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Maritime Alliance for fostering the European Blue Economy through a Marine Technology Skilling Strategy

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

Highlights of MATES Pilot Experiences

The Magnus Effect

Layman Report

March 2022

About this Report

This document was developed through the EC-funded Erasmus+ project **MATES: Maritime Alliance for fostering the European Blue Economy through a Marine Technology Skilling Strategy.**

The objective of the MATES project is to develop a skills strategy that addresses the main drivers of change in the maritime industries, in particular shipbuilding and offshore renewable energy. Both sectors are strongly linked and require new capacities to succeed in an increasingly digital, green and knowledge-driven economy.

Duration: January 2018 – April 2022 (52 months)

More information on the project is available at projectmates.eu.

Document information	
Short description	This document helps to develop effective approaches in delivering the Pilot Experience: The Magnus Effect.
Next steps	These results present a solid foundation for the Maritime Technologies Skills Strategy and the long-term Action Plan and sustainability.
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Task	4.5 Impact assessment
Deliverable	4.2 Layman report
Dissemination level	Public/Project Website
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Lead authors	Souto Otero, J.L. (CIFP Someso) & Sánchez Naya, F.J.
Contributors	Bastón, S. (Fundación CETMAR), Margaret Eleftheriou (AMC)
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Partners involved

CIFP SOMESO

Centro Integrado de Formación Profesional

Additional Collaborators

Navantia SEANERGIES

WINDAR renovables

Nervión GrupoAmper

Robot plus Empowering Robots.

gain AXENCIA DE INNOVACIÓN

INDASA

TMG TALLERES MECANICOS GALICIA

ACEBRON GROUP Mecanizado tecnológico

1. Context

MATES: Maritime Alliance for fostering the European Blue Economy through a Marine Technology Skilling Strategy, is an EC-funded, ERASMUS+ project with the objective to develop a skills strategy that addresses the main drivers of change in maritime industry, in particular shipbuilding and offshore renewable energy.

The MATES Pilot Experiences are vital components of the strategic design of the project. The experiences consist of a series of activities that align with priority areas needed to support training and development of the shipbuilding and offshore renewable energy industries.

The outcomes of the Pilot Experiences provide indispensable knowhow for bridging the maritime skills gap and increasing both sectors' overall competitiveness and attractiveness. The insights gained from these activities feed directly into the long-term MATES Action Plan, which contains policy recommendations and best practices.

This report summarises the outcomes and learning elements from one of those Pilot Experiences: The Magnus Effect.

The main aim of this PE is to apply in an educational environment new system of manufacturing and construction existing in the field of the offshore metal construction towards the promotion of green renewable energy. It is noteworthy that the area where this Experience took place has a long experience in shipbuilding, having been a rising sector in the manufacturing of offshore structures for these companies since 2014. Therefore, the construction of an offshore structure to be used for supporting wind turbines was replicated at a VET school strictly according to industry standards and procedures. Following this approach, the CIFP Someso, the VET school responsible for this PE, was supported, monitored and guided by companies involved in this business sector.

Besides the manufacturing processes, this PE also used the offshore wind energy as a common thread to widen the focus, therefore these activities at the workshop and/or classrooms were complemented with technical lectures for students and teachers and the implementation of a virtual reality tool for simulating the painting processes used for protecting these structures.

Target beneficiaries included students, teachers, trainers and new workers. Results of this Pilot Experience are particularly relevant for stakeholders such as Departments of Education (regional and national government), Research and development centres/Universities, VET institutions and Industry.

Within this Pilot Experience the following activities were undertaken:

- The construction of an offshore jacket
- A virtual reality tool was developed for simulating the painting process
- Technical lectures for students and teachers
- A technical study about an aerodynamic profile designed to be used in a wind turbine rotor according to the Magnus effect.

The PE has 3 cornerstones that support all its design aspects:

- Close collaboration and involvement of metal companies in educational activities
- Project-based learning (PBL)
- Use of cutting-edge resources related to digitalisation in VET institutions

These approaches in teaching, focused on labour market requirements, will make a significant contribution to increasing VET quality and attractiveness.

Transversal skills such as critical thinking, entrepreneurship and problem-solving are promoted; these are just some of the competences enshrined in the Skills Agenda for Europe. The acquisition of such skills, values and attitudes, requires the use of more participatory learning methods. By building this offshore structure, students' confidence, teamwork and organizational skills were enhanced.

A shortage of suitably skilled workers has been identified as blocking growth in nearly all blue growth economic sectors. This PE provided an updated training on professional skills demanded by metalworking companies working in offshore structures; therefore, it will be useful for providing a skilled labour force which responds to labour market needs.

2. Overview of the Magnus Effect

The Magnus Effect focused on offshore wind energy as its main topic. The reason for this decision was twofold: on one hand, the importance that this sector is acquiring as a consequence of the firm commitment of governments to green energy and on the other hand, the greater awareness of society in general of the need for a change in the energy model.

The metal sector in Galicia is a clear example of this commitment from the Spanish government and the new business opportunities that arise from it: there were disused facilities of a shipyard, Navantia[1] – Fene, which is being used nowadays for manufacturing metal support structures for offshore wind turbines (commonly known as jackets).

Today, thanks to the investment made by the Spanish multinational Iberdrola[2] in offshore wind farms, a specific industrial factory is being consolidated in the Ferrolterra area specialising in the manufacture of this type of structure. This new business requires new professional skills appropriate to the activity being developed. The PE Magnus Effect aims to respond to these needs by providing the students of CIFP Someso with specific training.

Towards this end, the students of CIFP Someso replicated the industrial processes related to the manufacturing of an offshore jacket in the workshops of the VET centre. For this purpose, actual technical documentation provided by our industrial partners was used. In order to render the manufacturing of this product feasible in relation to the existing facilities and resources in the educational centre, it was necessary to adapt both the final product, i.e. the jacket and the documentation, for which the teaching staff of the Mechanical Manufacturing Department were in charge.

Figure 1: CIFP Someso students with the 1/20th offshore wind jacket before being painted

[1] https://www.navantia.es/en/
[2] https://www.iberdrolarenovablesenergia.es/home

In parallel with this activity, with the aim of enriching the content and scope of the PE to include other training actions in the field of offshore wind energy, several lectures were organised on relevant technical issues for students' forthcoming integration into the labour market. With the collaboration of companies such as 3M[3] and Robot Plus[4], the CIFP Someso' students received training in risk prevention (PPEs) and collaborative robotics.

Figure 2: Technical lecture delivered by 3M on PPEs

Finally, in response to the growing importance of digitalisation in industry, the development of a virtual reality (VR) tool was developed and used in the classroom to simulate the processes of surface finishing (painting), to protect the jacket against corrosion. This product was developed in collaboration with the companies GAIN[5] (Galician Innovation Agency) and INDASA[6].

Figure 3: Demonstration of the VR tool "Airless" at a dissemination event

[3] https://www.3m.com/
[4] https://robotplus.es/
[5] http://gain.xunta.gal/
[6] https://www.indasa-abrasives.com/global/en

OBJECTIVES

- Implementation of innovative approaches in VET education: Project-based learning (PBL)
- Use of new technologies related to Industry 4.0 in VET schools: collaborative robotics and VR tools
- Reducing the gap between VET metalworking curricula and professional skills required by metal industry
- Making VET education more attractive
- Enhancing and developing soft skills among VET students such as:
  - Creativity and innovation to tackle difficulties and problems that appeared during the manufacturing processes
  - Decision-making in order to be able to respond appropriately to unforeseen problems
  - Teamwork and leadership due to the participation of several groups and levels of students

2.1. Manufacturing of a two (1/20th & 1/10th scale) offshore wind jackets

The target group of this PE were the VET students in the basic, intermediate and upper levels of VET degrees related to the department of Mechanical Manufacturing, specifically in the welding and metal construction sectors. Under the guidance of their teachers, they worked in coordination at all stages of the PE: planning, manufacturing and product quality control.

The manufacturing of the jacket was approached as a cross-cutting and multidisciplinary project where the integration of the professional subjects belonging to the VET degrees involved was sought: technical drawing, process definition, machining, welding, assembly, quality control and cost estimation.

It had the same design as the jackets that were manufactured at the Navantia facilities installed at Iberdrolas' wind farm in Saint-Brieuc (France). This has significantly limited the transfer of this Experience to other VET institutions, due to industrial privacy restrictions on the use of technical documentation provided by our industrial partners. Therefore, the information used by CIFP Someso to replicate the construction processes and working procedures provided by the collaborating companies cannot be made available to the general public.

Figure 4: Picture of the 1/20th jacket being manufactured at CIFP Someso workshop (left) and of the 1/10th jacket once located at Navantia Fene' grounds (right)

As a result, two jackets, at 1:10 and 1:20 scale, were built. The smaller one will be exhibited in the CIFP Someso as a sample of the work done and as a motivation for future generations of students while the larger will be delivered to Navantia to be placed in their facilities in Fene as a sign of the collaboration with the CIFP Someso.

Figure 5: Picture of the

It is noteworthy that the COVID-19 pandemic, very much prevalent at the time of implementing the PE, affected the planning of the tasks quite considerably, since the VET centre was closed for several months and activities at the workshops were restricted. Therefore, there were delays on the planned schedule that affected the PE deadlines in all its aspects. Finally, all these difficulties were overcome due to the commitment of students, teachers and partners, which made the realisation of this PE come true.

Table 1: Summary of participants engaged in the Magnus Effect (jacket manufacturing)

Location	**CIFP Someso Galicia (Spain)**
Number of teachers	**9 (4 women + 5 men)**
Number of students	**83 (3 women + 80 men)**

2.2. The RV tool "Airless"

The VR tool developed for simulating the painting process was called "Airless". It was designed by CIFP Someso' teachers with technical support from INDASA, a company specialist in surface finishing processes in the shipbuilding and offshore sector, and implemented by GAIN.

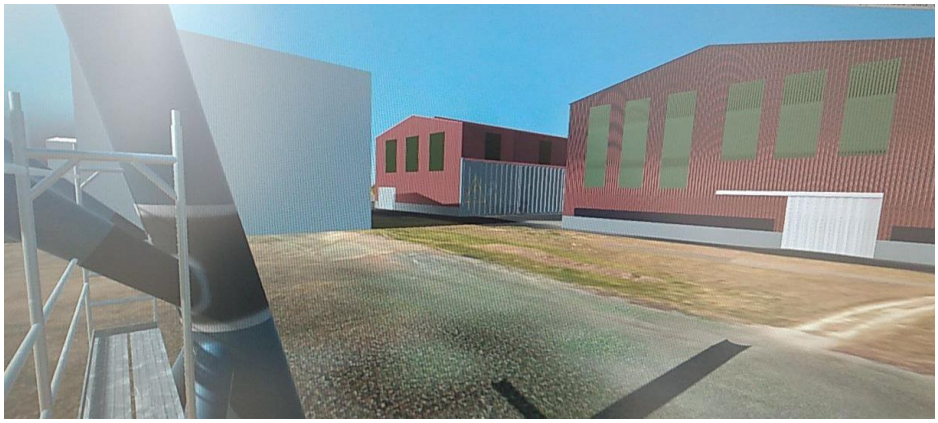


Figure 5: Screenshot of the VR tool "Airless" when simulating the painting process of a jacket node

This tool was developed with the UNITY 3D tool. The user puts on the HTC Vive goggles and with the control is able to paint a structure on a real scale immersed in a scenario that replicates the Navantia-Fene facilities, where offshore wind jackets are manufactured.

The VR tool represents the painting process graphically, but also there is a code underneath that collects and saves all the information (times, painting speeds, the trigger tightening %, the distance from the gun to the piece as well as the angle between the two, the paint consumption, etc.) from the simulation. This enables the trainer to assess the performance of each student, and in turn enables the student to improve his/her painting skills on large metal structures. The technical data used for running this resource include information about painting techniques, materials and consumption rates.

The "Airless" tool was also validated according the industry standards. These tests were carried out by experts belonging to INDASA.

2.3. Technical lectures

Within the framework of this PE, technical training about Personal Protection Equipment and collaborative robotics took place at CIFP Someso. The latter was delivered by the company Robot Plus. The two-week training was delivered twice, during the second and third quarters of the 2020-21 academic year. All the students had the opportunity of following an online course about programming a Universal Robot cobot as well as working *in situ* with the equipment.

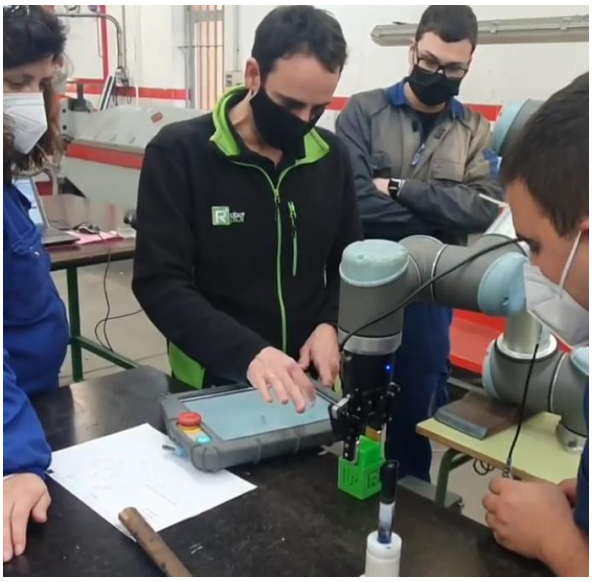


Figure 6: Training course about programming cobots

Depending on the professional profile of the students, several industrial applications were implemented during this training. The target students were mainly those enrolled in technical degrees such as mechanical manufacturing, automotive and wood processing, although there were also participants from other professional fields such as personal image and building and civil works.

Table 2: Magnus Effect key numbers (technical lectures)

Lectures	Number of participants	Hours of training provided
Cobots	256	15 (online+on site)
PPEs	183	16

2.4. Magnus effect

The purpose of this study was to carry out some initial tests of the Magnus effect, both through computer simulation and in a wind tunnel. We were interested in obtaining initial data on the behaviour of these systems, in order to determine their viability, in the future, for its application in practical classes of electricity generation as well as to assess advantages and disadvantages of this process and in which cases this technology could be applicable.

The first tests, based on theory, consisted of computer simulations of rotating cylinders subjected to a steady air flow. The tool used for this simulation was Open FOAM (Open Field Operation and Manipulation). This is a free and open source CFD (Computer Fluid Dynamics) software[7], which has a wide community of users in most areas of engineering and science, from both commercial and academic organizations. And the prototype used for this simulation was a cylinder.

[7] https://www.openfoam.com/

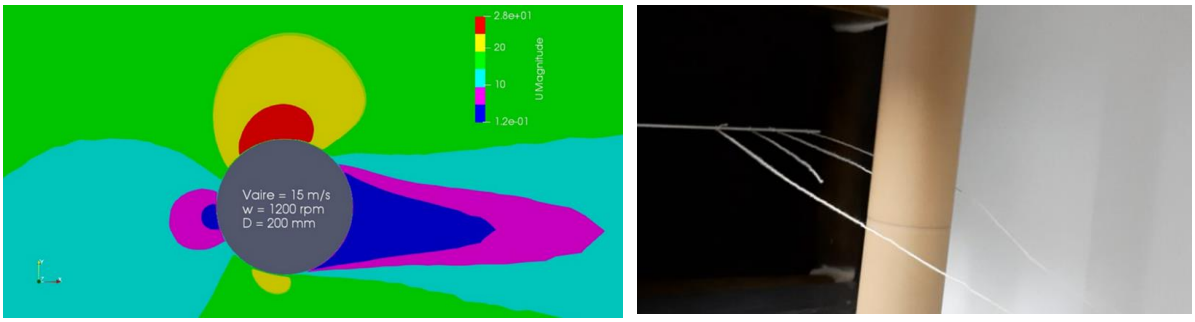


Figure 7: Screenshot of the simulation undertook in Open FOAM (left) and in the wind tunnel (right)

The factors analysed were the following:

a) Diameter

b) wind speed and

c) rotation speed

in order to check how relevant the Magnus effect is, i.e. how important the force appeared is.

For the test done in the wind tunnel, the profile used was a 60 mm diameter cylinder. The results proved that the Magnus effect exists but for tubes with a diameter smaller than 60 mm, the effect was negligible, with the available means. We think that the reason for this is that very high rotational speeds must be needed to show the effect.

The main conclusion from both experiences, regarding the possible use of the Magnus effect in electrical generators, was that for this effect to be of a practical magnitude it is necessary to use tubes with a diameter of the order of 20 to 50 cm, which are much larger than the one tested in this wind tunnel (60 mm). The full report of this study can be downloaded from here.

OUTCOMES

- **Greater engagement and motivation of VET students due to the use of new educational methodologies**
- **Improved VET student employability thanks to the updating of their professional skills in an emerging productive sector (offshore), not included in the current VET curricula**
- **Updating of current VET curricula to include issues associated with Industry 4.0, such as robotics or VR tools**
- **Implementation of the "Airless" VR tool in all Galician VET centres related to metal sector**

3. Achievements

The Magnus Effect PE provides a framework for replicating similar activities in other VET institutions across different geographic locations.

The key factor is, besides the education and training materials provided during its execution or the activities carried out, the design itself. This PE is based on close collaboration with companies with expertise in the ORE sector. Its involvement in the planned educational activities, providing technical information, monitoring on request and verifying the PE results allowed all the objectives to be fulfilled and to make the most of them, achieving great benefits for the students.

Therefore, this project-based education model may be used in any professional field if and when there are supporting companies willing to get involved in it. This is a key factor for transferring the industry know-how directly to VET institutions and their students.

3.1. Results: Education and Training Materials

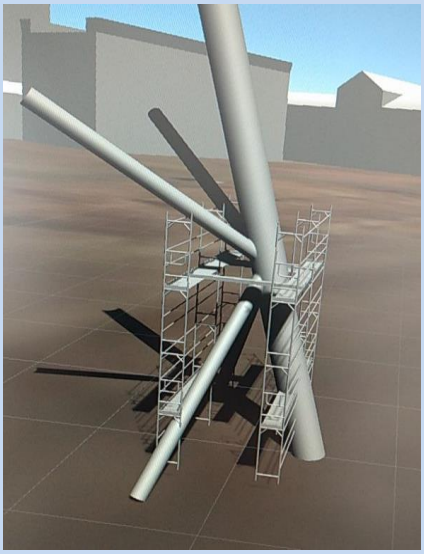
Materials developed in this PE are freely available through the MATES Project website. Please contact Francisco Javier Sánchez Naya at fsn@edu.xunta.gal if you need additional information. These are:

3.1.1 Project-based Learning (PBL)

Learning outcomes:

Participants learned the main concepts & technical vocabulary related to offshore wind energy. They became involved in all the construction phases from design to delivery, so that they **know** the key factors that lead to the manufacture of standardised jackets: modular foundation design, usage of standardised tubes, automated welded nodes and serial assembling. They **fitted pipes and other metallic elements** using electric welding & following the technical documentation. They **acquired labour and ethic habits** in his/her professional activity, **applied H&S regulations** concerning labour risk prevention and environmental protection during the manufacturing activities carried out in the workshop and **further developed their soft skills**, such as critical thinking, teamwork, problem-solving, and self-confidence among others.

3.1.2 The "Airless" VR tool



Learning outcomes:

Participants learned **how to paint flat and curved surfaces** using a VR tool that simulates real jacket painting conditions.

In addition, as a complement to these resources, in parallel with the jacket construction and aligned with the main topic of the PE, two technical courses were held addressing students of the CIFP Someso. The approach of both activities was eminently practical, looking for the active participation of the students in the dynamics of the lectures. The topics of these lectures were:

Personal Protection Equipment

The company that provided this course was 3M. The target audience was all the students belonging to the Mechanical Manufacturing department. It was held at the beginning of each academic year in order to raise awareness among students as to the importance of these issues.

Learning outcomes:

Students learned the necessity of using PPE and refreshed key aspects that have to be taken into account in their working routine.

Collaborative robotics (Cobots)

The company that provided this course was Robot Plus. The target audience were all the students of the technical professional families of CIFP Someso, i.e. Mechanical Manufacturing, Automotive and Wood and Furniture. It was delivered twice during the 2020-21 academic year, lasting 2 weeks each.

Learning outcomes:

Students learned how to **program and test robots** (specifically a cobot from the company Universal Robots) for simple industrial applications as material handling.

3.2. Main Impact

In principle, the options for scaling up this project in other contexts are limited. As indicated in section 2.1, the technical information used to manufacture the jacket is not available to the general public for Intelligence Property reasons. However, this PE should be understood as an innovative experience within a VET centre and its format is replicable, regardless of the subject matter. There are two key aspects: a) the involvement of cutting-edge companies within the professional sector of the project and b) Project-based learning (PBL). The combination of both factors makes it feasible to achieve the following results and impact:

- **Improved VET curricula**: Training curricula are not updated as often as they should be. This leads to a mismatch between the skills required by companies and the training provided in VET centres. Technology continues to advance by leaps and bounds and these result in new equipment and industrial applications. A clear example is the concept of Industry 4.0, which has not yet been implemented in the curricula of most VET degrees. This PE aims directly to fill this gap and that is why it includes robotics and its applications among the aspects to be developed. This also applies to the manufacturing technologies used in the production of the jackets. The resources provided by this PE have made it possible to overcome these gaps.
- **Improved student employability**: Offshore wind energy is an ever-growing sector both globally and locally. The medium-term forecast is for the installed capacity of offshore wind farms to multiply, so the business derived from the manufacture of jackets will continue to rise. In the case of the CIFP Someso local area, this previous analysis is fully valid thanks to the establishment in this market of the joint venture of Navantia and Windar as well as the strength of the Spanish multinational Iberdrola. Currently, there is a growing demand for metal professionals to work on this type of project. Those with specific training in this field have a greater competitive advantage than the rest. Our partners also agree with this statement.
- **Full evaluation of the learning objectives of the PE**: The implementation of the PE has allowed validation of the objectives of the MATES project. In other words, it has been possible to evaluate this method of addressing skills gaps in the ORE sector.
- **Increasing VET quality and attractiveness**: The involvement of the students in the different stages of the PE was at its highest level. Particularly noteworthy was the interest of the groups belonging to the basic level of VET education. These students, who may have behavioural problems and very often show a lack of discipline, performed the assigned tasks at a level similar to the other groups. Their commitment throughout the project was remarkable. In addition, this Project-based learning (PBL) approach enabled the students' motivation to be maintained throughout the duration of the PE. Coordination, teamwork and a feeling of responsibility for the work carried out by each of the different groups of participating students have been key to the success of the PE. In fact, students feel that they

are protagonists, not mere spectators, of this training activity. They feel proud of the result: the replica of the jacket. Finally, after participating in this Experience, it is expected that there will be more VET teachers interested in carrying out similar activities with students. A change of mentality is needed and, in the beginning, this approach is more demanding for the teachers involved than the traditional approach. However, the results obtained are worthwhile thanks to the many aforementioned benefits.

- **Creation of synergies with industrial partners** and the possibility of launching new partnership projects. Relationships between VET centres and industry are not usually seen as a priority; both parties generally live in parallel worlds, with trainees being the only bridge of communication between them. PBL can make possible to reverse this situation and be the first step towards collaborative contexts between them. The key factor is to identify the areas, topics or issues that match the partners' needs. This Pilot Experience has demonstrated how useful this close interaction is and can benefit both. So, due to the successful results of this PE, future collaboration with the involved companies, in new projects, is anticipated.

- **The "Airless" RV tool** can be used in both educational and industrial environments, as it was designed based on real data from painting processes in naval applications and was validated by our industrial partner. The tool enables the entire process with its key magnitudes to be monitored completely, and therefore facilitates the trainer's evaluation as well as the correction of procedural errors. This tool fills an existing gap in the training of Galician VET students who are studying at the intermediate level of Welding and boiler-making. The lack of material resources for training in surface finishing of metal surfaces in VET centres can be solved thanks to this resource. There is also interest in the "Airless" RV tool application from metalworking companies since it too produced successful results, i.e., it allows the painting process to be simulated with verisimilitude. The training of specialised personnel in this area is simpler and cheaper, as it saves on consumables and reduces the environmental impact of this training. This VR tool has attracted the interest of the Galician Department of Education, responsible for public VET centres located in Galicia. This entity is committed to implement this VR tool at the beginning of the 2022-23 school year in all public VET centres where intermediate and upper level degrees of welding, boiler-making and metallic construction are taught. In addition, INDASA, the company involved in the design and validation of the "Airless" is seriously interested in using it for training new workers. Its use will allow the first stages of training on site to be skipped, thus saving material resources, reducing operating costs (since the paint used for offshore structures or in naval sector is expensive) and is more environmental-friendly.

Once this PE was developed, its quality was assessed. Feedback from the students and the collaborative companies was received and used not only for the final evaluation but also at interim stages, seeking a constant improvement of the PE. As can be seen in Figure 6, the satisfaction level of the Pilot Experience is high: about 80% found the technical lectures interesting and the same percentage would recommend the PE to other VET students.

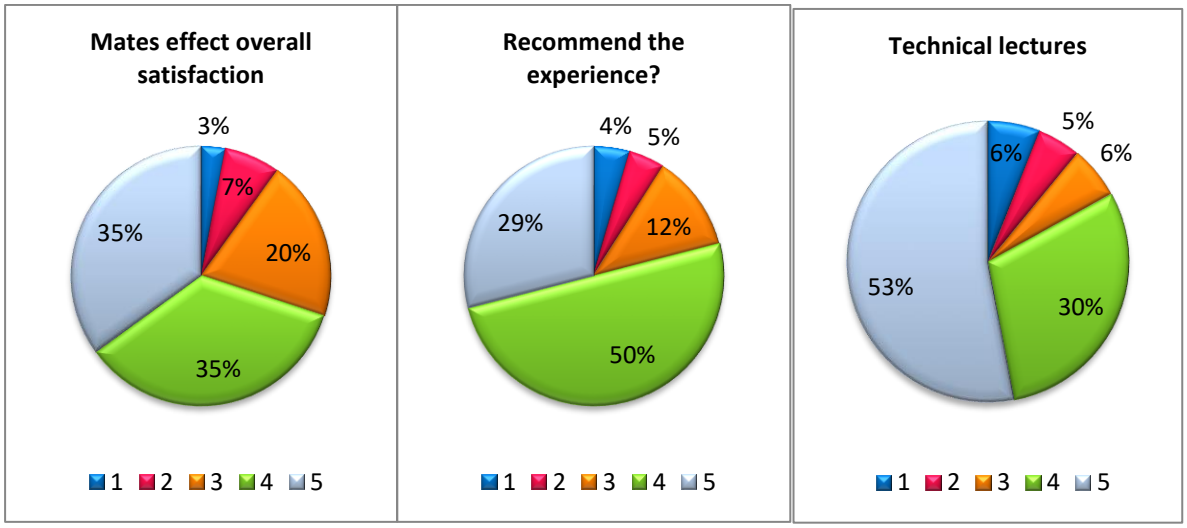


*Figure 8: Left chart: Results of the survey to the question: **Rate your overall satisfaction with the course**. (1= lowest, 5= highest). Middle chart: Results of the survey to the question: **Would you recommend this experience to your other VET students?** (1= lowest, 5= highest). Right chart: Results of the survey to the question: **Were the technical lectures interesting?** (1= lowest, 5= highest*

4. The European Added Value

This PE targeted EU Policy objectives shown as follows in Table 3.

Table 3: Details of how this PE targets are relevant for EU Policy Objectives

EU Policy Objective	How Pilot Experience targets the Relevant EU Policy Objective
Skills agenda[8]	- Providing direct involvement and knowledge exchange with companies with relevant expertise in the topics covered by this PE. - Fostering transversal skills among VET students. - Supporting the digital transition in VET centres due to the use of cobots and a VR tool for simulating painting processes on offshore jackets. All these results are a consequence of the PE design, highlighting the close collaboration with the companies, the project-based learning approach and the introduction of industry 4.0 skills in VET centres.
European Pillar of Social Rights	- Ensuring inclusivity is adhered to when selecting participants (gender equality, equal opportunities regardless of gender, racial or ethnic origin, religion or belief, disability, age or sexual orientation). - Providing active support to employment through upskilling and growing confidence by the incorporation of new knowledge into training curricula. - Promoting self-worth and interpersonal skills by integrating acknowledgement and certification of achievements.
Open science[9]	- Ensuring public accessibility to training resources generated from PE to the general public. In this case, the VR tool, the software, is openly available.
Blue Growth and Economy[10]	- Targeting energy sector relevant to blue economy by focusing on ORE in the curricula. - Promoting sustainable marine resources management through clean energy technology. Explaining the direct correlation between low carbon technology and the aims of blue growth and economy
DigiComp[11]	- The "Airless" VR tool fits in with the digitalisation strategy that is intended to be implemented in VET in Galicia in the short term. One of its key points is the commitment to tailor-made educational simulators.

For those interested in replicating this activity in a VET centre, careful planning is strongly recommended. The key recommendation is to identify the companies committed to the success of the project, since they are the know-how providers. Taking the time to engage with the industrial partners will also help to ensure its success.

[8]'New Skills Agenda for Europe - Employment, Social Affairs & Inclusion - European Commission'. [Online]. Available: https://ec.europa.eu/social/main.jsp?catId=1223.

[9]A. M. Kaplan and M. Haenlein, 'Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster', Bus. Horiz., vol. 59, no. 4, pp. 441–450, Jul. 2016.

[10]'COM (2012) 494 final. Blue Growth opportunities for marine and maritime sustainable growth', Policy Document.

[11] https://joint-research-centre.ec.europa.eu/digcomp/digital-competence-framework-20_en

All layman reports and education and training materials from all the MATES Pilot Experiences are available on the MATES website and include:

ED2MIT: Education and Training for Data Driven Maritime Industry projectmates.eu/pilotexperience/ed2mit
MOOCs on Industry 4.0 and the naval sector projectmates.eu/pilotexperience/mooc-training-course
Freeboard projectmates.eu/pilotexperience/freeboard
The Magnus Effect projectmates.eu/pilotexperience/the-magnus-effect
Innovation Manager in Shipbuilding Course projectmates.eu/pilotexperience/innovation-manager-course
Additive Manufacturing and Risk Management in the Shipbuilding and Ship Repairs Sectors projectmates.eu/pilotexperience/training-seminar
MOL^2 Maritime on the Loop of Ocean Literacy projectmates.eu/pilotexperience/mol2
Offshore Renewable Energy Courses projectmates.eu/pilotexperience/renewable-energies-crash-courses
Ocean Pro.Tec Lab projectmates.eu/pilotexperience/ocean-pro-tec-lab
Green Move projectmates.eu/pilotexperience/green-move
Definition of New Occupational Profiles projectmates.eu/pilotexperience/dop-definition-of-new-occupational-profiles

Contact

Lead Author: José Luis Souto Otero, jlsoutootero@edu.xunta.gal

Project Coordinator: Lucía Fraga, lfraga@cetmar.org

projectmates.eu