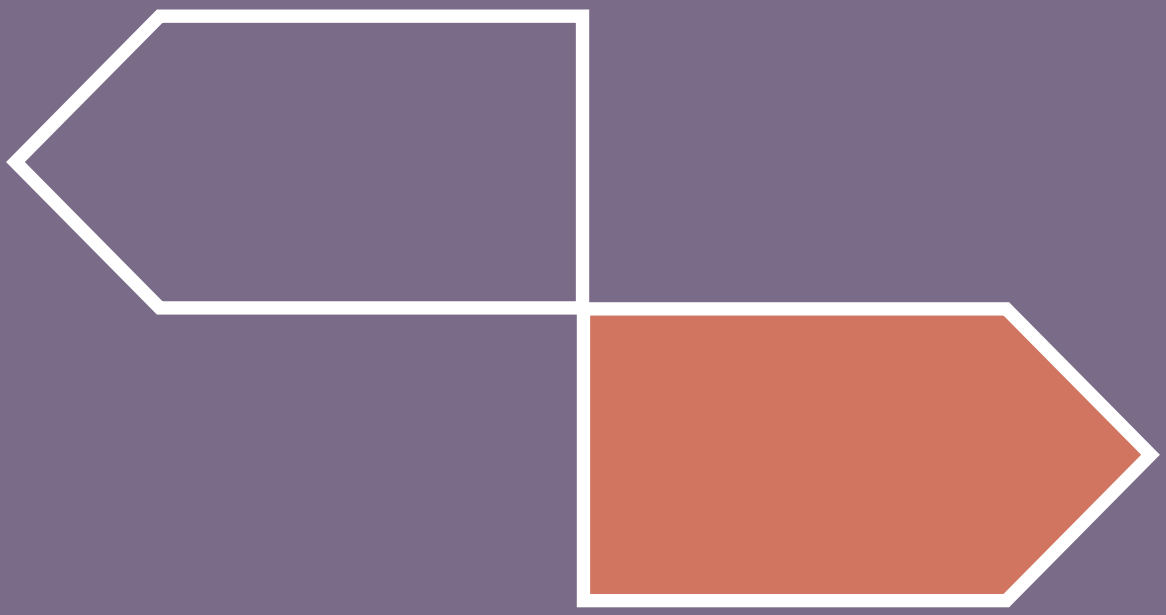
GUIDE FOR TEACHERS

Multidisciplinary Projects in an International Context



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MUPIC: MULTIDISCIPLINARY PROJECT IN AN INTERNATIONAL CONTEXT

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INTRODUCTION.

New technologies, along with globalization, have rapidly disrupted the business world as well as the academic environment. As a result, higher education has been forced to undertake profound changes, partnering with companies to prepare students more adequately for the labour market. Students, on the other hand, are expected to have a more active role in their education. This entails more autonomy, along with hands-on involvement in obtaining ever-changing competencies required by the labour market. Indeed, by designing engineering products proposed by the partner companies (or solving an engineering problem), and marketing them, students from four universities acquired valuable competencies. These competencies range from academic expertise and soft skills to real business projects and internship experience.

Furthermore, supporting and expanding manufacturing in Europe is becoming essential, since many of the European manufacturing processes have been relocated to other continents. And some of those processes are key for the European economy.

Within this framework, the Multidisciplinary Project in an International Context (MUPIC) was conceived. MUPIC, which has a three-year time horizon, was funded by the European Union's Erasmus+ KA2 programme and its objective is to help students acquire relevant and high-quality competencies. Those competencies include transversal and soft skills, as well as entrepreneurial, foreign language, and digital skills. All these foster employability and socio-educational and professional development through innovative and creative solutions, and a multidisciplinary/ multicultural approach in a socially responsible environment.

The purpose of the Guide for Teachers is to help universities to implement a MUPIC-like experience. This entails that students from different universities located in different countries and from different backgrounds work in teams to develop a product or solve an engineering problem, and to prepare a business strategy to market the product. All of this happens in multidisciplinary, multicultural, and virtual settings. MUPIC materials are available on its website.

This guide describes the MUPIC experience over the three-year period of the project and its implementation which materialized in two pilot projects, one in academic year 2019-2020 and the other in 2020-2021. This guide outlines the organization of the project, the partners' responsibilities, the MUPIC calendar, the necessary tools to conduct the two projects, the industrial partners' involvement and proposals, and the evaluation process. Additionally, it provides general information, along with a description of how the pilot projects were implemented. Finally, the closing section includes a description of the gained knowledge, the main results, and proposals for future similar projects.

The Guide for Teachers is organized as follows: Chapter I explains how to use this guide and outlines the target audiences. Chapter II contains the description of the project including its objectives, finances and duration, the partners, the description of the launching of the project, its implementation, and the evaluation of global results. Chapter III sets forth the project tools, while Chapter IV deals with project dissemination. Chapter V provides an analysis of knowledge gained and the proposed improvements. The conclusions are laid out in Chapter VI.

I. GUIDE FOR TEACHERS: TARGET AUDIENCE. HOW TO USE THIS GUIDE.

This guide gives an overall and clear view of the MUPIC project to ease the path for future endeavours. This guide is a step-by-step manual to assist teachers/lecturers and researchers to design and carry out similar projects successfully, overcoming unforeseen challenges. The method used in the development of MUPIC, along with the knowledge gained, can be incorporated by professors into their curricula. Other stakeholders that can be interested in the MUPIC project results are private sector companies and authorities responsible for the educational policy in the European Union.

Furthermore, teachers could integrate students into the development of learning activities and make the students protagonists of their education using a "hands-on" approach. Additionally, engineering professors could use this experience, especially when working in the fields of mechanical engineering, including relevant

sectors such as injection moulding machines, tramcars building, plastic injection machinery and battery manufacturing. Moreover, project management can use this guide to analyze the type of problems that can appear in the implementation of projects in general, and industrial projects in particular. Finally, marketing and business lecturers and trainers can be inspired by the MUPIC methodology in subjects that they teach as part of their curriculum.

This Teachers' Guide will highlight the types of problems that can appear when we integrate theory and practical activities in the learning process and the difficulties that can arise in marketing and launching a new industrial product. MUPIC experience will also help draw attention to the importance of soft competencies, such as communication, problem-solving, negotiation, conflict resolution and leadership, and the relevance of practising them before entering real working environments.

Companies in the industrial sector will be able to use this methodology since it will allow them to collaborate with training centres and their students/trainees to support their management processes. Additionally, MUPIC experience will give them an insight into the problems that appear when working in multicultural and multidisciplinary environments. It will suggest how to face the challenge of integrating different disciplines (mechanical engineering, project management, industrial design, and business & marketing) when launching a new product.

The authorities responsible for education policy will be able to use the experience of the MUPIC project to develop educational programs that integrate different disciplines, emphasizing the importance of combining professional and soft skills within university curricula. Furthermore, in a multicultural European environment and confronted with the need to integrate professionals from different disciplines, MUPIC project allows educational authorities to ponder about the importance of students practising in real environments before graduating or after graduation by the time they must enter the increasingly complex labour environments.

II. DESCRIPTION OF THE PROJECT.

II.1. Objectives, duration, and financing of MUPIC Project.

In recent decades, because of the accelerated development of information and communication technologies and globalization, higher education has been forced to undertake profound changes to meet the needs of a labour market with a greater degree of sophistication and interdependence (Alcón, 2011). In a context where the emphasis on the educational process has shifted from teaching to learning, students have been forced to learn actively and permanently, developing new skills and greater autonomy (Ponsa et al., 2015). Furthermore, companies are under pressure to be more socially responsible and so are academic institutions and their curricula.

Being aware of the changes in the educational paradigm and of the importance that generic competencies have within it (also called soft or transversal), four European universities, Florida Universitària (Spain), the University of West Bohemia (Czech Republic), Turku University of Applied Sciences (Finland) and Université de Mons (Belgium) have partnered to participate in the Multidisciplinary Projects in an International Context (MUPIC). MUPIC, which was planned for three years, was financed by the Erasmus+ KA2 programme of the European Union.

MUPIC focused on undergraduate and postgraduate studies in the fields of mechanical engineering, industrial design, product management, and business administration and marketing, has been conceived from two aspects:

a) A formative one, consisting of the development of an online course, made up of six modules (intercultural communication, online communication and virtual teams, industrial design and project management, business and strategy, engineering design and language), which students must complete during the project.

b) A hands-on project based on finding solutions to certain challenges posed by collaborating European companies.

The project has a duration of three years. During the first year, the four partners developed the online course, defined the objectives, and expected results, structured the measurement and evaluation instruments (assessment grid), and

prepared a glossary of terms related to engineering, project management, and industrial design.

In the second year, twenty specially selected participants from different disciplines (business & marketing, mechanical engineering, industrial design, and project management) were divided into multidisciplinary and multicultural groups. The groups, that worked both face-to-face and virtually, were in charge of developing and/or creating a product and/or solution based on the parameters proposed by the collaborating companies.

In the third year, the process restarted with new students, companies, and challenges. The project methodology and the material remained practically unaltered, except for little changes introduced to improve the whole experience. Among those changes, we can mention improvements in the modules (including more concepts and new definitions), the inclusion of new words in the glossary (related to the sectors in which Belgian partner companies operate), and minor changes in the assessment grid (giving more importance to communication in the evaluation of competencies and changing the way they will be evaluated).

The COVID-19 pandemic completely altered the development of the project in the last two years. During the first year (project preparation), the situation was normal. After the second year, the project conditions changed completely, making it necessary to replace face-to-face meetings with virtual ones. This situation affected Pilot I in Plzeň when students met each other only once during the kick-off week, and completely changed Pilot II during which all meetings were held virtually.

Each team consisted of participants from different fields of knowledge (mechanical engineering, business & marketing, industrial design, and project management) and developed skills related to cooperation, intercultural communication (face-to-face and virtual), teamwork, conflict resolution and negotiation, innovation, creativity, leadership, and ethical commitment. Throughout the project, the technical and soft competencies acquired by the students were evaluated.

MUPIC Project was designed and developed to enhance college students' education. This is accomplished by using innovative teaching techniques, such as

inverse teaching or problem-based learning, all within a multicultural and multidisciplinary environment.

MUPIC was divided into two parts. One was academic, with online courses in four fields of study: industrial design, project management, intercultural and online communication, and virtual teams. The other part was a hands-on project focused on solving various challenges laid out by partner companies. In the first pilot, which was held in Plzeň (Czech Republic), partner companies were Škoda Transportation (www.skoda.cz) and Engel (www.engelglobal.com). During the second pilot in Mons (Belgium), the main partners were Desimone (www.desimone.be) and Vesuvius (www.vesuvius.com).

II.2. European Universities participating in the project.

The MUPIC initiative is implemented by the following partner universities: Florida Universitària (FLO, Spain), University of West Bohemia (UWB, Czech Republic), Turku University of Applied Sciences (TUAS, Finland) and Université de Mons (UM, Belgium)/Polytech Mons. MUPIC targets undergraduate and postgraduate students of these universities, in the fields of mechanical engineering, industrial design, project management, and business & marketing.

II.2.1. Partner Organizations.

University of West Bohemia in Plzeň (UWB)

The University of West Bohemia in Plzeň (UWB) is the only public institution of higher education based in the Plzeň Region. Currently, the University has eight faculties consisting of more than sixty departments and three institutes of higher education. More than 16,000 students studying at the University can choose from a wide range of undergraduate, postgraduate, and doctoral study programs The choice of form of study, for example a full-time, part-time or combined form, is matter of course.

The educational activities at the University of West Bohemia in Plzeň include life-long learning programs for the public in general, in the form of lectures, courses and comprehensive training programs, including the popular Third-Age University. In addition to its educational activities, the University is also an important centre of research and development, with massive investment in university development and construction activities on the University campus.

Turku University of Applied Sciences Ltd. (TUAS)

Turku University of Applied Sciences Ltd. (TUAS) is a multidisciplinary institution of higher education that offers competitive qualifications for international careers in seven educational fields. One of the main aims of TUAS is the development of higher professional education and expertise in Southwest Finland. Future-oriented education and RDI measures contribute to prosperity and well-being based on ecologically and ethically sustainable development.

TUAS, one of the leading universities of applied sciences in Finland, hosts 9,500 students studying for a bachelor's or master's degree. The range of the degree

programmes provides a good platform for interdisciplinary learning. Turku University of Applied Sciences enjoys an excellent location in Southwest Finland, where technology, education and culture are engaged in mutually beneficial co-operation with commerce and industry. Regional development is one of the main goals of TUAS, and close interaction with the operational environment helps TUAS to react to any changes in a highly flexible way.

TUAS was the first university in Finland that established a Finnish master's degree program in project management and from the very beginning, the programme has included an international project management part in the curriculum. TUAS is also committed to internationalisation: the organisation is engaged in lively co-operation with its international partners around the world for example in terms of student and staff exchanges as well as numerous international projects.

University of Mons (UMONS)

The University of Mons abbreviated to "UMONS", is a French-speaking university in the province of Hainaut, Belgium, near the French-Belgian border. UMONS has around 150 different degree programmes on offer at Bachelor, Master and PhD levels in fields as diverse as Law, Psychology, Social Sciences, Biomedical, Economics, Electricity, Management, Material Sciences, Mechanics, Urban Planning, Information Technology, Architecture, Interpretation, Linguistics, Physics, Speech-Language Pathology, Mathematics, Chemistry, Pharmacy, Translation, Education, Biology, Geology, Medicine, and many more.

The University of Mons comprises more than 1.500 members of staff (teachers, scientists, researchers, and technical and administrative staff), more than 150-degree courses, ranging from Bachelor, Master and PhD level, about 10.000 students across 40 nationalities, 300 international partnerships with more than 50 countries across 5 continents, approximately 90 research teams, 3 partner research centres, 10 research centres (materials, risks, etc.), and a dozen spin-off companies.

Florida Universitària (FLO)

Florida Centre de Formació, coop. V. is a Valencian worker co-operative created in 1977 working in the field of education. It has a wide experience in education and training in several education levels: higher education (university degrees, postgraduate courses and master's degrees), vocational education and training (higher and lower levels), continuous training and training for unemployed people, and secondary education. Some years ago, Florida has diversified its activity by creating NINOS Gestión Educativa, coop. V., a network of childhood education centres in the Valencia Region, comprised currently of 15 centres. Since 2016, Florida also has had a childhood and primary education centre, and therefore, provides education from 0 to 99 years old.

The University qualifications provided by Florida are officially recognized by the University of Valencia (affiliated since 1993) and by the Polytechnic University of Valencia (affiliated since 1996). University degrees offered by Florida are related to Business Administration, Tourism, Engineering, Education and Video Games.

Florida is an education and cooperative experience, in relation to its environment. Florida's mission is to train persons, foster initiative, autonomy, and personal growth capacities, in order to achieve professional and social integration. As a cooperative, it is characterised by being an autonomous association of persons united voluntarily in order to satisfy their common needs and economic, social and cultural aspirations by means of a shared company, with democratic management procedure. In this way, the majority of Florida's workers are also members of the cooperative. Currently, Florida has more than 250 professionals working in a campus located in Catarroja (municipality in the metropolitan area of Valencia). The campus is composed of 6 buildings covering 26,869 m2. Every year Florida hosts more than 4,000 students.

II.2.2. Partners' Role.

In a MUPIC-like project, several universities and one or more companies will have to contribute to make the project successful.

The universities will have to

- recruit students in all fields connected with the type of project expected to be completed during the MUPIC project: mechanical engineering, project management, business/marketing and industrial design; ideally with an equal number of students from each partner.
- provide experts to support and/or evaluate the students involved in the task (all fields must be covered globally but not by each university).
- manage contact with companies (only one university can take this role), namely inform them of their commitment with respect to universities and students.
- provide coaches to help teams to manage their project. Each team is assigned a coach who is not necessarily an expert but should be familiar with project management fundamentals. The coach is also responsible for providing feedback after each preliminary report, which requires summarizing and globalising all feedback.

On the other hand, the companies have to define the task(s), to present it (them) to the students at kick-off, to provide a contact person for day-to-day support, to participate in evaluation and possibly give quality feedback.

During the MUPIC project, partner universities coordinated different aspects of the MUPIC project as follows:

- **University of West Bohemia** (Czech Republic) provided expertise in the fields of engineering design, industrial design, language learning, online communication, and ICT skills. The Faculty of Mechanical Engineering has broad experience with student project teams. The University of West Bohemia provided students of mechanical engineering and industrial design. It also managed communication with Škoda and Engel during Pilot I.

- **Florida Universitària** (Spain) has vast experience in several areas relevant for this project, such as education methodologies development and counselling, student project management in multidisciplinary, multicultural, and virtual teams, and co-creation processes between students and companies. The institution is also comprised of a skilled team of researchers, counsellors, and professionals with expertise in the above-mentioned areas. Florida University was responsible for the assessment grid, the teachers' guide and the exploitation and sustainability of the project results. The university provided students of marketing and management.
- **Turku University of Applied Sciences** (Finland) provided experts from the field of project management, engineering, language learning, intercultural communication, online communication, and ICT skills. Turku University of Applied Sciences was responsible for developing an online module on virtual teamwork and online communication. It was also responsible for the teachers' guidelines and course curriculum development. The university provided students of project management to work in the international teams.
- The **Faculty of Engineering of UMONS** (Belgium) has broad experience with student project teams. They implement the CDIO approach which makes students aware of planning, management, and communication issues. The university also provided experts from the field of economics and business. UMONS was responsible for developing the Glossary of Industrial Design Terms. The university also participated in the development of the online module for design. It selected engineering students to work on the assignment in the international teams. Finally, UMONS took care of the communication with Desimone and Vesuvius companies during Pilot II.

During MUPIC Erasmus+ project, partner companies represented organizations from two countries, the Czech Republic and Belgium, in which the two pilots were held. Partner companies in the Czech Republic were Engel (www.engelglobal.com) and Škoda Transportation A.S. (www.skoda.cz), while in Belgium they were Desimone (www.desimone.be) and Vesuvius (www.vesuvius.com).

II.3. Partner Companies.

MUPIC project partner companies comprised organizations from two countries, the Czech Republic and Belgium, in which the two pilots were held. Partner companies in the Czech Republic were Engel (www.engelglobal.com) and Škoda Transportation A.S. (www.skoda.cz), while in Belgium they were Desimone (www.desimone.be) and Vesuvius (www.vesuvius.com).

A total of four companies participated in the MUPIC project. During the first year of MUPIC implementation, students worked with two companies from the Czech Republic. The University of West Bohemia was in charge of selecting the companies and acted as the liaison between MUPIC participants and the companies. During the final year, students worked with two Belgian companies. In this collaboration, the Faculty of Engineering of UMONS chose the companies and supervised the arrangement.

Pilot I - Plzeň

	**Škoda Transportation**
Škoda Transportation, a leading European manufacturer of vehicles for city and railway transport, is a dynamic and fast-growing company with a vast tradition of production lasting more than 150 years. The field of transport engineering is still undergoing dynamic development at this company. This field has huge potential worldwide. Škoda is currently number one in the field of rail vehicles in Central Europe. Modern electric locomotives, metro units, low-floor tramways and other important components of rail vehicles are dispatched to both domestic and foreign customers from factories on the main premises in Plzeň.	
Škoda Transportation challenge for MUPIC. Tramcars operate both in busy city centres with high density of buildings and operation, as well as in peripheral areas of the city, which do not have such density	

of buildings and further operation. Each of these areas has its own, completely different, specificities that generate specific, sometimes contradictory, requirements for the tram vehicles. From the safety point of view, several collision scenarios need to be addressed. It is necessary to consider collisions with pedestrians (A), with cars (B1 and B2), trucks/trailers (C1 and C2) and tanker trucks (C3) as well as with other tramcars (D), all at different collision speeds. This fact results in protection solutions on several different levels, or, say, for several different scenarios.

Current tram crash legislation is inadequate, and manufactures try to improve their products to meet all the diverse requirements. At the same time, manufacturers try to integrate and simplify the entire system by different crash measures. At this point, the legislation requires elements absorbing collision energy in case of a front collision of two tramcars or a tramcar and a truck vehicle. No effective measures are required to prevent the underachievement of a smaller vehicle or elements preventing the person from being trapped under a tram vehicle (TV). Moreover, the case of a tram vehicle and a tank truck collision is solved only marginally.

The aim of **Škoda challenge for MUPIC Project is to find and market such a configuration, concept, and preliminary constructional design of the vehicle front with such structure and mechanical and mechatronic engineering design measures, which would ensure maximal passive safety of all participants of all accident scenarios – tramcar driver, passenger cars drivers and passengers, pedestrians, etc.**

These systems should be conceptually solved in the project:

- Body shell structure of the vehicle front face → optimal structure from loading and system integration point of view.
- Crash absorbers.
- Safety structures, mechanisms, and measures.
- Tram vehicle-coupling system.
- Glazing → driver's lookout maximization.

- External lining – logical panels partitioning, suitable shaping, concept of fixing.
- Lighting → correct position, safe, and sufficient space.
- Windscreen wiper and washer → optimal position in terms of pedestrian safety and wiped area in terms of clean driver's lookout.
- Visual Information systems → good visibility and sufficient surface for all useful information.
- Other systems placed on vehicle front.

ENGEL	**Engel**

Engel challenge for MUPIC.

Integrated conveyors are peripherals to ENGEL injection moulding machines. They allow customers a subsequent handling with produced mouldings. In typical application, the produced mouldings are being put down on the conveyor belt by an automatic handling equipment/robot. The mouldings (variety of plastic parts) are then transported to the operator, outside the moulding machine. Integrated conveyor is embodied in the injection-moulding machine. It is located in the section called "HLi safety guard". Integrated conveyors represent the basis of the portfolio of the Department of the Conveyor Systems in the plant ENGEL Kaplice.

This product has been sold for over 18 years without major changes. With new technologies and often-stricter standards, innovation is needed in construction and design, while preserving or reducing costs. Conveyors often only serve for transporting parts from a place A to a place B.

The ENGEL Company now identifies a need to integrate another technological function (e.g. packaging, separation, cooling, etc.) into the conveyor. Also, the conveyor is often the weakest part of the injection cell (injection moulding machine–robot– conveyor) because the conveyor does not have any diagnostic system, unlike other cell devices. Some of the customers (typically the automotive segment)

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cannot allow an unexpected production interruption caused by a conveyor failure. Integrating "smart" functions into the conveyor could attract these customers.

The objective of this project is to innovate and market the product (technology, design), following the specification and other implicit requirements, while maintaining or decreasing the production costs.

Pilot II - Mons

Students worked in the following two projects:

	**Vesuvius**

Vesuvius is a global leader in metal flow engineering, providing a full range of engineering services and solutions to its customers worldwide, principally serving the steel and foundry industries.

Vesuvius challenge for MUPIC.

Vesuvius was looking for solutions to fully automate preparation of one of its core designs: a proportional valve for molten steel. This equipment is commonly used in steel plants to control the flow of steel while transferring the molten metal from one container to another, cast and manufacture final products (beams for the construction sector, slabs for naval industry...). Preparation and maintenance of those valves are critical, dangerous, and labour-intensive operations. Vesuvius is working on robot-based solutions to automate regular maintenance and replacement of consumable pieces inside the ladle gate during its operation cycle.

The replacement of the refractory pieces includes manual setting of mortar to ensure a good tightness between each of the components. This operation is critical,

as a bad sealing results in a major incident (molten steel leakage through the valve).

The aim is to design and automate a mortar-setting machine for refractory components before installation inside the ladle gate. Mortar layer should be controlled through a dedicated inspection system, as it is a safety-critical operation. A broader objective will be to analyze commercial viability of the robotization of ladle gate maintenance are through key indicators:

- **Technical proposal**. Technical analysis and solution proposal for plates and collector nozzle mortar setting. Including inspection system.
- **Commercial analysis**. The economic contribution will include an analysis of the steel market around the world: business model, world distribution, type of company, industrial culture, environmental, production and safety regulations, future trends, among others. This analysis will be used to assess the economic viability of ladle maintenance robotization and possibly derive a marketing approach.

Desimone	**Desimone**

Desimone is a company located in Belgium, subsidiary of British Desimone Plc. Its economic activity is based on manufacturing custom-made machines and automating production processes. They have 30 years of experience in the sector that allows them to integrate various technological solutions including HMI, vision control, laser technology, eddy currents, metrology instruments, printing, marking, gluing, IT systems and network integration.

Desimone challenge for MUPIC.

Desimone, in collaboration with two research centres (CRM and CSL), launched, under the aegis of the “Pôle Greenwin”, a R&D project based on thermal energy storage, by exploiting the potential of phase change materials. This project has been successful and ended in 2018. The results are very encouraging and should

permit the consideration of a competing product as an alternative to the classical electric battery storage.

The next step of this challenging project is to realize an industrial system inspired from the prototype (from TRL4 to TRL8). This industrial (and « saleable ») product has not been realized yet. Objectives are:

To use the R&D results to develop a thermodynamic model of the system allowing to dimension the components of Accutherm according to the parameters of a real installation.

To develop and realize a software for driving the installation according to the user parameters.

To optimize the industrial design of the whole system, and to determine how to manufacture the tank and the heat exchanger.

To develop a whole system from the perspective of mass production.

Economic aspect is also important: energy pricing policies are very different between the countries, even between regions. **An international market study evaluating the commercial potential of Accutherm should be realized, as well as an analysis of the competitors.** The study should analyze the Return On Investment of the product following these two points: the type of customer and the sales territories. This study should determine from these data the selling price and the volumes to expect, which would allow DeSimone to calibrate its future manufacturing line.

An analysis should be realized to validate the optimal business model for Desimone. Companies specialized in refrigeration systems will be the link between Accutherm and final customers. The ideal business model would be a partnership between one or several major suppliers and Desimone, avoiding in this way the slow and tedious task of building a distribution network from the scratch. Analysis should take care of potential profit margins but also identify potential partners for different countries and even establish informal contacts.

Both analyses described above should give rise to a launching calendar, on top of which a communication strategy will be deployed. This strategy will be very

dependent on the conclusions of the business model analysis: integration to the partners' products, direct marketing with the customers, indirect marketing with installers, press communication.

II.4. Project Launching & Development.

We suppose in the following that the consortium of partners has been established and that the latter agreed on the type of projects to be proposed to students. In the case of the Erasmus+ project, tasks concerned principally mechanical engineering along with business/marketing aspects and consisted in the design or improvement of a specific device or machine.

II.4.1 Project preparation

The core activity in a MUPIC-like project is the completion of the task by the teams. During this Erasmus+ project, each team worked on the task during the whole academic year. Such a project requires that several actions happen before the actual launch of the project: some of them are valid universally, others are related to specific conditions.

- Define the typical composition of teams: number of students and expected profiles; ideally, each team should involve at least one student from each participating university.
- Provide online resources to students so that they have the necessary information and methodology to complete all parts of the task.
- Define the typical calendar of the academic year with specific objectives for each milestone.
- Define the roles of experts, coaches, and companies.
- Define the communication channels to the students, to the teams, among partners.
- Define the rules of the game for the interactions between teams and experts, between the teams and the company, and, finally, for the evaluation.

During the MUPIC Erasmus+ project, the students could consult so-called modules, described more extensively later, available in the Moodle course. Some modules

were related to English language, intercultural and online communication, virtual teams, and project management and universal. Modules about mechanical engineering, industrial design and business/marketing were specific to the kind of task that had been selected. Along modules, a glossary was constructed. In the same way, the glossary has sections that are universal (e.g., project management) while others provide vocabulary related to mechanical engineering/industrial design, or domains in connection with the proposed tasks (railway, robotics, thermodynamics…).

The calendar of this Erasmus+ project included the kick-off week and the final week, both expected to take place in face-to-face manner (cancelled unfortunately due to COVID). Three checkpoints were evenly distributed between them. The calendar is presented in Figure 1 while more detailed objectives for each checkpoint can be found in the MUPIC matrix (appendix).

MUPIC Project had three defined phases. In the first phase, all the preliminary work aimed at project approval was carried out. The four partners developed the online courses, defined the MUPIC objectives and expected results, determined the appraisal method, and built an engineering and industrial design glossary.

In the second phase, the program was further developed by the implementation of Pilot I (Plzeň). The last phase involved project implementation of Pilot II (Mons). It began in 2019 and ended in the fourth quarter of 2021 along with the finalization of the project as a whole.

During the initial phase of MUPIC, the following tasks were performed:

- Responsibilities were distributed among faculty and the companies' personnel.
- Individual project phases, modules, and tasks scheduled for completion were established.
- Coordination and communication systems were put in place.
- Competencies to be graded were specified.
- Evaluation systems were put in place.
- Project sustainability was underscored.

The second phase involved the development and launching of MUPIC. Responsibilities were established as follows:

- A1: Project management by University of West Bohemia
- A2: MUPIC Development by Turku University of Applied Sciences
- A3: Piloting by Turku University of Applied Sciences
- A4: Students' and project evaluation by Université de Mons
- A5: Project promotion by University of West Bohemia
- A6: Project applications and sustainability by Florida Universitària.

Furthermore, the intellectual outputs of MUPIC (required project tasks developed by all the partners) were developed in cooperation between the partners, and were defined and assigned as follows:

- IO1. Six online modules (supporting educational materials) were established (led by the University of West Bohemia): M1 Intercultural and Virtual Communication; M2 Language, M3 Project Management, M4 Engineering Design, M5 Business and Strategy, and M6 Industrial Design. The University of West Bohemia coordinated the online course, supported by the other partners. When developing the first pilot course, the MUPIC project team decided to merge proposed M1 Language and Intercultural Communication and M2 Online Communication and Virtual Teams. At the same time, it was decided to possibly add M4 Industrial Design. During the two pilot courses the need for development of a module on Business and Strategy was identified. Therefore, the project consortium also decided to develop the M5 Business and Strategy Module. After analysing the students' feedback on language support provided in the learning diaries, the developers of M1 (UWB and TUAS) decided to return to the original plan and form a separate Language module. Therefore, the final version of the MUPIC online course includes 6 modules:

  M1: Intercultural and Virtual Communication

  M2: Language

  M3: Project Management

M4: Engineering Design

M5: Business and Strategy

M6: Industrial Design

- IO2. Engineering, industrial design and product management glossaries were prepared in English and French (by UMONS), in Spanish (by Florida Universitària), in Finnish (by TUAS), and in Czech (by University of West Bohemia).
- IO3. A Guide for teachers, led by Florida Universitària.
- IO4. Evaluation systems and the assessment grid, led by Florida Universitària.
- IO5. Program curricula led by Turku University of Applied Sciences (TUAS).
- IO6. MUPIC multiplier events and papers were created by all partners.

II.4.2. Project Implementation.

For each MUPIC-like project implementation, a series of tasks must be completed

- Recruit companies and get the tasks description in time.
  Possibly complete the available documents (modules, glossary...) if the proposed tasks require.
- Establish a calendar with dates of the kick-off and final weeks, deadlines for check-point deliverables, check-point feedbacks and the final report. This task is not straightforward, as dates of academic years in different countries do not correspond. A good compromise must be found.
- Recruit students at each university to reach the expected composition of each team: this requires a call with minimum requirements (e.g., B2 level in English), deadline for applying and the selection procedure. In general, It is easier to recruit students when they know what kind of project they will work on and what the schedule of the project will be. When the students are selected, the teams can be built.

- Reserve accommodation for face-to-face activities.
- Define the schedule of the kick-off week. It typically includes:
    - a welcome session with presentations of all people involved (experts, coaches, companies...).
    - information about the project: objectives, organization, rules of the game including evaluation, composition of teams.
    - a presentation of the available material and the way to access it.
    - an introduction to the main modules (e.g., project management).
    - team activities: it is essential that teams must produce something together during the kick-off week: from choosing a logo/motto to completing the first design/analysis exercise; it is advisable that teams define the roles of individual members, establish the communication channels that they are going to use, and specify the organization of their teamwork.
    - getting feedback from students through an anonymous survey (paper or online).
- define the organization of the feedback to students after each checkpoint.

In the second year of the MUPIC project, twenty students from the four universities and different backgrounds, with good academic credentials and an English level of B2 or higher, volunteered to participate in the MUPIC program. Students in the MUPIC project were expected to work in a diverse multicultural and multidisciplinary team setting, and, at the same time, autonomously. Therefore, the project offered a positive academic and professionally challenging experience for students, that helped them acquire many required job competencies. Indeed, at least one of MUPIC students was hired by a partner company.

Students participating in Pilot I started working in September 2019. They were assigned to four multicultural and multidisciplinary teams as described in Table 1. Students in teams worked on hands-on projects proposed by two Czech companies, Škoda Transportation (a leading engineering company in the transport industry, which manufactures trams and train coaches), and Engel Corporation (a leading company in the manufacture of injection moulding machinery). The teams were to work face-to-face, as well as online, on the challenges proposed by the partner

companies. However, due to the current pandemic, most of the face-to-face sessions were cancelled. Two students quit before finishing the project for personal reasons.

Table 1 - Number of students participating in the first MUPIC project, by field of study and by university. Pilot I.

2019-20	Engineering	Business & Marketing	Project Management	Industrial Design	TOTAL
UWB	3	-	-	4	**7**
TUAS	-	1	4	0	**5**
UMONS	3	-	0	-	**3**
FLORIDA	2	3	-	-	**5**
TOTAL	**8**	**4**	**4**	**4**	**20**

Source: own source.

(1) Two students failed the project, one Czech and one Spanish.

Table 1B - Composition of teams in the first MUPIC project, by field of study and by university (Figure in red gives final figure in case of change). Pilot I.

2019-20	Engineering	Business & Marketing	Project Management	Industrial Design	TOTAL
Team 1	2 (BE, SP)	1 (FI)	1 (FI)	1 (CZ)	**5**
Team 2	2 (CZ, SP) 1 (CZ)	1 (SP)	1 (FI)	1 (CZ)	**5** **4**
Team 3	2 (BE, CZ)	1 (SP)	1 (FI) 0	1 (CZ)	**5** **4**
Team 4	2 (BE,CZ)	1 (SP)	1 (FI)	1 (CZ)	**5**

TOTAL	**8**	**4**	**4**	**4**	**20** **18**

Source: own source.

During the third and last year, 19 new qualified students participated in MUPIC (Table 2), following the footsteps of their predecessors. Two Belgian manufacturing companies headed up the project in the third year. Vesuvius, a global manufacturing leader in metal flow engineering, providing a full range of engineering services and solutions, principally serving the steel and foundry industries, and Desimone, a manufacturing company involved in individual optimization of production sites. In both years, students had to apply what they had learned in college, as well as what they learned in MUPIC. One of the students from the Spanish team left the project before finishing Checkpoint 1 and one student from the Czech Republic remained until the end of the project but failed because of reduced commitment.

Table 2 - Number of students participating in the first MUPIC project, by field of study and by university. Pilot II.

º	Engineering	Business & Marketing	Project Management	Industrial Design	TOTAL
UWB	2	-	-	2	**4**
TUAS	-	1	4	-	**5**
UMONS	5	-	-	-	**5**
FLORIDA	-	5	-	-	**5**
TOTAL	**7**	**6**	**4**	**2**	**19**

Source: own source.

(2) One of the students decided to quit the project before the evaluation of Checkpoint 1.

Table 2B - Composition of teams participating in the first MUPIC project, by field of study and by university (Figure in red gives final figure in case of change). Pilot II.

º	Engineering	Business & Marketing	Project Management	Industrial Design	TOTAL
Team 1	2 (BE)	1 (SP)	1 (FI)	1 (CZ)	**5**
Team 2	2 (BE)	1 (SP)	1 (FI)	1 (CZ)	**5**
Team 3	2 (BE,CZ)	2 (SP)	1 (FI)	-	**5**
Team 4	1 (CZ)	2 (FI, SP) 1 (FI)	1 (FI)	-	**4** **3**
TOTAL	**7**	**6**	**4**	**2**	**19** **18**

Source: own source

In the MUPIC project, students worked in teams as well as on-line on the assignment given by the external company to create a final product/solution, following their advisers' guidelines. Consequently, this project developed, created, and tested a learning method based on multidisciplinary and multicultural teamwork.

Every group had a coach that helped them with problems that arose, and with any aspects of the work that required guidance. Meetings with coaches were held regularly, and coaches were in constant communication with students. Additionally, students could consult with experts (by email, by online sessions and by telephone) in each area of knowledge included in the project (communication, engineering, project management, industrial design, and business & marketing). Meetings and contacts with experts were held on demand.

II.4.2.a. Use of the coaching system during MUPIC project

Right after the teams are formed, a coach is assigned to each group. The coach is a member of one of the universities involved in the project who provides guidance to the team in several aspects.

Contact between the team and the coach

The team manager is responsible for the communication with the coach. It is strongly advised to set up regular meetings between the coach and the project team, so the coach has full knowledge of the interaction between the students. The communication uses an online platform preferred by the team members (Teams, Zoom, Skype, Hangouts…).

Additionallyit is recommended that the team gives the coach access to the documents shared for the project so a global view of the workflow is available at any moment.

Roles of the coach

The coach plays a role in several dimensions linked to the organization of the work. It is expected that, during meetings with the students, several levels of guidance are provided:

- Listening: the coach provides active listening for the project leader or the entire group to identify issues as early as possible and propose adequate ways to solve them. It can be either linked to organizational problems (efficient communication in the team, meeting organization, collaboration between students…) or technical ones (suggestion to contact a specific expert for a part of the project, additional contact with the company representative in case of delay, explanation on the expected requirements for the checkpoints…)
- Questioning: the coach can help the group by asking questions not arising from general discussion to help the group make progress if a weakness in the

approach is identified. The coach can, for example, suggest the use of a particular analysis method, or an additional information source.

- Feedback: the coach is responsible for the synthesis of the evaluation of all checkpoints and the transmission of the information to the team (see later).

It is crucial to establish confidence within the team and the coach so that all problems can be discussed freely. Nevertheless, the limits of the role must be clear: the coach provides guidance to the team, but it is up to the team to solve the problems.

Organization of feedback

As mentioned earlier (see II.4.3), all checkpoint reports provided by the teams are evaluated using the MUPIC assessment grid in terms of mechanical engineering, industrial design, project management, and business & marketing. The marks on all items are provided by experts in the fields from different universities. Free comments are also collected in a collaborative document. To provide uniform feedback to the team, the coach is responsible for the analysis of the comments, the synthesis of all opinions provided, and the transmission of coherent feedback to the team. Individual marks on all criteria are not provided, only the mean value on each criterion is given.

Benefits of the coaching

During the first round of projects, in addition to the role described previously, the contact between the coach and the students allowed to identify at an early stage the need for clarification of several items required for the deliverables of the projects.

At the beginning of the first round of the project, the feedback sent to the team was a complete document showing all individual comments without prior analysis. It led to some (hopefully rare) contradictory comments that were confusing for the students. Adding the coach as a ‘filter’ allowed for providing more accurate feedback to the teams.

II.4.3. Evaluation of the Global Results.

Since each team consisted of students from different universities and different backgrounds, they were encouraged to cooperate, communicate, work in teams, resolve conflicts, negotiate, innovate, lead, and display ethical behaviour. Lecturers from the four partner universities and personnel from the partner company oversaw evaluating the competencies acquired by the students during the entire process.

MUPIC aimed to assist students to acquire the following transversal competencies:

- **G1.** Intercultural communication.
- **G2.** Online communication and work development in virtual teams.
- **G3.** Written and oral communication: presentation of planning, reports, and a final presentation of the solution.
- **G4.** Teamwork: team building and collaborative work.
- **G5.** Conflict resolution: solution of situations related to decision making.
- **G6.** Initiative, innovation, and creativity: each team will resolve the problem posed by each company in a different way.
- **G7.** Leadership: each person will assume responsibilities in the process and coordination of tasks to be developed.
- **G8.** Lifelong learning: identify evidence of what has been learned so far, to project his/her professional itinerary.
- **G9.** Use of digital communication technologies.

Furthermore, students were appraised based on the acquisition of competencies embedded in the 6 modules or fields of study, which resulted in 5 learning outputs. Therefore, students were evaluated based upon the acquisition of the competencies summarized in the next 6 learning outputs:

a) **Learning Output 1 (LO1). M1 Intercultural and Virtual Communication.**

Participants can:

- Recognize the need for and importance of learning and exploring intercultural communication in the context of MUPIC (international teams, dynamics within teams, dealing with companies, orientation week abroad).
- Become aware of their own cultural identities and build an appreciation for others (personal, social, and cultural identities).
- Understand and formulate ways how culture affects communications (Edward T. Hall's High-Low Context dimension, perceptions of space and approaches to time).
- Identify specifics of online intercultural communication.
- Understand the meaning and applications of the Individualism vs. Collectivism concept as the most widely used terms in comparing cultures; recognize the constraints of the concept.
- Build an overall comprehension of the major cultural values underlying different behaviours and understand leading values dimensions (Hofstede's Values Orientation Model) using the acquired knowledge, formulate their experience from working in the international group (Belgium, Czech Republic, Finland, and Spain).
- Come up with tips for effective cross-cultural communications: how to become adaptable in intercultural interactions (include experience from the course and suggest practical solutions).
- Share data, information, and digital content with others through appropriate digital communication technologies.
- Understand the differences between face-to-face and virtual communication and apply appropriate code of conduct.
- Adapt behavioural norms and netiquette of the employer while using digital technologies and interacting in digital environments.
- Understand how to build and lead an effective virtual team.

b) Learning Output 2 (LO2) M2 Language

Participants can:

- Recognize the difference between various levels of formality in language and be able to use them.

- Recognize different levels of formality in the English language and use the proper means of communication in different working environments.
- Be able to write a report using appropriate language considering the target groups.
- Be able to give an effective presentation of solutions.

c) Learning Output 3 (LO3). M3 Project Management.

Participants can:

- Understand general project management concepts especially from the product development viewpoint: have a good overall view of developing the project life cycle and project phases.
- Understand the importance of project communication and stakeholder management.
- Understand special characteristics of requirements management in the product development context.
- Have an overall comprehension of the basics of development project planning. Be able to describe how the WBS (Work Breakdown Structures) are used as a basis for planning.
- Use project risk management tools and understand the risk management principles. Understand the importance of quality management in development projects.
- Write and compile a basic development project management documentation.

d) Learning Output 4 (LO4). M4 Engineering Design.

Participants can:

- Have an overall comprehension of a product life cycle and the engineering design process (and its interaction with overall project management for product development, along with economic, marketing, and communication issues).
- Write a list of requirements with quantitative technical specifications.

- Develop their creativity and innovation and apply related implementation techniques.
- Recognize the constraints linked to standards, patents, utility models.

The engineering students of MUPIC will be able to:

- Understand and synthetize the functional principles of a mechanical system.
- Justify the selection of machine elements.
- Produce an overall drawing under the formal conventions of technical drawing.
- Evaluate quantitatively the performance of the designed mechanical system and locate the proposition with respect to the state-of-the-art.
- Write a synthetic report with computation and design notes.
- Respect the standards and safety constraints.
- Develop his/her criticism regarding his/her own design process.
- Be aware of socio-economical, environmental, and ethical constraints.

e) Learning Output 5 (LO5). Business and Strategy

Participants can:

- Review the analysis and existing tools within the discipline of Strategic Management.
- Carry out the strategic diagnosis of an organization and its summarized presentation in the SWOT matrix.
- Suggest strategies to correct weaknesses, face threats, maintain strengths and exploit opportunities (CAME Matrix).
- Review the CANVAS model and the bases for generating a new business.
- Develop a marketing strategy.
- Understand the importance of incorporating social objectives into the business model.
- Learn how to make a company more socially responsible.

e) Learning Output 6 (LO6). Industrial Design

Participants can:

- Understand the goal of Industrial Design.
- Understand the role and work of an Industrial Designer.
- Recognize and suggest innovative solutions.
- Become familiar with the Design Thinking Method.
- Describe their work in a broader cultural context.
- Explain the chosen solutions.
- Understand the difference between design and styling.
- Interpret and evaluate creative work.

To guarantee MUPIC success, students should:

- Participate in all the scheduled face-to-face and virtual meetings and seminars.
- Perform all required tasks in a timely and adequate manner.
- Be in close contact with their mentors/advisors.
- Maintain fluent communication with their team members, mentors, and the partner company.
- Honour partner companies' NDA.
- Behave in a respectful manner with the rest of the team members and help resolve any conflict that may arise (through communication, negotiation, and conflict resolution).
- Team-up and actively participate to achieve the project objectives.
- Co-evaluate the project results.

For the development of the MUPIC Project, different learning and support activities were programmed, including the successful completion of specific assignments designed to assess the acquisition of competencies (Graphs 1 and 2).

In Pilot I, each MUPIC Project team had to prepare and deliver the following (as also illustrated in Figure 1):

- One report for the virtual pre-assignment in August.

- One report for each of the activities assigned under Checkpoint 1 (October 28, 2019), Checkpoint 2 (December 16, 2019) and Checkpoint 3 (March 31, 2020).
- A final report at the end of May 2020 (a description of the work carried out and a solution to be given to each of the partner companies).
- A public defense of the solutions prepared by each team. Each team can choose the format of the presentation that fits best the proposed solution.

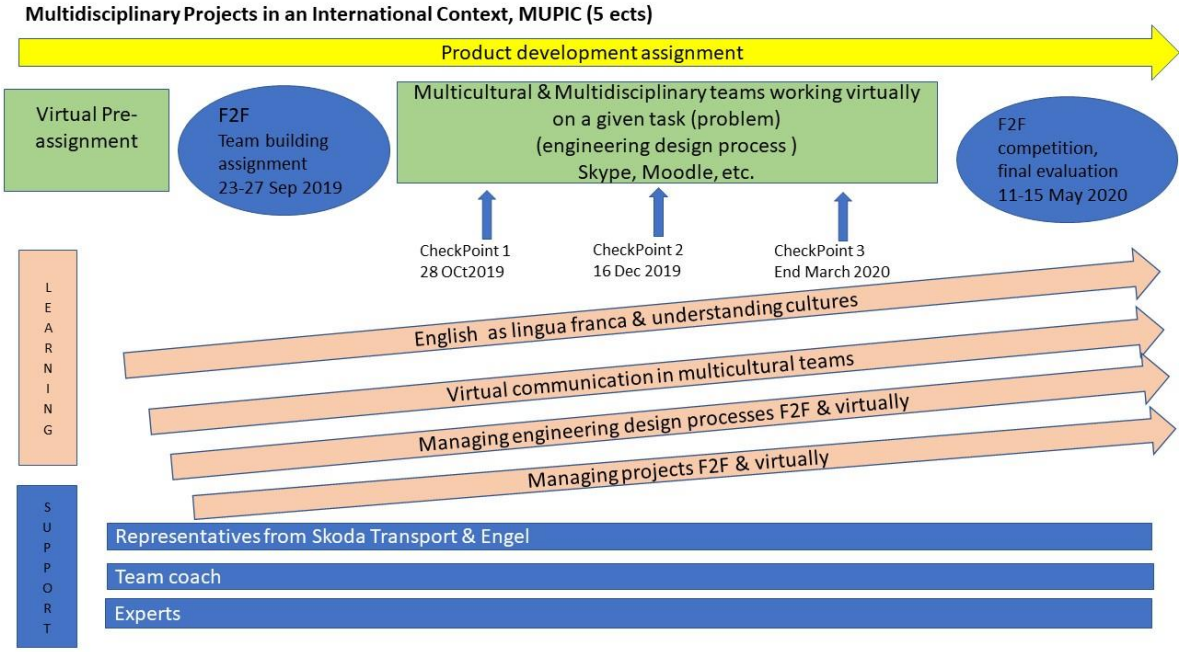
During Pilot II, the checkpoints were scheduled for November 11, 2020, December 18, 2020, and March 29, 2021. Teams were expected to accomplish specific objectives for each checkpoint in the field of Business & Marketing, Engineering, Engineering Design, Communication, and Project Management. Consequently, the acquired competencies were evaluated, and feedback was given to the teams accordingly.

The final work submission deadline for Pilot II was May 3, 2021, and the final presentation was held online on May 19, 2021. At this point, students were evaluated by each university, by the partner companies, and by the students themselves (Figure 2).

Students are never left unsupervised. They are assigned a coach and an expert for each field of study. Academic experts answer their questions regarding general issues and methodology, but not specific technical solutions, which are handled by coaches and/or the companies' experts. Therefore, student teams work closely with their teachers and the companies' liaisons.

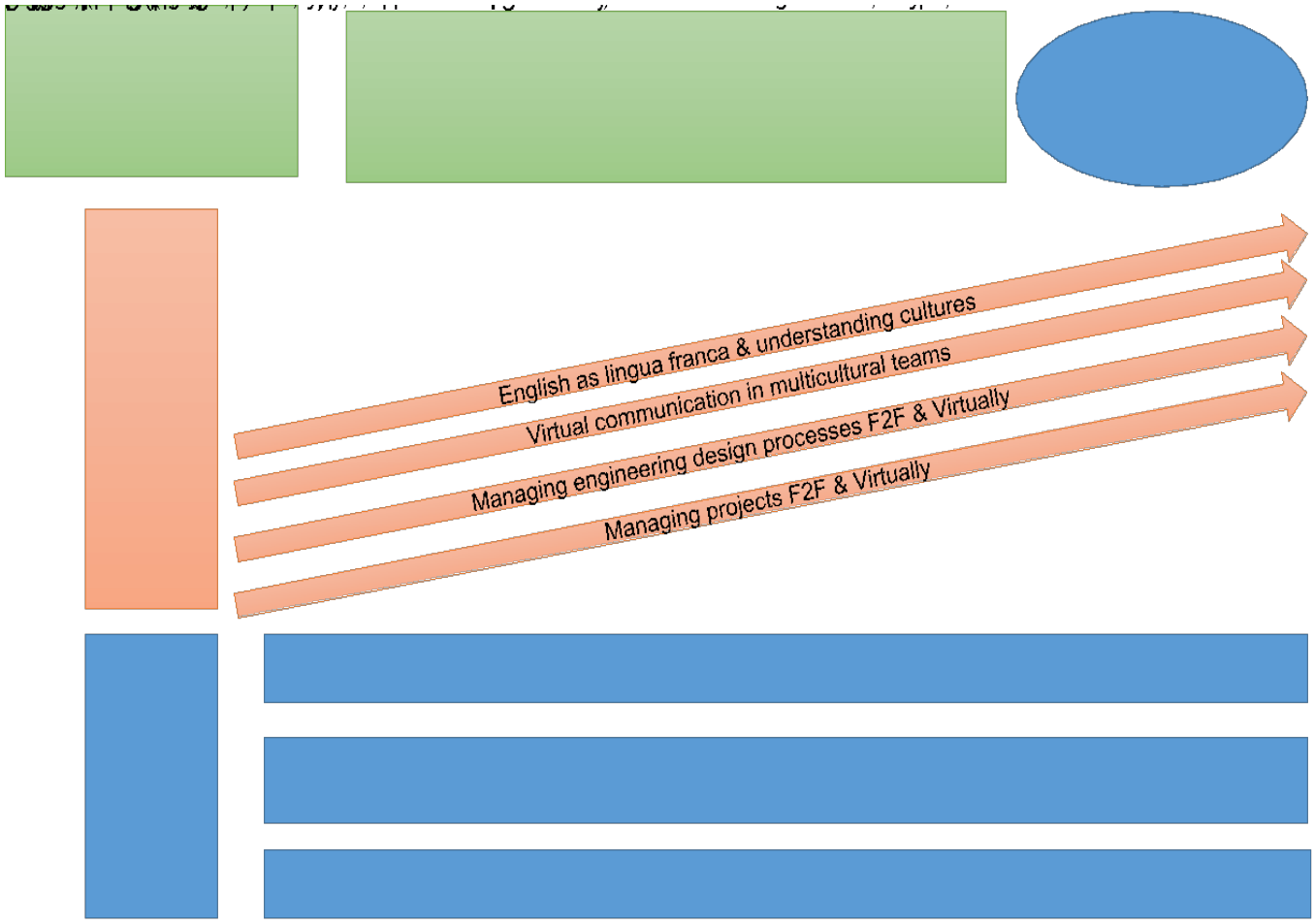
Their work was closely monitored, and their progress was evaluated four times during the project. There were three checkpoints spread throughout the academic year, culminating in the final evaluation.

Figure 1. Calendar of students' assignments and deadlines for Pilot I.



Source: MUPI

Figure 2. Calendar of students' assignments and deadlines for Pilot II.



Source: MUPIC

Finally, the teachers and companies provided a global evaluation to appraise MUPIC success, along with the students' satisfaction, their academic achievements, and the recommendations given to the students' final project presentation. Teamwork is so relevant in MUPIC that it has a higher grading value. Students who successfully completed the project earned 5 ECTS and received a completion certificate and an achievement certificate (see appendix 5). Nevertheless, some partner universities granted additional ETCS to their participating students. All these evaluations followed the guidelines laid-out in the assessment grid.

II.4.3. Final Results.

The MUPIC project evaluates each student's individual work, as well as the team's performance. The final score is the result of allocating all the scores obtained by the team to each student and adding their individual scores. Scores reflected the level of acquisition of specific and transversal competencies associated with the MUPIC project. Consequently, the final grade was set up as follows:

- **A: Assignments: 20%.** Evaluation carried out by team coaches and experts, based on the Rubric of Written Work. Each assignment was evaluated based on four areas of knowledge: mechanical engineering, industrial design, project management and business & strategy.

- **FR: Final Report: 35%.** Evaluation carried out by the representatives of the universities as well as the partner companies, based on the Rubric of Written Work and the four areas of knowledge.

- **PP: Project Presentation: 15%.** Evaluation made by team coaches and representatives of partner companies based on Rubric of Presentation and Oral Communication.

- **ILPE: Individual Learning Process Evaluation: 20%.** Evaluation based on all the evidence gathered in the project development process: attendance in training, meeting minutes, attendance and participation in virtual classes, attendance and participation in the sessions in Mons, interaction with partner companies, and contributions to the self-reflective learning diaries.

- **CE: Cross Evaluation among students: 10%.** Evaluation carried out by the members of each team based on the Cross-Evaluation Rubric.
  All rubrics for evaluations are included in Annex 3.

MUPIC PROJECT SCORES
(A*0,20 + FR*0,35 + PP*0,15) + (ILPE* 0,20 + CE * 0,10)

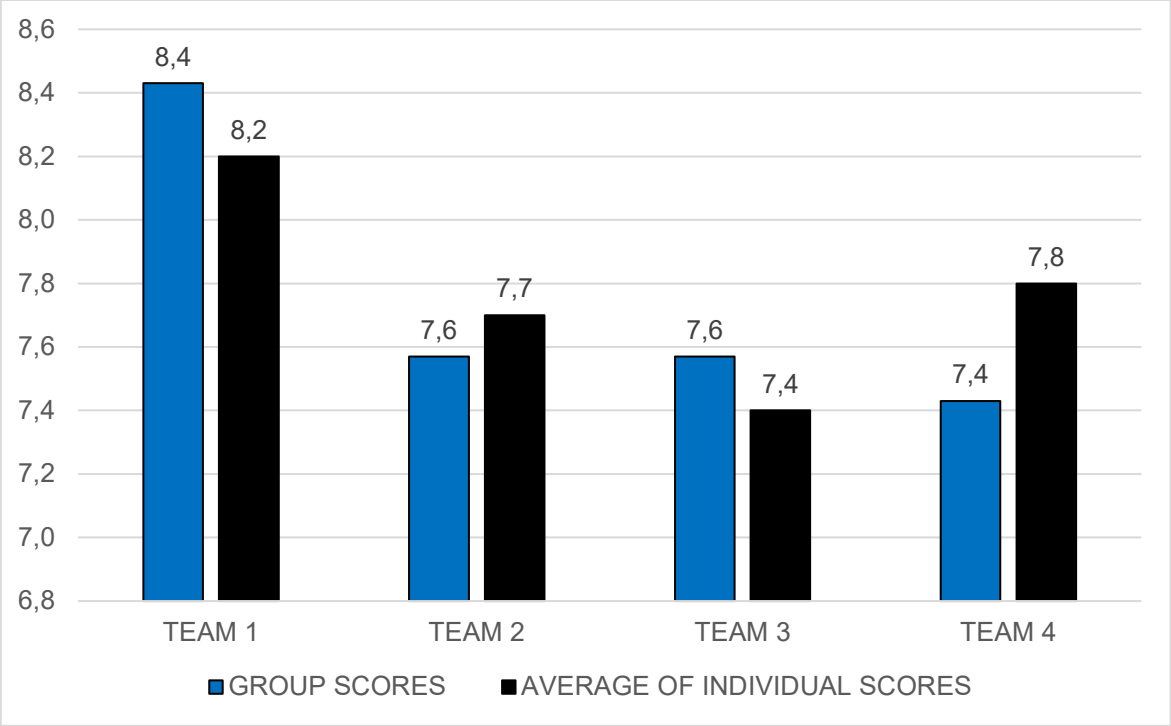
The group score represents 70% of the total, while the remaining 30% represent the evaluation of individual competencies and the cross evaluation. In the group scores, 20% of the total score represent the results from the checkpoints, 35% correspond to the final report and 15% to the project presentation. In the individual part of the score, the main aspects are the results of the individual learning process evaluation which represent 20% of the total, and the cross evaluation among students representing the remaining 10%.

During Pilot I, the following competencies were also evaluated in the Individual Learning Process Evaluation (ILPE, 20% of the total):

- Teamwork.
- Oral and written communication (+ English).
- Use of ICT.
- Conflict resolution / negotiation.
- Initiative, innovation, and creativity.
- Project management.
- Leadership.
- Ethical commitment and responsibility.

However, due to the complexity of the process of evaluating these soft skills, the partners decided to omit them in Pilot II, and substitute them by the learning diaries (see section IV for details).

Figure 3. Group Scores and Individual Average Scores for Pilot I.



Source: MUPIC.

During Pilot I, final grades unveiled that two students did not meet the minimum MUPIC standards (see Annex 1). Something very similar happened with one student during Pilot II (see Annex 2). Thus, those students did not earn any credits for the MUPIC programme.

In Pilot I, group scores (70% of final scores) ranged from 5,2 to 5,9 out of 7 (between 74% and 84%), while total scores (group scores plus individual ones) were in an interval between 7.4 and 8.2. In general, individual scores were high except for the cases when students failed to provide learning diaries according to the instructions given. (See Figure 3 and Annex 1).

Results were very similar in Pilot II (Figure 4 and Annex 2), where group scores ranged from 5.1 to 6.2 out of 7 (between 73% and 89%), while total scores (group scores plus individual ones) were in an interval between 7.1 and 9.1. In general, individual scores were high except for those cases in which students failed to provide learning diaries according to the instructions given

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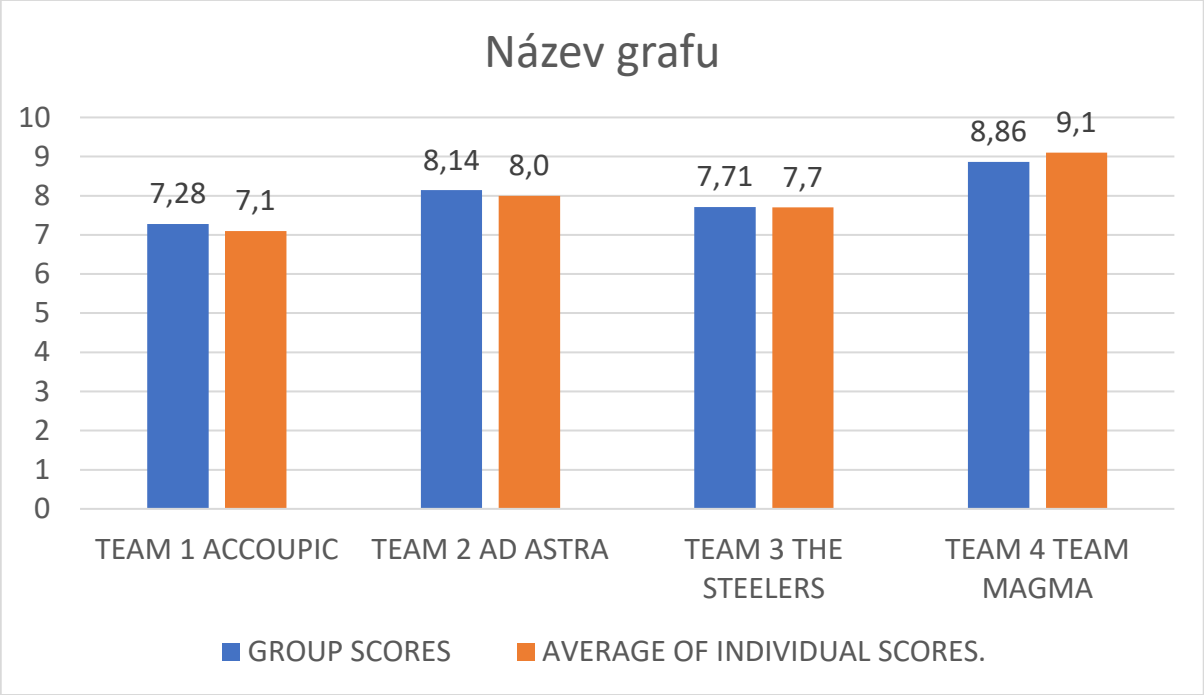
Figure 4. Group Scores and Individual Average Scores durifor Pilot II.



Source: MUPIC.

III. TOOLS.

III.1. Modules.

Modules are the 6 different areas of knowledge that students had to complete during the MUPIC project. They all included supporting educational material to assist students in carrying out the project successfully.

This multimodal course contains the following 6 modules or areas of knowledge.

- M1: Intercultural and Virtual Communication
- M2: Language
- M3: Project Management
- M4: Engineering Design
- M5: Business and Strategy
- M6: Industrial Design

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These modules focus on the core skills students should achieve, such as: improving their language skills to communicate effectively in the working environment; improving/gaining intercultural competencies that are important for working in international teams; learning how to communicate online properly using formal language in synchronous as well as asynchronous learning/working environments; learning how to work in virtual teams effectively; applying what they had learned in college (engineering, business, etc.) to a real-life project.

The modules include supporting educational materials for each of the specific areas of knowledge (engineering, business, communication, and project management) to help students complete their assignments. Additionally, some modules offer online courses which provide students with guidelines and suggest methods of working in teams.

a. Intercultural and Virtual Communication Module

This module focuses on the core skills in communication that the students should acquire to communicate effectively in the working environment: improve/gain intercultural competencies that are essential for working in international teams, learn how to communicate online appropriately in synchronous as well as asynchronous learning/working environments, and learn how to work effectively in virtual teams.

One of the main goals is to give students an authentic experience of multicultural teamwork. Intercultural communication issues are addressed by asking the students to start by completing individual culture profiles. The development of their intercultural communication skills is monitored through the reflective learning diaries that students keep throughout the course.

Learning objectives related to virtual communication, teamwork, and intercultural communication are integrated into the team project work. However, at the beginning of the course, it is convenient to set some specific tasks. During the teamwork, the teams reflect their progress within the team and report it as part of the team progress report. Additionally, all team members reflect individually on teamwork and their own development in a learning diary.

Virtual project teams are heavily using computer-mediated communication and have only limited face-to-face interaction when collaborating, innovating, and completing their tasks. Communication effectiveness has been identified as playing a critical role in the success of virtual projects. A shared understanding of activities to be performed is achieved through appropriate and regular communication and interaction. Effective communication facilitates coordination of teamwork, individual socialization, and group integration. Especially in project work, which involves the start, end, and a varying number of phases between these points, communication is emphasized.

The learning objectives of this topic are:

- Sharing data, information, and digital content with others through appropriate digital communication technologies.
- Adopting behavioural norms and netiquette of the employer while using digital technologies and interacting in a digital environment.
- Understanding how to build and lead an effective virtual team.

To improve understanding of the subject theoretical framework, every team member can study the following:

- Theory of media synchronicity (MST).
- Choice of media (+ cultures and English as lingua franca).
- Company netiquette, ethical aspects (professional/personal identity in social media, work time/free time).
- Conflict/diversity management, importance of trust, IMGD by Susan Wheelan.

Intercultural communication: working on projects always requires smooth and open communication. When working in multicultural teams, everyone should be aware of possible differences within national and professional cultures. However, in many task-related projects, we should focus on similarities rather than differences.

Intercultural communication and team building discussed above are closely intertwined. Team members face challenges in the process but if they are openly addressed, everyone learns to understand each other's behaviour better.

The goals for Intercultural Communication are that each team member:

- Recognizes his/her own cultural identities and builds an appreciation for others (personal, social, cultural, and professional identities).
- Reflects on major cultural frameworks.
- Understands and formulates ways how culture affects communications.
- Identifies specifics of online intercultural communication.
- Comes up with tips for effective cross-cultural communications.

To understand more about the subject theoretical framework, every team member can study the following:

- Claude Koehl (2016), Managing Diversity: 10 steps to multicultural team success: https://trainingmag.com/managing-diversity-10-steps-multicultural-team-success/Culture
- The Lewis Model (2018), By Cross Culture: https://www.crossculture.com/about-us/the-model/.
- Vulture (2012), 33 Tips on Working in Multicultural Teams [4]: https://www.commisceo-global.com/blog/33-tips-on-working-in-multicultural-teams.
- Juliet Bourke, Working in multicultural teams: https://www2.deloitte.com/au/en/pages/human-capital/articles/working-multicultural-teams.html
- Watch: The diversity challenge - role play.

To get a more practical and personal view on the subject, everyone should do a self-assessment in form of culture profile (self-assessment form https://drive.google.com/file/d/1y532Lv_akMvznlIY8NP0gU2DvOekaKjz/view?usp=sharing) and share and discuss the results within the team. This will help in creating understanding and trust from the very beginning.

Experience has shown that most differences are seen in the concept of time and leadership style. Based on the comments, the differences do not become a problem if everyone is aware of them.

Below is a student's example of how Intercultural Communication can be applied during the project. The list also gives tips to team building in general.

1. Select a cross-culturally competent team leader.
2. Make the kick-off phase personal.
3. Take time to build relationships and trust.
4. Learn about differences, focus on similarities.
5. Clarify expectations, don't assume!
6. Communicate, communicate, communicate!
7. Set and respect deadlines.
8. Be alert to signs of trouble, tackle them at once.
9. Assess the team's work.
10. Play for the same goal!

Student teams´ virtual communication and collaboration was supported by encouraging the teams to discuss and reflect how they share and create knowledge with others through digital communication technologies. How does diversity of the team members affect virtual communication and choice of media?

Moreover, the students were asked to discuss and create communication rules and netiquette for their own MUPIC project team to facilitate teamwork work (time/free time). Additionally, this module had activities that aimed to support creating trust and leading a virtual project team through various stages of a project. Moreover, all students were asked to take the Oxford English placement test to estimate the students' level of English at the beginning and at the end of the course.

The student can:

- Recognize the need for and importance of learning and exploring intercultural communication in the context of the MUPIC project (international teams, dynamics within teams, dealing with companies, orientation week abroad).
- Become aware of their own cultural identities and build an appreciation for others (personal, social, and cultural identities).
- Understand and formulate ways how culture affects communications (Edward T. Hall's High-Low Context dimension, perceptions of space, approaches to time).
- Identify specifics of online intercultural communication.

- Understand the meaning and applications of the Individualism vs. Collectivism concept as the most widely used terms in comparing cultures; recognize the constraints of the concept.
- Build an overall comprehension of the major cultural values underlying different behaviours and understand leading values dimensions (Hofstede's Values Orientation Model, brief overview of other models, i.e., Gesteland and Globe Project); using the acquired knowledge, formulate their experience from working in an international group (Belgium, Czech Republic, Finland, and Spain).
- Come up with tips for effective cross-cultural communications: how to become adaptable in intercultural interactions (include experience from the course and suggest practical solutions).
- Share data, information, and digital content with others through appropriate digital communication technologies.
- Understand the differences between face-to-face and virtual communication and apply appropriate code of conduct.
- Adopt behavioural norms and netiquette of the employer while using digital technologies and interacting in digital environments.
- Understand how to build and lead an effective virtual team.

b. Language Module

In this module, students find material that can help them understand how language skills affect team performance and the project's success. It is essential to mention that the students wishing to participate in MUPIC – like courses should have at least a B2 level of English. However, students with lower levels can be accepted as project participants (if highly motivated, the team will support them and lead them to a final increase in the level of English). The improvement of English is one of the main aims of the project work. The student's level of English was monitored, at the beginning and the end of the project course work by an official assessment tool (Oxford Placement Test). Students are also advised to complete a self-assessment of their language skills during the pre-task activity.

In Module 2, students should improve their language skills to communicate effectively in the intercultural, virtual, and multidisciplinary working environment. The module content deals with the formality of language, the style of writing reports, language in a working environment, and gives a summary of commonly made mistakes. Finally, it provides instructions for the final oral presentation.

The aim of the module topics is that each student can:

- Recognize different levels of formality in the English language
- Use the proper means of communication
- Provide language support to the team and project communication.

The module contains material on the following:

- Definition(s) of formality in language
- Levels of formality, their characteristic features, and practical implications, such as why formality in diverse workplaces matters
- Definition of synchronous and asynchronous working/learning environment, and advantages and disadvantages of both
- Writing formal emails (sources of materials)
- Meeting minutes (sources of materials)
- Conference calls (sources of materials)
- Language quizzes
- Instructions on writing a report
- Frequently made mistakes in reports
- Instructions for the final oral presentation of the project results.

The student can:

- Understand the difference between various levels of formality in language, and be able to use the right one
- Recognize different levels of formality in the English language and use the proper means of communication in various working environments, including synchronous and asynchronous communication

- Write a report
- Recognize the commonly made mistakes in reports.

c. Project Management Module

The students form teams, and one team member is nominated as Project Manager (PM). Principles of the project life-cycle model by PMI PMBoK give structure for the project execution and teamwork. In the beginning of the project, emphasis is on project definition, target, stakeholder analysis, requirements, and risks identification. It is important to agree on team's working methods (team meetings, communication tools and practices) early in the process.

The PMI (Project Management Institute; Snyder 2013) project life-cycle model is introduced to student teams during the kick-off week. The project management model gives important structure and management model for teamwork. Led by the Project Manager, teams develop the project Charter with targets, scope, initial project requirements, stakeholder analysis, and, finally, detailed project plan. Stakeholder recognition and analysis are important phases for the student teams to create the view of the project and all the persons, groups, and organization parts they need to connect and communicate with during the project.

Stakeholder analysis also leads to the project's communication plan. The team creates a communication plan with key stakeholders, including all aspects, e.g., goals for communication, methods, types, styles, time schedules and communication tools to be used.

Learning objectives related to virtual communication & teamwork, intercultural communication, and language will be integrated in teams´ project work. However, at the beginning of the course, it is good to have some specific tasks to address the importance of communication inside the student team and with the key stakeholders.

The Project Manager is responsible for keeping the teamwork going effectively and smoothly according to the plan aligned with the engineering, business and marketing and other project work packages.

During the project, project progress reports are provided. Part of the progress report is also learning related to communications. Additionally, all team members reflect individually upon teamwork and their development in a learning diary.

At the project closing phase, a Final Presentation is given to the project's industrial customer. From the project's point of view, also the Project Closure report, as well as a the Lessons Learned document, are produced for the team to recognize what went well, what could have been improved and why.

Project management: important learning targets for students:

1. Project initiation phase:

- Defining project objectives, scope, initial requirements, success criteria.
- Identifying and analysing project (key) stakeholders.
- Identifying project risks.
- Understanding the project triangle relationship: scope, time schedule, resources (costs).
- Organizing the project team and teamwork.

2. Project planning phase:

- Detailed project plan with Work Breakdown Structure, time schedule, resourcing.
- Project requirements and deliverables.
- Change management plan.
- Communication plan.

3. Project implementation phase:

- Progress report.
- Change and risk management.

4. Project closing phase:

    - Deliverables according to the plan, including the Final Presentation for the customer.
    - Project closure report.
    - Lessons Learned.

There are plenty of Project Management learning videos available for students to learn PM. E.g., YouTube Channel "Project Business" includes several 5-20 min learning videos on common Project Management topics.

When the project Charter is completed and reviewed in the first checkpoint, detailed project planning with WBS (Work Breakdown Structure), time schedule and resource allocation is finalized by the team. During the project execution phase, PM is monitoring and managing project scope and schedule, reporting progress and possible changes. Project communication and stakeholder management have proven to be important factors in a project's success.

Finally, when the project reaches the closing phase, the focus is on final deliverables for the customer (the company). The Final Week's student team's presentation is an important part of the project outcome as well as the detailed technical, industrial design and business development customer reports. From the project management point of view, before the team adjourns, it is important to discuss and collect lessons learned knowledge material from all the team members.

The student can:

- Understand general project management concepts especially from the product development viewpoint: have a good overall view of development project life cycle and project phases.
- Understand the importance of project communication and stakeholder management.
- Understand special characteristics of requirements management in the product development context.

- Have an overall comprehension of the basics of development project planning. Be able to describe how the WBS (Work Breakdown Structures) are used as a basis for planning.
- Use the project risk management tools and understand the risk management principles.
- Understand the importance of quality management in development projects.
- Write out and compile the basic development project management documentation.

d. Engineering Design Module

The course is divided according to the main phases of the project: general framework of engineering design, writing of specification, evaluation of the state of the art, creativity in the design process. The systematic approach proposed by Eder and Hosnedl [8] is proposed as a framework for this part of the project.

Student can:

- Have an overall comprehension of a product life cycle and the engineering design process (and its interaction with overall project management for product development, with economic, marketing, and communication issues).
- Write a list of requirements with quantitative technical specifications.
- Develop their creativity and innovation and apply the related implementation techniques.
- Recognize the constraints linked to standards, patents, utility models.

The engineering students of MUPIC would be able to:

- Understand and synthetize the functional principles of a mechanical system.
- Justify the selection of machine elements.
- Produce an overall drawing under the formal conventions of technical drawing.
- Evaluate quantitatively the performance of the designed mechanical system and locate the proposition with respect to the state-of-the-art.
- Write a synthetic report with computation and design notes.
- Respect the standards and safety constraints.
- Develop his/her criticism regarding his/her own design process.

- Be aware of socio-economical, environmental, and ethical constraints.
- Understand the iterative nature of an engineering design process of a technical system subject to economic, technological, societal, and environmental constraints.
- Establish product requirements specifications.
- Refer to standards, regulations, among others.
- Establish a state-of-the art including patents search.
- Predict the performance, quality, and competitiveness of an engineering design proposal with objective property indicators.
- Perform a multidisciplinary engineering project in a structured framework, with innovation-driven contributions.

e. Business & Strategy Module

In this module, students apply what they have learned in college to the MUPIC Project, following the partner company's instructions. This module includes a review of the analysis and existing tools within the discipline of Strategic Management. Special emphasis is placed on how to carry out the strategic diagnosis of an organization and its summarized presentation in the SWOT matrix. Likewise, strategies to correct weaknesses, face threats, maintain strengths and exploit opportunities (CAME Matrix) are suggested. Furthermore, a review of the CANVAS model and the bases for generating new business have been incorporated, as well as Corporate Social Responsibility guidelines.

Therefore, students should apply different business tools to learn more about the countries where the company operates, and the ones that the company tries to sell to (if any). They should also use business tools to learn more about the specific industry where the company operates, as well as its current and potential customers. Furthermore, students must delve into the company, their products, culture, production process, customers, workforce, vision, mission, strengths, weaknesses, opportunities, threats…

- Students may analyze the macro and micro business environment for the company, using different business tools they learned in college.
- They may apply SWOT to delve into the company's resources and possibilities, as well as the CAME analysis.
- They may study the company's current and potential customers.
- They may search for their target segments of the markets for the new products.
- They may pinpoint the company's competitive advantage.
- They may build a business strategy.
- They may build a marketing plan.
- They may build a business plan.
- They will recommend a plan of action.
- They will work within the company's culture and mission, and the framework of the company's social responsibility. That benefits all the stakeholders, not only the shareholders and investors.
- They will adapt to any other requirement that the company may request.

The learning material for the business & strategy module is available on the MUPIC web page for students to use. Additionallystudents can review the business & strategy references such as:

- Osterwalder, A. & Pigneur, Y (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley and Sons.
- Osterwalder, A. & Pigneur, Y (2014): Value Proposition Design: How to Create Products and Services Customers Want. Wiley.
- Blank, S. & Dorf, B. (2012). The Startup Owner's Manual: The Step-By-Step Guide for Building a Great Company. K & S Ranch.
- Varona Alabern, M. (2020): Incentives to Encourage Companies to Become Socially Responsible. Nuevas Tendencias. n. 103. https://revistas.unav.edu/index.php/nuevas-tendencias/issue/view/1385
- Kramer, Mark R and Pfitzer, Marc W. (2016): The Ecosystem of Shared Value. Harvard Business Review.

- Porter, Michael E., Hills, Greg, Pfitzer, Marc, Patscheke, Sonja and Hawkins, Elizabeth (2011): Measuring Shared Value. Harvard Business Review.
- Porter, M. and Ktamer, M. (2011): What is shared value. Harvard Business Review.
- Bonini, Sheila, Timothy M. Koller, and Philip H. Mirvis (2009): “Valuing Social Responsibility Programs,” McKinsey on Finance, July.
- Faupel, Christian and Susanne Schwach (2011): Measuring Corporate Sustainability, Maximizing Shareholder Value. Ernst & Young, May.
- PwC (2012): Responsible Investment: Creating Value from Environmental, Social, and Governance Issues, March.

f. Industrial Design Module

Students will become knowledgeable in the field of industrial design. The field deals with finding innovative solutions for industrially manufactured products. It primarily combines functionality and aesthetics.
Students focus on human-centred design and are able to define human needs and satisfy those needs with their design.

Students will learn about the methods used by the creative industry. They will be able to present and explain the results of their work in an attractive way to the public thanks to their knowledge of visual simulation methods, with a possible transfer to AR/VR in the case of 3D models.

The course is divided into three parts:

- Definition of values – a human being a universal measure. The human needs and applying them to the proposed design. Emotions in design.

- Definition of design - students can define the product. Technical constraints, user stories, costing. Creating an annotation and theoretical description of what we are looking for.

- Designing, feedback, testing. Based on our product definition, creative ideas and concepts are generated, typically documented through sketches and simple models. Different types of testing are used to get feedback - for example, we can use virtual reality or present the designed product in the form of a comic.

The course introduces students to the relationship between shaping (styling), design, and engineering. They will attempt to place their work in a socio-cultural context.

References:

- Kolesár Z., Kapitoly z dějin designu. Praha: Vysoká škola umělecko-průmyslová, 2009 ISBN 9788086863283
- Umberto Eco, Come si fa una tesi di laurea: le materie umanistiche. Milan: Bompiani, 1977
- Jak napsat diplomovou práci. Překlad Ivan Seidl. V Olomouci: Votobia, 1997. 271 s. Velká řada; sv. 27. ISBN 80-7198-173-7
- Daniel Kula a Elodie Ternaux, Materiology, 2012, Praha, Happy Materials, ISBN 9788026005384
- Gerhard Heufler;Michael Lanz; Martin Prettenthaler, Design Basics: From Ideas to Products, Niggli, 2019, EAN: 9783721209884

III.2. Engineering, Industrial Design, and Project Management Glossaries.

To ensure that all participants understand each other while discussing technical or managerial aspects, they must be able to translate the concepts from their mother tongue into English which is the lingua franca of the project. For that purpose, the glossary was translated into Spanish, English, French, Finnish, and Czech. Each partner translated it into their language, and during the first pilot, they also provided the original vocabulary for their field of expertise. Inside the glossary, each entry groups the words for an object or concept in the five languages, as well as the most usual verbs and adjectives. For a more complete definition of the word, links are provided to online resources and references. To avoid possible confusion, the inputs are also assigned a domain. Presently, there are seven general domains (engineering and industrial design, project management, strength of materials, general mechanics, CAD, machine elements and mechanical transmissions) and four specific domains, which were added according to the topics proposed by the companies (railway, metallurgy, thermodynamics, and robotics). For the sake of efficiency, the glossary was constructed through a shared Google sheet. For a more user-friendly access by the students, the glossary will be transferred into the MUPIC Moodle course in the form of a database. The use of other applications is open.

The technical glossary was completed by MONS for Pilot I and Pilot II. In Pilot II, new terms were added to the glossary to include those required by two new projects at Vesuvius and Desimone. Therefore, 2,257 words make up the final glossary (Table 3).

Table 3. Number of words per domain in Pilot I and in Pilot II.

PILOT I	Number of Words
• Engineering and Industrial Design	123
• Project Management	670
• Strength of Materials	127
• General Mechanics	133

• CAD	65
• Machine Elements	231
• Railway	108
• Mechanical Transmissions	63
Subtotal	**1.520**
PILOT II	**Number of Words**
• Metallurgy	309
• Thermodynamics	318
• Robotics	110
Subtotal	**737**
Grand Total	**2.257**

Source: MUPIC.

III.3. Evaluation Systems and the Assessment Grid.

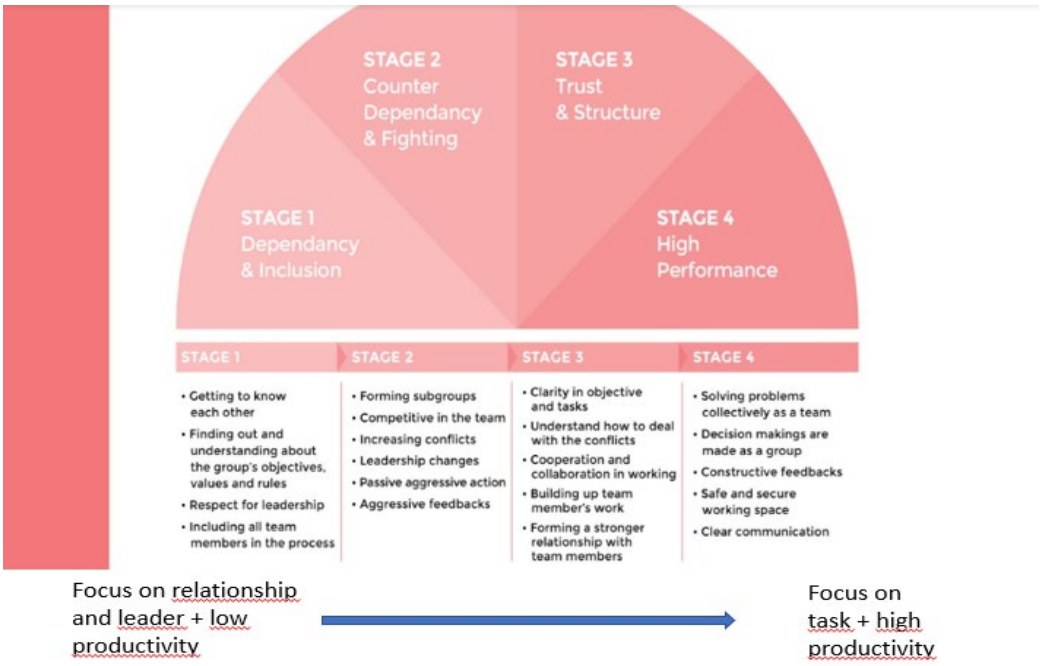
This is a sophisticated and well-designed tool, that has had a prominent role in MUPIC's success. Its making required a great deal of complex calculations that enabled partners to do a 360-degree students' evaluation, including a great variety of diverse competencies: from teamwork to soft skills, critical-thinking, problem-solving, academic competencies, etc. Consequently, during Pilot I, some partners had trouble understanding how to use the sophisticated tool, since there was a rubric for each soft skills competency. By Pilot II, however, those problems were solved by reducing the number of rubrics. Then, every partner became familiar with the tool and was on board. Detailed information about the assessment grid has been provided in the previous paragraphs.

III.4 Learning diaries:

Writing reflections on the project work is encouraged to enhance the project-based learning experience. Students' learning diaries were introduced and graded in Pilot I and II, as stated earlier. Students were asked to reflect in their diaries both their own learning and teamwork in multicultural virtual teams. Reflecting on the virtual project work is encouraged to enhance project-based learning experience by keeping individual diaries. Students had to provide diary reflections in the learning platform three times during the project work. Additionally, a final reflection was provided when the project work was over. Language and communication experts gave feedback and comments on the diaries and motivated students to develop and practice their skills further. Wheelan´s group development model was followed in diary reflections in each CP.

The questions asked from students were based on Wheelan´s group development model (Graph 5).

Graph 5- Learning diaries diagram.



Source: Wijaya (2018)

In all CPs, students were also asked about their teamwork experience (project management, leadership, language, virtual communication, cultures, trust, conflict management, engineering design, marketing):

- What went well?
- What could be improved?
- What did I learn?
- What am I going to exploit in practice?

  Answers varied.

In the final reflection, students were asked to answer the following questions:

- What stage did you reach with your team? (According to Wheelan´s model).
- Think about your own role in teamwork and the influence of communicative styles on reaching common goals. Which cultural factors affect your communication? What is your own preferred role?
- How did your level of English affect your work in the team and productivity?
- How did your language skills improve?
- Do you want to lead, or do you want to be led? Did something change during this project?
- Reflect on the importance of netiquette during the project. Agreed rules, tools, and schedules? Have you had any conflicts in your team during this course? What really happened? Describe how you solved them. Did something change during this project?
- Read the Politeness Theory article and think about the relationship between politeness and formality. Reflect the importance of politeness and formality in your team/teacher/company communication during the course. Politeness Theory https://www.universalclass.com/articles/business/communication-studies/politeness-theory.htm
- How did your educational and professional background affect the team progress (team building and productivity)?

III.5 Communication tools:

Emails, Moodle, Teams, Zoom and Google Drive were used as well as the MUPIC web page https://MUPIC.eu/, where information and reports were posted. Nevertheless, Google Drive was also used by the partners to upload files that were shared and could be modified or commented on by any partner. Social media channels LinkedIn and Twitter were used to invite stakeholders to the student teams final presentations (@MUPIC4, #MUPIC4). Consolidating all the information under one host would have probably been a more efficient way to operate.

It would be beneficial if the common teamwork platform could have some tools/capabilities to support project work. At any rate, it is important that student teams themselves decide what platforms/tools they use to communicate with each other.

The main communication tool among partners and students were emails, but the meetings were held either by Zoom or Teams.

IV. PROJECT DISSEMINATION. MULTIPLIER EVENTS

MUPIC has been a positive and enriching learning experience for all participants, becoming a milestone for similar projects.

Therefore, various MUPIC promotional initiatives were carried out: publication of scientific papers, multiplier events, and participation in conferences. All the dissemination material is available on the MUPIC website.

V. LESSONS LEARNED AND PROPOSED IMPROVEMENTS

MUPIC has been an enriching experience for all participants. Nevertheless, it has encountered several challenges. Some of them should be taken into consideration in the development of similar projects.

1. The principal one was the current pandemic which has altered MUPIC's initial planning, thus putting some constraints on it. Indeed, one of the objectives of MUPIC was to promote student immersion into a multicultural environment, enhancing their education and their personal growth. Yet, the Covid-19 pandemic prevented students from working face-to-face, undermining some of MUPIC main objectives. Therefore, all MUPIC participants worked remotely, partially solving those problems. On the other hand, the situation provided all parties excellent practice in how to work effectively in a completely virtual environment.
2. Another challenge that the MUPC team faced was the lack of commitment by some of the students who initially signed up to participate in this project. The fact that MUPIC was not part of the college curricula demotivated a few students who did not need the credits to graduate. Therefore, for future projects, we recommend that these programmes be part of the curricula and be graded accordingly.
3. Furthermore, the MUPIC students' age differences and backgrounds have also been a challenge but, on the other hand, the diversity of the team members provided a more authentic working life experience as at the workplaces people normally work together with colleagues with different levels of experience and of different ages. Undergraduate students were matched up with much older graduate students to complete the projects. Those two groups had little in common and younger students were at a clear disadvantage, failing to achieve MUPIC's multicultural and teamwork goals.
4. Managing a diverse team located in different countries was a big challenge. Furthermore, the pandemic put additional constraints. This is why the project managers needed leadership skills. Those skills include empathy and emotional intelligence, taking advantage of diversity and understanding the differences, learning from each other, and, finally, integrating the skills to successfully complete the project. Furthermore, each team member is in charge of their work, and project managers should encourage them to lead

the team when the team is working in an area of their expertise. Thus, leadership will change hands when the project requires it.

Diversity is a must in today's ever-changing environment. It is a source of creativity and innovation, bringing a fresh pair of eyes to any project. However, it may also be a source of conflicts and challenges that should be considered and addressed ahead of time.

5. Additionally, even though coaches had a very relevant role in guiding and helping students complete the project, they mostly communicated with the project manager of each team. Direct contact with the rest of the students would have improved the results and eased the way to the finish line.
6. The proposed number of students per team is 5, which includes 2 engineering students, one business student, one product manager and one industrial designer. Additionally, the participating students should represent different universities and nationalities.
7. Students did not understand some of the terminology used in MUPIC. Therefore, a "MUPIC glossary" presented in the kick-off week will help clarify all the terms used in MUPIC.
8. There should be a single clear schedule with all the important dates in it. This Master Time Schedule should be available for all partners (students, teachers, coaches, experts, partners/customers), and it should be placed in an easy-to-find spot of the learning platform (Moodle, Teams etc). It should be released during the kick-off week and should be kept up to date.
9. Coaches met with students regularly - once, twice a week or every other week. Experts met with students as well, from time to time.
10. During PILOT I, a pros-cons analysis was conducted. It could be a good idea to do the same in each Pilot.
11. Students also suggested having a written description of coaches' and experts' roles. They requested consistent feedback from them as well.

12. Some problems arose when the company's goals were not aligned with the MUPIC's ones. Therefore, partner companies should be well aware of MUPIC's requirements and objectives and comply with them.
13. Coaches should regularly meet with all the students of their assigned teams, not only with the project manager.
14. Very restrictive Non-Discloser Agreements clauses requested by some of the partner companies become an obstacle for the completion of MUPIC project. Therefore, partners should pay close attention to NDA clauses to prevent them from putting additional unnecessary constraints on the development of similar projects in the future.
15. The partner companies' personnel supporting the MUPIC students were mostly engineers. Consequently, it was more difficult for business students to get the information they needed to complete their assignments. The rest of students experienced delays in the companies' feedback as well.
16. Finally, the Business & Marketing module, with an emphasis on corporate social responsibility, should have been incorporated into the programme from the very beginning since it was a very important part of the project.

VI.CONCLUSIONS

This guide gives a comprehensive and clear picture of the MUPIC project to ease the path for future endeavours. It is a step-by-step manual to assist teachers/lecturers and researchers to design and carry out similar projects successfully, overcoming unforeseen challenges. The method used in the development of MUPIC, along with the knowledge gained, can be incorporated by professors/researchers into their college curricula.

The Multidisciplinary Projects in an International Context (MUPIC) is a multicultural and multidisciplinary project that helps students acquire relevant and high-quality competencies. Indeed, by designing engineering products proposed by the partner

companies (or solving an engineering problem), and marketing them, students from the four universities acquired valuable competencies. Those competencies include technical skills, entrepreneurial, foreign language, and digital skills, as well as transversal and soft skills. Therefore, students came up with innovative and creative solutions, using a multidisciplinary/multicultural approach in a socially responsible environment. All these factors foster employability and enhance their socio-educational and professional development.

MUPIC had a three-year time horizon and was funded by the European Union Erasmus+ KA2 programme.

Furthermore, this project supports and enhances the European manufacturing industry, and benefits the academic as well as the business world, and the society as a whole.

MUPIC is a complex project which involves diverse players with different backgrounds and from different environments. Indeed, all the partners worked together on truly complex assignments. Therefore, it was a demanding process, as a result of which students and professors were under pressure during the development of the project. Nevertheless, it was a rewarding and proud experience for all participants when they successfully completed it.

Due to MUPIC complexity, we recommend that these programmes be incorporated into the students' college curricula and be graded accordingly. It will make it easier to recruit students for similar projects, motivate them, and enhance the students' commitment. Furthermore, these projects should emphasize and encourage teamwork and reciprocal learning. They should avoid unnecessary rivalry among students, emphasize what unites them, and minimize what separates them. Building awareness of corporate social responsibility should also be among the program goals.

ANNEXES

ANNEX 1. Main results of Pilot I per group.

Group Evaluation – TEAM1				
	CHECKPOINT 1	CHECKPOINT 2	CHECKPOINT 3	SCORES
ASSIGNMENTS	8,1	8,1	8,1	8,1
FINAL REPORT				8,5
PROJECT PRESENTATION				8,7
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE (8.1 x 20% + 8.5 x35% + 8.7 x 15%)				5,9

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	ILPE / COMMUNICATION (20%) *	GROUP SCORE (70%)	TOTAL MUPIC SCORE
Student 1	(3.5 x 10%) 3,5	(5 x 20%) 5,0	5,9	7,3
Student 2	8,4	9,0	5,9	8,5
Student 3	8,3	9,0	5,9	8,5
Student 4	9,5	10,0	5,9	8,9
Student 5	5,9	6,0	5,9	7,7

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This project has been funded with support from the European Commission.

Group Evaluation – TEAM1				
	CHECKPOINT 1	CHECKPOINT 2	CHECKPOINT 3	SCORES
ASSIGNMENTS	8,1	8,1	8,1	8,1
FINAL REPORT				8,5
PROJECT PRESENTATION				8,7
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5,9

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	ILPE / COMMUNICATION (20%) *	GROUP SCORE (70%)	TOTAL MUPIC SCORE
Student 1	3,5	5,0	5,9	7,3
Student 2	8,4	9,0	5,9	8,5
Student 3	8,3	9,0	5,9	8,5
Student 4	9,5	10,0	5,9	8,9
Student 5	5,9	6,0	5,9	7,7

Group Evaluation – TEAM2				
	CHECKPOINT 1	CHECKPOINT 2	CHECKPOINT 3	SCORES
ASSIGNMENTS (20%)	6,5	6,5	6,5	6,5
FINAL REPORT (35%)				7,4
PROJECT PRESENTATION (15%)				9,1
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5,3

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	ILPE / COMMUNICATION (20%) *	GROUP SCORE (70%)	TOTAL MUPIC SCORE
Student 1	8,9	8,5	5,3	7,9
Student 2	8,6	8,0	5,3	7,7
Student 3	9,3	8,0	5,3	7,8
Student 4	8,1	6,5	5,3	7,4

Co-funded by the Erasmus+ Programme of the European Union

PROJECT NUMBER: 2018-1-CZ01-KA203-048151
This project has been funded with support from the European Commission.

Group Evaluation – TEAM3				
	CHECKPOINT 1	CHECKPOINT 2	CHECKPOINT 3	SCORES
ASSIGNMENTS (20%)	6,7	6,7	6,7	6,7
FINAL REPORT (35%)				7,8
PROJECT PRESENTATION (15%)				8,1
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5,3

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	ILPE / COMMUNICATION (20%) *	GROUP SCORE (70%)	TOTAL MUPIC SCORE
Student 1	9,3	10,0	5,3	8,2
Student 2	7,5	6,5	5,3	7,4
Student 3	7,5	5,0	5,3	7,1
Student 4	9,6	4,0	5,3	7,1

Group Evaluation – TEAM4				
	CHECKPOINT 1	CHECKPOINT 2	CHECKPOINT 3	SCORES
ASSIGNMENTS (20%)	7,3	7,3	7,3	7,3
FINAL REPORT (35%)				7,4
PROJECT PRESENTATION (15%)				7,6
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5,2

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	ILPE / COMMUNICATION (20%) *	GROUP SCORE (70%)	TOTAL MUPIC SCORE
Student 1	3,7	1,0	5,2	FAILED
Student 2	9,4	8,0	5,2	7,7
Student 3	8,8	9,0	5,2	7,9
Student 4	8,5	8,0	5,2	7,6
Student 5	1,6	0,0	5,2	FAILED

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(*) Evaluation of competencies includes teamwork, digital competencies, innovation & creativity, self-regulation & responsibility, continuous learning, problem solving, leadership and commitment & ethics.

ANNEX 2. Main results of Pilot II per group.

Group Evaluation – TEAM1 ACCOUPIC				
	CHECKPOINT 1	**CHECKPOINT 2**	**CHECKPOINT 3**	**SCORES**
ASSIGNMENTS (20%)	7.0	7.0	7.0	7.0
FINAL REPORT (35%)				7.1
PROJECT PRESENTATION (15%)				7.8
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5.1

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	**ILPE / COMMUNICATION (20%) ***	**GROUP SCORE (70%)**	**TOTAL MUPIC SCORE**
Student 1	7.6	2.7	5.1	**6.4**
Student 2	8.4	9.8	5.1	**7.9**
Student 3	8.4	9.8	5.1	**7.9**
Student 4	6.4	2.7	5.1	**6.2**
Student 5	1.5	0.0	5.1	**FAILED**

Group Evaluation – TEAM2 AD ASTRA				
	CHECKPOINT 1	**CHECKPOINT 2**	**CHECKPOINT 3**	**SCORES**
ASSIGNMENTS (20%)	6.7	7.0	7.4	7.0
FINAL REPORT (35%)				8.4
PROJECT PRESENTATION (15%)				9.4
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				**5.7**

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	**ILPE / COMMUNICATION (20%) ***	**GROUP SCORE (70%)**	**TOTAL MUPIC SCORE**
Student 1	9.4	9.8	5.7	**8.6**
Student 2	9.1	9.7	5.7	**8.6**
Student 3	9.3	8.5	5.7	**8.4**
Student 4	8.2	6.2	5.7	**7.8**

Student 5	7.9	1.0	5.7	**6.7**

Group Evaluation – TEAM3 THE STEELERS				
	CHECKPOINT 1	**CHECKPOINT 2**	**CHECKPOINT 3**	**SCORES**
ASSIGNMENTS (20%)	7.2	7.2	7.2	7.2
FINAL REPORT (35%)				7.5
PROJECT PRESENTATION (15%)				9.0
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				5.4

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	**ILPE / COMMUNICATION (20%) ***	**GROUP SCORE (70%)**	**TOTAL MUPIC SCORE**
Student 1	9.8	9.3	5.4	8.2
Student 2	10.0	9.9	5.4	8.4
Student 3	9.7	9.7	5.4	8.3
Student 4	8.5	1.5	5.4	6.6
Student 5	8.6	2.4	5.4	6.7

Group Evaluation – TEAM4 MAGMA				
	CHECKPOINT 1	**CHECKPOINT 2**	**CHECKPOINT 3**	**SCORES**
ASSIGNMENTS (20%)	8.4	8.4	8.4	8.4
FINAL REPORT (35%)				8.7
PROJECT PRESENTATION (15%)				9.6
TOTAL GROUP EVALUATION EXCLUDING INDIVIDUAL SCORE				6.2

INDIVIDUAL EVALUATION (FROM 1 TO 10)

	CROSS EVALUATION (10%)	**ILPE / COMMUNICATION (20%) ***	**GROUP SCORE (70%)**	**TOTAL MUPIC SCORE**
Student 1	9.8	9.5	6.2	9.0
Student 2	9.9	9.4	6.2	9.0
Student 3	9.8	9.7	6.2	9.1

(*) Evaluation of competencies includes teamwork, digital competencies, innovation & creativity, self-regulation & responsibility, continuous learning, problem solving, leadership, and commitment & ethics.

Annex 3.

Rubric of Written Work

1	EVALUATION OF COMPETENCES BY PARTNER: FINAL REPORT EVALUATION						
	MONS						
		EXCELLENT	GOOD	SUFFICIENT	INSUFFICIENT	WEIGHT	SCORE
		4	3	2	1	%	Between 1 and 4
	INFORMATION SEARCH	There has been a very good search of information and the best sources have been chosen. Those sources consulted have been referenced correctly.	In general there has been an effort to search for information. Information have been selected correctly although sources were not referenced properly.	An effort is found in the search for information, although not always the information selected is the most appropriate. Sources were not referenced properly.	Little effort in the search of information; few or no sources have neither been consulted nor referenced.	10%	
	ELABORATION OF THE CONTENT	The content has been developed very well; it adapts to the demands raised by MUPIC Project and its approach is original and innovative.	The content has been developed quite well and adapts to the requirements settled by MUPIC Project.	The content adapts sufficiently to the demand raised by MUPIC Project, but does not provide too much added value.	The content is not adapted to the demand raised by MUPIC Project and has been little elaborated and argued. It contains "copy-paste of internet", not referenced.	35%	
	LEVEL OF CONCLUSIONS	The work ends with a perfectly argued final conclusion that shows the scope in the reflection of the students.	Some conclusions are drawn up with a brief reflection. The work has some added value.	The work is concluded with a brief conclusion but with little added value.	There are no conclusions or they are very poor and do not reflect a final reflection from the students.	35%	
	ORGANIZATION OF THE CONTENT	It shows a very clear and sequenced planning. The different aspects in the index are defined correctly.	The organization of the work is clear and its planning is easy to understand. There is no index or it was not prepared properly.	The work is sufficiently well organized, although the format can / must be improved.	The work is not well organized, the points to be discussed are not understood and it is difficult to understand its outline.	10%	
	FORMAL PRESENTATION	Well worked and visually attractive, original and innovative.	Careful and well worked.	Acceptable presentation but without any added value.	Neglected and unattractive presentation.	10%	
						TOTAL	0.0
						REF. TO 10	0.0

Source: MUPIC.

Rubric of Presentation and Oral Communication

2	EVALUATION OF COMPETENCES BY PARTNER: PROJECT PRESENTATION						
	ALL PARTNERS / PARTNER COMPANY / COMMUNICATION TEAM						
		EXCELLENT	GOOD	SUFFICIENT	INSUFFICIENT	WEIGHT	
		4	3	2	1	%	
	PREVIOUS PREPARATION	It shows that the presentation has been prepared carefully and in detail, showing all aspects of the work done and all resourses used during the project.	It shows that the presentation has been prepared quite well, although some kind of improvisation is shown.	The preparation of the content is quite evident but there were many improvisations during the presentation.	There is no prior preparation, and there are conceptual errors in the presentation.	15%	
	DEVELOPMENT OF THE CONTENT	The content has been very well developed, it adapts to the demands raised by MUPIC Project and its approach is original and innovative.	The content has been quite well developed and adapts to the requirements of MUPIC Project.	The content adapts sufficiently to the demand raised by MUPIC Project, but does not provide added value.	The content is not adapted to the demand raised by MUPIC Project and has been little elaborated, connected and argued.	30%	
	GRAPHIC ELEMENTS	The graphic elements of the presentation are totally appropriate and in line with the requirements of a professional work.	The graphic elements of the presentation are appropriate, but other elements could have been used to facilitate understanding.	Although the speech is well organized, by excess or default, the graphic complements of the exhibition are quite poor.	There are no graphic elements included in the presentation.	15%	
	ORAL LANGUAGE	Establishes a total communication with the audience, provokes interest and involvement with his speech.	The presentation gets the audience to listen but the presenter has some deficiencies in verbal fluency.	Although the presenters speech are more or less coherent, it do not manage to get the attention of a significant percentage of the audience.	The presentation is quite boring, does not attrach the audience and denotes many deficiencies.	20%	
	NON-VERBAL COMMUNICATION	The presentation is accompanied by the gestures, tones, uses of space, looks and speeches that are close to perfection.	In most cases, presenters manage to accompany their speeches with gestures, tones, looks and uses of space that are correct.	Acceptable presentation of non-verbal resources, but without any added value or pretty limited.	Null accompaniment of the non-verbal component to the oral discourse, causing monotony, poor commitment and disconection in the audience.	20%	
						TOTAL	0.0
						REF. TO 10	0.0

Source: MUPIC.

Cross-Evaluation Rubric

STUDENT 1					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1 (SELF EVALUATION)					
STUDENT 2					
STUDENT 3					
STUDENT 4					
STUDENT 5					

STUDENT 2 (SELF EVALUATION)					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1					
STUDENT 2 (SELF EVALUATION)					
STUDENT 3					
STUDENT 4					
STUDENT 5					

STUDENT 3 (SELF EVALUATION)					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1					
STUDENT 2					
STUDENT 3 (SELF EVALUATION)					
STUDENT 4					
STUDENT 5					

STUDENT 4 (SELF EVALUATION)					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1					
STUDENT 2					
STUDENT 3					
STUDENT 4 (SELF EVALUATION)					
STUDENT 5					

STUDENT 5 (SELF EVALUATION)					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1					
STUDENT 2					
STUDENT 3					
STUDENT 4					
STUDENT 5 (SELF EVALUATION)					

STUDENT X (AVERAGE)					
	CROSS EVALUATION - GROUP X FROM 1 TO 10				
	Perform the tasks assigned by the group within the required deadlines	Actively participate in team meeting spaces, share information, knowledge and experiences	Collaborate in the definition, organization and distribution of group tasks	Take into account the views of others and do feedback constructively	SCORE
STUDENT 1					
STUDENT 2					
STUDENT 3					
STUDENT 4					
STUDENT 5 (SELF EVALUATION)					

Source: MUPIC.

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ANNEX 4 MUPIC Matrix

Milestones	Date	Project Management	Intercultural, Virtual Communication and Language	Business - Marketing	Industrial Design - Art	Engineering Design
Kick-off week	2-9.10 2020	Project Management introduction -Project life-cycle, phases -Project communication -Requirements for Check Points Students' teamwork on communication planning	-Presentation of the learning objectives, content in Moodle and main theories (to be applied in the teams' project plan). -Requirements for checkpoints -Discussion on the pre-tasks Setting learning objectives.			Presentation of Part 1 (general outline of the design process - 1,5 h - on Wednesday); Presentation of Part 2 (specs) and group activity (Wednesday PM)

Milestones	Date	Project Management	Intercultural, Virtual Communication and Language	Business - Marketing	Industrial Design - Art	Engineering Design
Check Point 1	9. 11.2020	Project initiation: - Project Charter - Stakeholder analysis - Preliminary requirements (from all the stakeholders) - Preliminary project plan	**Individual diary reflection** on a) communication and intercultural aspects in virtual teams (follow instructions in Module 1): • cultural identity • media synchronicity MST. b) on learning Communication report with **team reflections** on communication and intercultural aspects in virtual teams: (as part of the project report!)	Stakeholders identification Market research - setting economic targets - market analysis with a focus on competitive or related products	Design study - competitive - expected	Elaboration the problem State-of-the-art (partial) (SWOT of competitive products, analysis of patents, ...) Potential innovation space Requirements specifications
	Each MUPIC Project team has to prepare and deliver: A reflective learning diary (individual assignment). One report for each of the activities to be assigned for Check Point 1. Each team should submit a file divided to sections according to the field-specific requirements described in this document. One file per each team should be uploaded to Moodle under Check Point 1 (except individual reflection diary entries under communication).					

Milestones	Date	Project Management	Intercultural, Virtual Communication and Language	Business - Marketing	Industrial Design - Art	Engineering Design
Check Point 2	18.12.2020	Project plan: -Detailed plan -Work Breakdown Structure - Requirements documentation Project progress report (intermediate report)	**Individual diary reflection** on a) communication and intercultural aspects in virtual teams. (follow instructions in Module 1): • communicative styles • trust & conflict management b) on learning (instructions in the diary) Communication report with **team reflections** on communication and intercultural aspects in virtual teams: (as part of the project report!)	Adding product requirements based on the "market" analysis (Must have – Should have – Could Have – Won't have) PESTEL analysis (intermediate report)	Concept Draft Design Sketch Consultation of expected design Rough concept of presentation of the project (intermediate report)	State-of-the-art (final) Conceptual Product Design (incl. conceptual alternatives, their SWOT evaluation and decision (prediction of properties and performance is an inherent introductory part of the SWOT evaluation and decision) (intermediate report)
	Each MUPIC Project team has to prepare and deliver: A reflective learning diary (individual assignment). One report for each of the activities to be assigned for Check Point 3. Each team should submit a file divided to sections according to the field-specific requirements described in this document. One file per each team should be uploaded to Moodle under Check Point 3 (except individual reflection diary entries under communication).					

Milestones	Date	Project Management	Intercultural, Virtual Communication and Language	Business - Marketing	Industrial Design - Art	Engineering Design
Check Point 3	29.3. 2020	Project progress report (intermediate report) Project change management documentation	**Individual Diary reflection** on a) communication and intercultural aspects in virtual teams (follow instructions in Module 1): • netiquette and ethical aspects • communication problems b) on learning (instructions in the diary) Communication report with **team reflections** on communication and intercultural aspects in virtual teams: (as part of the project report!)	Cost evaluation Quality prediction	Consensus concept with construction and economic optimisation for the preliminary layout	Constructional Product Design "First iteration" = rough (initial) layout Innovation proposals based on the (suboptimal) conceptual alternative. SWOT evaluation of the 1st Draft proposal (update of the prediction of properties and performance)
	Each MUPIC Project team has to prepare and deliver: A reflective learning diary (individual assignment). One report for each of the activities to be assigned for Check Point 3. Each team should submit a file divided to sections according to the field-specific requirements described in this document. One file per each team should be uploaded to Moodle under Check Point 3 (except individual reflection diary entries under communication)					

Final Work Submission	Date	Project Management	Intercultural, Virtual Communication and Language	Business - Marketing	Industrial Design - Art	Engineering Design
	3.5. 2020	Project management: -Deliverables according to the plan -Project closure report -Lessons learned documentation	Evaluation of reflections/learning Setting new individual learning objectives. Communication report (as part of the final project report) Communication (oral and written communication) of the results in the final presentation English Language test after the course	Reflecting of benefits Marketing proposal, product cost prediction	Visualisation and final design base on the final design Final design study	"Second iteration" = definitive (dimensional) layout: global drawing of the system, with nomenclature (bill of materials) + additional drawings relative to the Detail Product Design (defining original parts you designed, assemblies, ...) Completed design project documentation (technical report including SWOT evaluation of the alternatives, description of the proposed design, dimensioning of machine parts, description of assemblies, CAD models and drawings) Project presentation

ANNEX 5

Multidisciplinary Projects in an International Context

Certificate of Completion

This is to certify that

[redacted]

has successfully completed

The Multidisciplinary Projects in an International Context Course

The course consisted of: language and intercultural communication, online communication in virtual teams, engineering design and project management modules in virtual learning environment system. 5 ECTS

21th May 2021

MUPIC coach, University of West Bohemia | MUPIC coach, University of Mons | MUPIC coach, Turku University of Applied Sciences | MUPIC coach, Florida Universitaria | MUPIC project coordinator | Industrial Project Owner, Desimone | Industrial Project Owner Vesuvius

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Multidisciplinary Projects in an International Context

Certificate of Achievement

Is hereby presented to

[redacted]

Team Ad Astra - Desimone wants to thank the whole Ad Astra team for their management of the project, despite the unusual pandemic circumstances. Global team spirit and excellent leadership of the manager made that you deserve to win this contest. Congratulations!

Presented on 21th May 2021

Industrial Project Owner, Desimone

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