborative moments together, to advance with the small project/product design stages;
- converge towards shared opportunities for product development by means of pros/cons evaluation (the focus, here, is on the environmental improvements the proposed solution brings).

3.4.3 How it was implemented

In the "Creativity for Sustainable Design" course, hackathon methodology was implemented by structuring the project work to simulate a hackathon environment within some of the practical activities the students have to carry out within the course, whose duration was never below 2 hours or exceeding 4 hours in a row. More specifically two events can be classified as hackathon like events, despite the adaptation also involves the adaptation of the kick-off and the final event structure.

Kick-Off: This Kick-off meeting shares these elements with the related ProHackin KO event:

- The teaching staff presents the overall structure of the project work which will be used for the evaluation of the course at the end of the semester
- The company presents the case study to the participants and receives questions to clarify the context of the "design topic", which is not structured as a challenge anyway (Figure 4)
- The students can start building on each other's reflections together with the company from the very beginning in plenary context (no team subdivision)

Figure 4: Excerpts from the presentation held by the company (Elettrotecnica ROLD) to introduce the case study/design project work

First event (Hackathon-like): The first event shares common elements with the first hackathon proposed within the ProHackin' course structure, as here the teams have to:

- create a shared perspective of the problem boundaries, here it is done by means of refining their product system model [process model] altogether, after they have carried out some work individually, which includes the breakdown of the product parts, which is essential in order to identify the elementary flows of the process model (Figures 5 and 6).
- students have to retrieve the relevant primary data from different sources, using different digital tools or instruments, to feed their product system model with the data required to run effectively an LCA study coherently with one of the provided models to estimate the potential environmental impacts due to the product lifecycle (the analysis is carried out with a cradle to gate logic, but this mostly depends on the traceability of the product used for the case study during its life cycle).

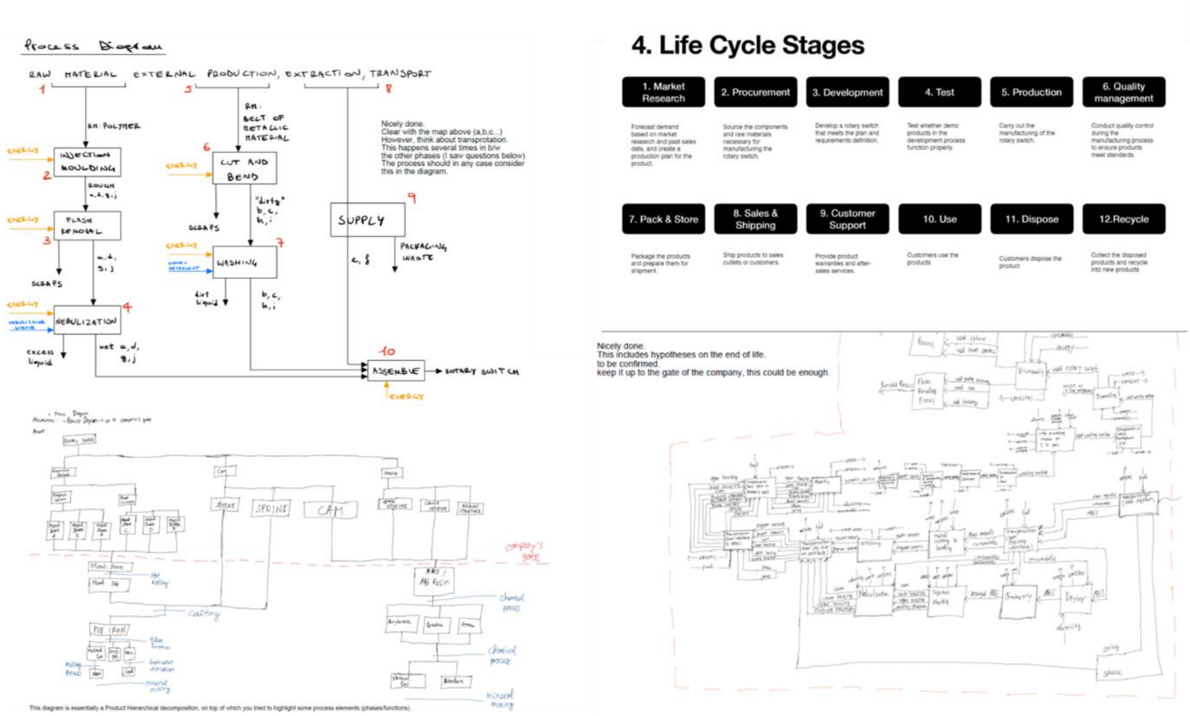

Figure 5: Some individually created process diagrams (product system models) for the creation of the Life Cycle Inventory the students shared during the first hackathon-like event

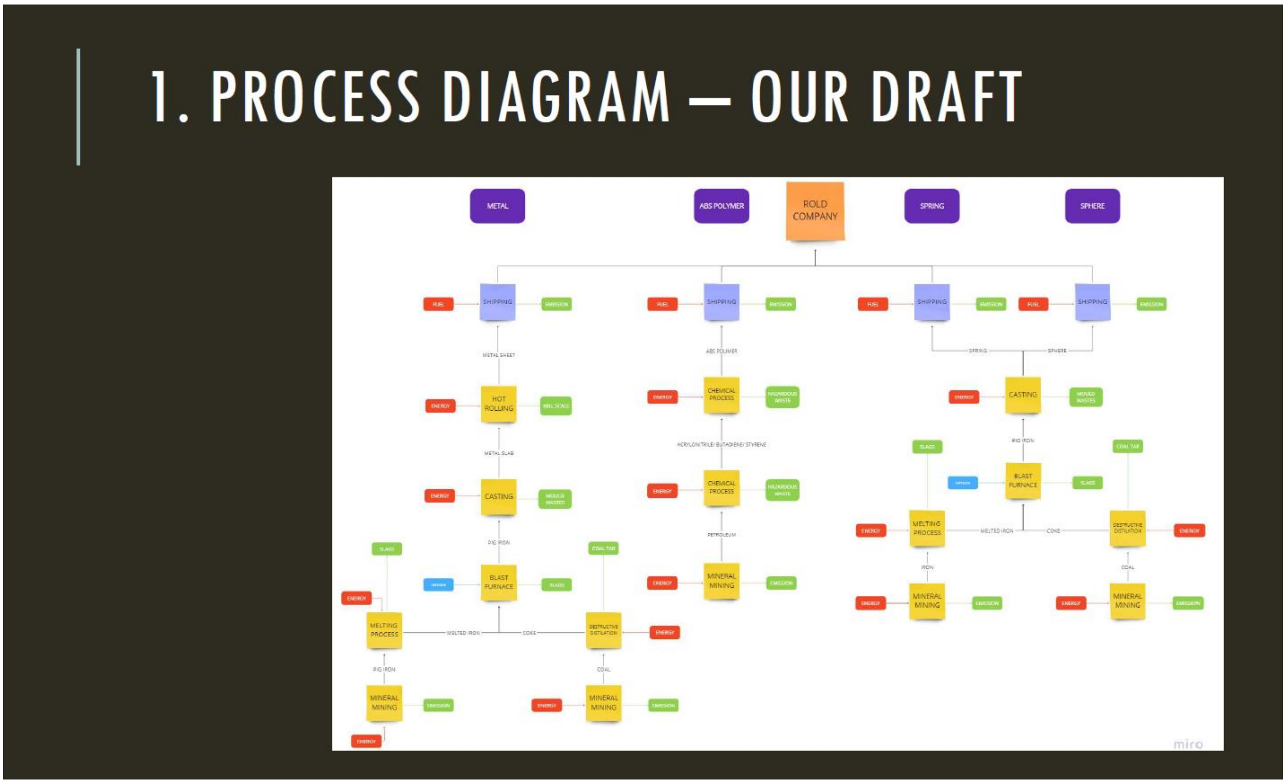

Figure 6: the process diagram that the team created after reconciling the individual contributions proposed at the beginning of the hackathon

Second event (Hackathon-like): The second event shares common elements with the second hackathon of the Pro Hackin course structure as the teams have to:

- Consider the problems that are affecting the product development (despite for such implementation the focus is oriented, by definition, towards problems of environmental sustainability – Figure 7) and further explore them, so that they can define them according to different perspectives (reformulation) and, according to the inherent requirements;
- Generate an adequate set of ideas by addressing all the different problems they have identified, potentially converging towards one or more directions of solution that harmonize their views into a coherent development strategy that might support the identification of relevant product concepts (Figure 8)

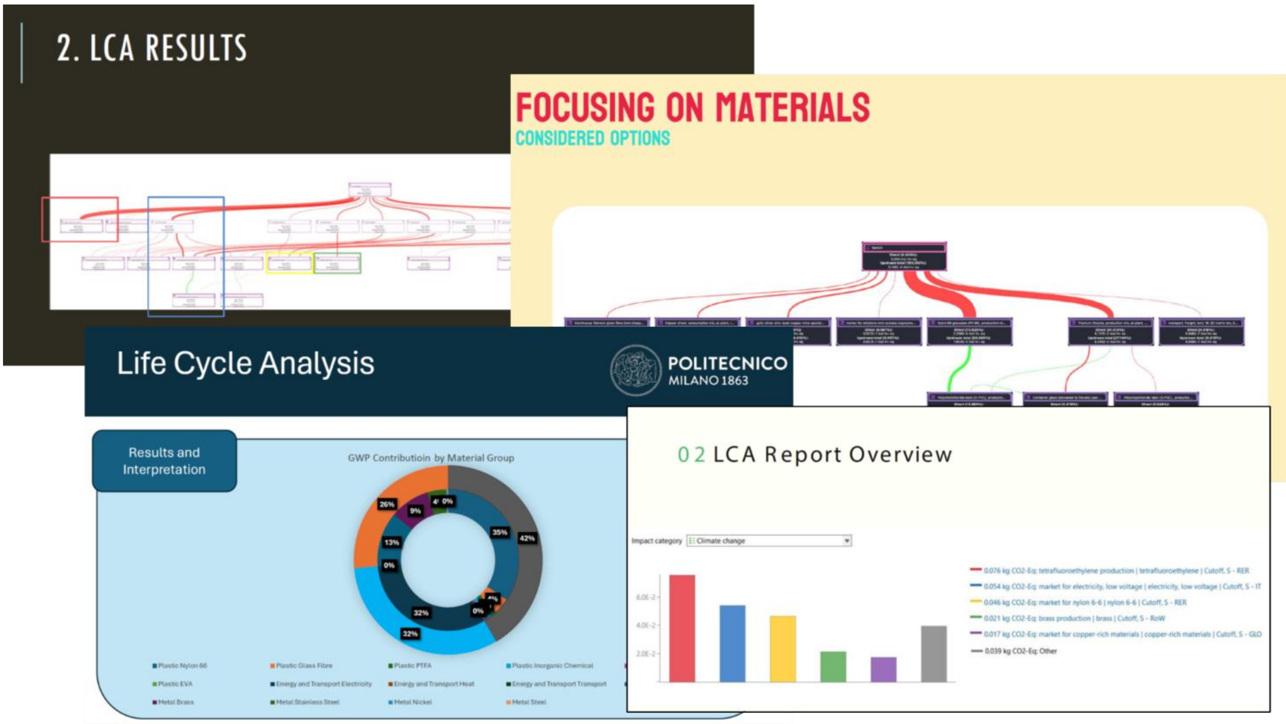

Figure 7: Excerpts of the LCA results obtained by the 4 teams that participated in the second hackathon-like event

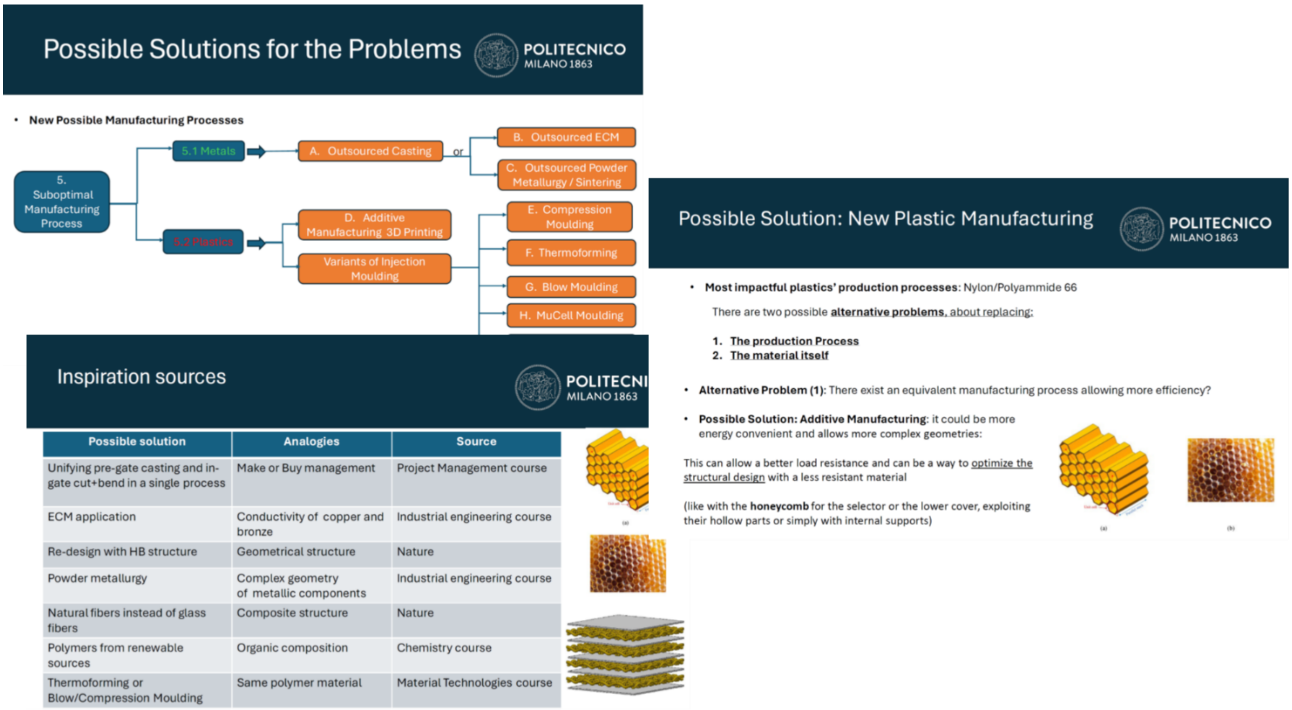

Figure 8: An example of directions of solutions identified by one of the 4 teams participating in the hackathon event and the identification of the most promising one to be considered for implementation

Final Event: The shared elements with the final event of Pro Hackin' mostly concern the way the results are presented to the evaluators, as the team show the work done with a presentation and a shared pitch where all the team members present part of the outcomes from the beginning of the project work (presentation of the method used and the outcomes achieved)

3.4.4 Observed benefits

The students participating in the course benefited from the hackathon like activities because these make it possible to let them familiarize with practices which are not common in standard university courses. The engaging environment of the hackathon-like events facilitated their active participation in the project work. Beyond this, the project work they carried out by means of this Pro Hackin-based implementation enabled the achievement of different knowledge acquisition objectives as well as practical skills. In particular, these activities enabled:

- The creation of a working context where they were induced to collaborate, so that their communication and sharing skills should be practiced, with mutual benefits deriving from the observation of errors as well as best practices of peers that students can replicate within this course and in other contexts
- The direct application of theoretical concepts the students have been exposed to during the course implementation with traditional lectures. These implementation activities required them to use online collaboration tool they can rely on also beyond the duration of the hackathon-like event (e.g. MIRO as a shared board for concept sharing and development)
- The concurrent search for information they needed to harmonize by means of intra-group discussions for the reconciliation of different and potentially discording perspectives, towards the selection of reliable information sources versus the exclusion of non-reliable ones.

4. Conclusion: Summary of the benefits and replicability of the implementations

4.1 Transversal benefits of hackathon like implementations

The implementation of hackathon-like activities across various institutions has yielded a multitude of benefits, enhancing both the learning experience and skill development of students. The observed benefits include the acquisition of skills as well as good practices. The following paragraphs highlight the ones that emerged more frequently with reference to the above presented experiences.

Enhanced Teamwork and Collaboration Skills: The collaborative nature of hackathons fostered improved communication and teamwork. Students learned to work effectively in teams, mirroring real-world engineering environments where collaboration is essential. All institutions noted that teamwork was a cornerstone of the hackathon experience. Students developed essential soft skills such as communication, conflict resolution, and cooperative problem-solving, which are critical in professional environments.

Improved practical skills and hands-on experience: Students actively engaged in tasks such as product disassembly, conceptual design, and rapid prototyping. This hands-on approach facilitated a deeper understanding of theoretical concepts by directly applying them to real-world scenarios. By engaging directly with practical tasks, students could better grasp complex concepts and see the real-world applications of their theoretical knowledge. This approach bridged the gap between classroom learning and practical execution. (Mentioned by TUWien, Uni Ljubljana, and Politecnico di Milano)

Increased Engagement and Motivation: The dynamic, time-constrained environment kept students engaged and motivated. The intense exchange of ideas and immediate feedback sustained their interest and encouraged active participation throughout the learning process. The competitive and dynamic nature of hackathons kept students invested in their work. The urgency and excitement of the events drove them to be more attentive and committed to their projects. (Mentioned by TUWien, Uni Zagreb, and Uni Ljubljana)

Boosted Creativity and Problem-Solving Abilities: Working under pressure to quickly develop and refine ideas enhanced students' creativity and problem-solving skills. They were challenged to think innovatively and find effective solutions within tight deadlines. Time constraints and collaborative settings pushed students to think outside the box. They had to quickly generate and iterate on ideas, enhancing their ability to innovate under pressure. (Mentioned by Uni Ljubljana, Uni Zagreb, and Politecnico di Milano)

Immediate Feedback and Improved Supervision: Real-time guidance from teaching staff helped students refine their approaches and improve outcomes. Enhanced supervision allowed for critical evaluation of individual and team performance. Continuous interaction with instructors allowed for on-the-spot guidance and correction. This immediate feedback loop helped students adjust their strategies promptly, leading to better learning outcomes. (Mentioned by TUWien, Uni Zagreb, and Politecnico di Milano)

Improved Project Management and Adherence to Deadlines: The structured, time-limited format taught students to prioritize tasks, manage time effectively, and deliver tangible results promptly.

Managing projects within a limited timeframe taught students to organize tasks efficiently and respect deadlines, skills that are highly valued in any professional setting. (Mentioned by Uni Ljubljana and Uni Zagreb)

Reflection of Real-World Engineering Challenges: Students encountered professional challenges such as coordinating tasks, managing conflicting schedules, integrating subsystems, dealing with version control, and ensuring component compatibility. This exposure prepared them for industry complexities. By simulating professional engineering problems, students gained insights into the complexities of the industry. They learned about project coordination, system integration, and technical collaboration, preparing them for future careers. (Mentioned by Uni Zagreb and Politecnico di Milano)

Use of Online Collaboration Tools: Utilizing tools like MIRO facilitated virtual teamwork and collaboration, skills that are increasingly valuable in remote learning and professional settings. Familiarity with digital collaboration platforms prepared students for modern work environments where remote communication and teamwork are common. (Mentioned by TUWien and Politecnico di Milano)

4.2 Main points of concerns/lessons learned

The implementations presented above provided an essential testbed to validate the key-points of the PRO HACKIN' methodology, together with the observed benefits highlighted above, there are also elements which deserve attention from different angles. The achievement of learning outcomes is facilitated via active learning activities. The hackathon-like approach effectively improved practical skills, teamwork abilities, and overall student engagement. By bridging the gap between theoretical knowledge and practical application, students were better prepared for professional engineering practice.

The implementation of the hackathon into existing courses also brought a new spirit in the same, potentially raising their attractiveness to other students. The extension of these practice might be beneficial if extended to other domains and/or academic subject still in the domain of engineering design. The flexibility in implementing hackathon methodologies allowed institutions to tailor activities to specific course objectives and student needs. Adaptations included virtual workshops during facility renovations, adjustments for interdisciplinary teams, and modifications to fit existing course structures. On the other hand, this also mean that implementing hackathon-like activities necessitated significant adjustments to traditional course structures. Educators had to redesign course timelines to incorporate intensive work periods without overwhelming students. This involved condensing tutorials into workshops, (re)scheduling hackathon events, and ensuring these changes aligned with the course's learning objectives. The hackathon-like events, then, should also be organized so that it complies with the already accredited course structure and syllabus to keep its legal validity for the awardability of the degree.

The benefits are at the same time balanced by some additional efforts which are required, at least at the very beginning of the activities (e.g. before a series of hackathon-like events). Hackathons are human-intensive events. On the one hand, educators needed to adapt to new roles as facilitators of collaborative, intensive learning environments. This included preparing to introduce students to hackathon principles, supervising team-based projects, providing real-time feedback, and developing fair assessment methods for group work. Some coaches/facilitators needed some dedicated training sessions for full functionality within the project. This also means, that hackathon-like events required additional resources to support hands-on activities and collaborative work. This included materials for prototyping, access to online collaboration tools for virtual environments, coordination with industrial partners, and logistical support for both physical and virtual hackathon events.

On the side of students' engagement there are essential elements of concern that everyone interested in the implementation of hackathon-like events should carefully consider. The different implementations carried out in regular courses highlighted something that a fully vocational course did not let emerge so clearly. Ensuring equal participation among team members was a challenge. Differences in confidence levels and communication skills could affect team dynamics and individual engagement, requiring active facilitation by educators to promote inclusivity. Some students were also suffering stress and pressure, e.g. due to the frequent deadlines and the challenge with the other teams. In fact, while time constraints increased engagement, they also introduced potential stress. Some students experienced pressure due to tight deadlines and intensive work periods, highlighting the need for educators to monitor well-being and provide support to alleviate anxiety. There was a need to carefully manage students' workloads to prevent burnout due to the intensive nature of hackathon activities. Educators had to balance the demands of time-constrained projects with the overall course requirements, ensuring that the workload remained appropriate for the allocated ECTS credits. Careful planning ensured that the time constraints and demands of the projects did not overwhelm students, maintaining a sustainable level of motivation.