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

"The role of competition and mobility in VET Education"

IO3: A6 – Final Publication "The role of competition and mobility in VET education"

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Project information

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Executive Summary

It has been observed that students with better performances in the classroom and with more job opportunities have been involved in robotics competitions, independently from their socio-economic background. This has been observed by CEPROF, one of the members of the project's Consortium, that has been successfully testing and consequently implementing the "Learning by Competing" ("LbC") pedagogic approach among its VET students. This has captured the interest of other VET and/or knowledge providers in transferring this approach. To do so, there were activities accomplished during the implementation of the project, which were fundamental for pursuing the realization of the partnership's key objectives which were to:

- create and test innovative teaching methodologies;
- introduce competition in teaching and learning methods;
- develop ICT and mobility competencies;
- promote perseverance and resilience as success tools;
- develop soft skills and use the motivational effects of robotics to excite students about science and technology.

With this in mind, the partnership saw **Robotics** as the topic of learning to be addressed, since the mentors of the LbC learning approach – CEPROF – saw the most dramatic positive effects in this subject. Moreover, Robotics is an innovative digital technology expected to transform the EU labour market in the near future, which will make the present professional skills out-of-date. The LbC approach intends to make the trainees play an active role in working as a team, searching for and discussing ways of solving problems and/or challenges during the competition. After the end of it, all the participants share common stories/adventures, and this will help them to strengthen their attachment to the class and, consequently, to the school, thus increasing motivation and decreasing rates of premature school leaving. In addition, the educational staff involved encourage trainees with lower self-esteem to thrive, and this enables a whole new perspective for the enhancement of their soft skills.

Starting from these assumptions, the partnership felt that mobilities would be a great way of creating new social experiences and reinforcing the openness of trainees to professional mobility, and so the Consortium proposed organizing three flows, including three different competitions. These mobilities were key to pilot-test the four training modules on Robotics created by the partnership. They are available from a basic to an advanced level, in an e-learning format, and free of charge. This Moodle e-course includes a set of comprehensive step-by-step videos, textbooks, workbooks, tests, and other helpful features divided into four different topics/chapters. The mobility participants are given access to the platform and they get instant access to the first chapter. Once they watch all the step-by-step videos and pass the final test, they are able to move to the next chapter. After the trainees finish the intensive training on the platform, they will participate in the mobility's competition.

Therefore, this Final Publication aims to be an accurate description of the project's methodology and the main conclusions obtained from the trainees' interaction with the project tools and their participation in the project mobilities. It will be key for replicating the pedagogical approach in the Partnership institutions. The publication has been prepared by Ovar Forma (who has played the role of knowledge provider in the Consortium) given its familiarity with the most complex technical terms on Robotics. After the end of the project, and once validated the positive results of the new "Learning by Competing" methodology, this publication will be delivered in digital format and printed form to the most important financing entities for school education in technologies, and to the schools of the region.

Introduction

This publication has the main goal of being used by the stakeholders to replicate or to disseminate the "Learning by Competing" pedagogical approach in their institutions, to the most important financing entities for school education in technologies, and to the schools of the region. And since the partnership is composed of different VET schools, it has been planned to keep the concept running, with independent financing, and the Consortium will try to engage other schools in this way. Over and above that, this methodology will most likely promote continuous interest in the relevant areas of the project and transferability of this training programme to other trainees, reaching a population that will benefit from the project's results and resources.

The title of this publication "The role of competition and mobility in VET Education" points to the fundamental role that competition and mobility can play in Vocational Education and Training, making trainees better prepared for the current world of work without neglecting the improvement of several soft skills essential to the much-desired implementation of the knowledge economy, which is commonly being sought by most European countries, including the ones represented in the partnership: Portugal, France, Spain, Italy and the United Kingdom.

The present document will explain all the steps followed during the implementation phase of the project, from the writing of the training modules, through the creation of the e-learning platform, to the pilot-testing during the mobility periods, in which the competitions were also organised.

Lastly, the partnership will seek to share the lessons learnt during the implementation of the project, which shall be helpful for institutions interested in knowing more about the Learning by Competing approach.

1. Methodological Approach

When writing the application, the partnership considered several priorities, which served to best apply the Learning by Competing methodology to the project's objectives:

- The change of cultures and societies results in the need to update the pedagogical approaches in education;
- VET, given its special practical nature, is one of the areas of education that has a higher demand for continuous updating of pedagogical approaches;
- Previous studies reported that a competition is a driver for the promotion of learning for students;
- Furthermore, the integration of the concept of "learning by competing" in the VET courses of Electronics and Mechatronics at CEPROF also showed that the trainees that had higher performance in classes were the ones who integrated the inter-schools competitions of Robotics, independently of their socio-economic background. This concept resulted in the union of the class in the fulfilment of a common goal - the victory; promoted the intercultural skills of the trainees and the receptivity for mobilities during the international competitions and also promoted the culture of fair play among the teams, which together strongly improved the learning process and the motivation of the VET trainees (and of the trainers);
- The proposal to test this concept at the European level will have as a main expected result the "Further strengthening of key competencies in VET";
- The European Agency for safety and health at work in its discussion paper "A review on the future of work: Robotics" states that according to the EU Robotics Strategy 2020 "Robotics Technology will become dominant in the coming decade. It will influence every aspect of work and home. Robotics has the potential to transform lives and work

practices, raise efficiency and safety levels, provide enhanced levels of service, and create jobs." Furthermore, issue 13 of the publication "*The Future of Work - Skills and Resilience for a World of Change*" published by the European Commission claims that "*certain estimates expect automation to lead to a net loss of more than 5.1 million jobs across 15 major advanced economies*" and estimates that for example in Germany – the largest European Economy – 55% of the people have their job at risk with the automation of jobs. This indicates that Robotics is one of the main new technologies "in a digital era";

- This project used the concept of "Learning by Competing" as a working model because of its positive impact on future jobs; because this was already a successful model reported in the literature for "learning by competing" and for the reason that it is also the model applied with success in CEPROF. Since robotics is one of the new technologies of the digital era, and since the concept of "learning by competing" is innovative at the VET level, one of the main expected results of this project is the "Open and innovative practices in a digital era". Finally, these fields of action meet European priorities concerning the development of digital competencies and the development of autonomous learning, since the trainees will apply digital tools and skills to find solutions for the problems encountered in robotics competitions.

The methodological options were carefully analysed and selected at the design stage of the project and fine-tuned before the implementation stage.

The training modules, resources, and platform

Regarding the original project application, the partnership envisaged a first Intellectual Output, linked to the research phase, in which partners would analyse the competition areas in the school environment and their relation with schools results and trainees' motivation, thus contributing to the understanding of the good practice. However, as the National Agency considered that there were already many valid sources to consult for relevant information about the scope of the project, this IO was cut. Therefore, the partnership moved directly

to the second IO "Learning by Competing - Digital platform, modules and resources", in which it worked on the creation of the training platform, which allows the hosting of training materials and resources, and the creation of the training modules 1, 2, 3 and 4, divided by different levels of difficulty, and their training resources (manuals, exercises, step by step videos, tests). All the activities that make up IO2 were designed to enrich the training materials that will be used for the knowledge acquisition that will be tested through competition.

The mobilities and the competitions

Concerning the third Intellectual Output of the project "Pilot Testing and mobility for competition", was dedicated to the testing and validation of the modules and resources and the concept "Learning by Competing". The main elements of innovation are related to the idea of introducing three topics: methodology of a challenge, intergroup competition, and mobility in the learning process of VET courses, to encourage the VET trainees to find the right motivation for learning and successful educational performance. The innovative practices implemented throughout the development of this output combine new teaching/learning methods, appealing materials, effective use of ICT in learning environments and competition and short mobility experiences as promoters of mobility-prone generations. The methodology that frames the whole work consists of preparing the target groups to participate in three Robotic Competitions after learning some concepts and content online that allowed them to build a small robot and add functionalities. Trainees were given a set of tasks to be accomplished, and they were also expected to test the product and then participate in the competitions that were structured in different levels of difficulty, as well as the modules that support the contents. At this point, after the conclusion of the activities, it is expected that the new methodology of teaching "Learning by Competing" can be transferred to other VET teaching areas as it is a favourable way to promote the motivation and engagement of VET trainees in the learning process.

The participants

For the preparation of the blended mobilities (and, consequently, the preparatory activities), the candidates were selected by the staff assigned to the project. Some of the aspects that were valued in the evaluation of the participants were: the motivation for the project and for the mobility and the potential of the selected trainees as "opinion makers" in the student's community; potential for social-economic promotion by participating in the experience of the mobility, potential of empowerment by the participation in the project, potential of capacity building, equality of economic and social opportunities, initiative capacity and group work skills. The language competence was also considered since the teams were consisted of trainees from different countries. The selection of participants comprised the following stages: application; questionnaire; interview and selection.

The adjustment of the methodological approach

The pandemic situation constrained the methodological approach followed in the implementation phase of the project. It hit the participating countries in different waves and caused the organisations to country lock-down periods and home office practices. The project activities were harshly affected by the constraints imposed to travelling periods, which critically affected the organisation of the first project mobility. Nonetheless, the partnership found a creative way of dealing with the situation, and remote mobility was successfully organised and implemented. The same problem affected the implementation of face-to-face transnational meetings between partners, who found in online meetings the most suitable solution for dealing with the problem. However, the first and the last meetings took place in person.

The implementation

The general methodological approach during the implementation stage consisted of the following actions: the creation and constant update of the training platform; the development of the four training modules and their training resources; the preparatory activities for the pilot-testing, the pilot-testing activities and the consequent validation of the four training modules; the blended mobilities; the Round Table and the Final Publication.

2. The Project

The context

The project aims at testing and transfer the pedagogic approach of "Learning by Competing" to other VET schools in other European countries. It has been tested by CEPROF successfully and the partners that are VET providers and knowledge providers/ receivers are very interested in the transferability of this approach. It has been observed that the students that better perform in classes and that obtain more job opportunities are those who were involved in the robotics competitions.

The partnership

The Learning by Competing partnership is made of seven organisations from 5 different European countries: France, Portugal, Spain, Italy, and the United Kingdom.

This project integrates the transfer of the good practices of "Learning by Competing" of one of the partners (**CEPROF**) into other VET providers. Additionally, it is built on a previous project "ROTeNA" (2016-1-UK01-KA202-024437) that made a basic open-source training on Robotics and 3D Printing and intends to create synergies with the results of the recently closed project

"IAEJE" (2018-1-FR01-KA201-048131), in which **CEPROF** is a partner and the legal representative of **HdB MUN** is the project coordinator. Hence, the partnership consists of the central team of both projects – the coordinators and the main knowledge providers of each project – and two more partners from the regions under focus:

- **DEFOIN**, a training center, with over 750 trainers with a large experience in the design, implementation, development and evaluation of training programs at National, Regional and local level with national network of more than 200 training centres all along Spain and providing training opportunities to 35,000 students. Defoin cooperates together with other educational center as VET schools, universities and Primary Schools.
- **CONFORM**, a VET provider from Italy that has a focus on VET training but also on business consulting, thus providing a perspective from the business market to the partnership. Italy is a country under focus in this project. It is the EU-28 country with the highest percentage of youth that considers it important to have opportunities for mobility experiences (99%) according to the "*Flash Eurobarometer 466*" from 2018.

To enhance the coordinating experience in the partnership, the team also incorporates the partner **EU15** from the UK, that was the coordinator of the ROTeNA project and that has vast experience in the management of Erasmus+ projects and has been participating in this project mostly as Quality Assurance Manager.

Last but not least, and after the departure of LbC's former partner ORTAKOY (from Turkey), it was crucial for the Partnership to replace them with an organisation capable of dealing with the technical challenge of building a simple yet comprehensive training platform, capable of incorporating all the key materials for delivering the best learning experience (namely, the training modules and its resources). Therefore, **APSU** – Associação Portuguesa de StartUps, from Portugal, was invited to be part of the partnership with the main goals of building the training platform and adding expertise to the Consortium

in terms of labour market knowledge, a vital perspective for a team who is preparing the next generation of modern workers.

The partnership consists of **4 VET providers and 1 education center – 2 knowledge providers in Robotics** and **2 knowledge receivers**. It is coordinated by HdB MUN, that joins the VET perspective of its legal representative (a VET trainer) with the dimension of the political intervention and social participation of the youth that is given by this institution.

Name of the partner	Country	Role in the project
HdB MUN	France	Coordinator, VET provider
CEPROF	Portugal	VET provider + Good Practice promotor
OVAR FORMA	Portugal	VET provider, knowledge provider in Robotics
DEFOIN	Spain	Education centre
CONFORM	Italy	VET provider and business consulting expert
APSU	Portugal	Expert in web development and labour market
EU15	United Kingdom	Expert in EU projects management, and general training and software development consultancy

Table 1 *- The LbC partnership*

The project's objectives

The project has **five main goals**:

- create and test innovative teaching methodologies;
- introduce competition in teaching and learning methods;

- develop ICT and mobility competencies;
- promote perseverance and resilience as success tools;
- develop soft skills and use the motivational effects of robotics to excite students about science and technology.

The project's target groups

- **Direct target-groups**: Trainees; Trainers; Training institutions; VET Schools and Centres; SMEs and Labour Market as a whole.

- **Indirect target groups**: Local, regional, or national level authorities working in the areas of teaching (e.g., schools, universities); Chambers of commerce and Local Authorities and Municipalities; Social partners; Training providers; Enterprises; Public Bodies.

The project's results

The LbC's final results will be:

- four training modules on Robotics and resources;
- a training platform;
- better performance of the students and better multicultural skills;
- higher interest for foreign languages;
- higher motivation for mobility and interest of other schools in the methodological approach of "Learning by Competing".

The project is summarised within this publication, which aims to present the methodology applied during the project lifetime that will guide other institutions in the implementation of the Learning by Competing approach.

3. The Learning by Competing approach

The ultimate goal of the "*Learning by Competing – Promotion of Training in Robotics and of mobility, by the participation in International Competitions in Robotics*" Erasmus+ KA202 project is to test and transfer the pedagogic approach of "Learning by Competing", tested by CEPROF within the VET School under its administration – the Espinho VET School, to other VET schools in other European countries.

The best way to introduce this approach could be by quoting a well-known Chinese proverb: "T*ell me and I'll forget; show me and I may remember; involve me and I'll understand*": this is the principle of active learning in the classroom and, according to CJ Chung, Dr (2008)[1], one of the best ways to actively involve students in a class would be to establish classroom competitions, as, according to the author, they have been motivating and promoting students to strive themselves, to work harder, to ask more questions directly or indirectly (e.g. via classroom or emails). Furthermore, Dr Chung adds that students, to win the competition, try to learn way beyond the curricular structure given in classes, making the classroom a learner-centric environment. These conclusions were obtained through various case studies, in which the author (also a Robotics teacher) introduced some assignments in his classes. For example, in one of the various competitions organised within Dr Chung's classes, the assignment was to design, implement, and train an Artificial Neural Network (ANN) that would enable a robot to follow a solid or dashed line, integrating many concepts learned in class. A winner prize was given to a student who passed all the different test cases flawlessly. After the competition, the winning student had a chance to share ideas, algorithms, know-how, and learning experiences with the class, making it a fruitful and learning-effective occasion. Thus, competition-based learning, as is shown in this case, can be defined as a student-centric learning method, combining project-based

[1] https://www.robofest.net/LBA/CBL.pdf

learning, problem-based learning, and competitions. According to the testimony provided by Dr Chung within his experience-based study, students had higher motivation, asked more questions, took more responsibility for their own learning, worked more seriously and, on many occasions, they worked beyond the class topics. Overall, competitions held in class enhanced the learning objectives. Moreover, Dr Chung stated that class competition could be a way to ignite a flame in classes, as a motivation for students to strive, helping them to be leaders in the future.

The same conclusions have been observed within the context of VET School of Espinho ("ESPE") Mechatronics classes. Since Robotics is part of the learning curriculum in the Mechatronics EQF level, two VET courses, ESPE's VET trainers found that robot competitions could be an engaging way of promoting learning among trainees. Along the implementation of this learning approach, VET trainers started to notice that students were performing better in classes after being involved in the robotics competitions. Since CEPROF noticed the most dramatic positive effects of the "Learning by Competing" approach in the Robotics VET area, it was chosen as the topic of learning for implementing this project. In addition, following the conclusions of the 2020 World Economic Forum Report[2] Robotics is also an innovative digital technology that is forecast to transform the European labour market in the near future, making many of the current professional skills outdated.

During the activities performed along the implementation of "Learning by Competing" in the VET School of Espinho, the trainees worked as a team, they searched for and discussed innovative ways of solving challenges and problems faced, and they also shared common experiences and stories. This ended up consolidating their bonds to the class and to the school, consequently increasing the levels of motivation and decreasing the rates of early school leaving, which is one of the greatest educational goals for ESPE[3].

[2] https://www.weforum.org/press/2020/10/recession-and-automation-changes-our-future-of-work-but-there-are-jobs-coming-report-says-52c5162fce/

[3] https://espe.pt/wp-content/uploads/2021/10/Projeto_Educativo_ESPE_2021-2024_-V_Final_07102021_publicado-em-website.pdf (page 26)

Likewise, many students declared that the group work within the team pushed the ones with lower self-esteem levels to strive.

Since "Learning by Competing" has been implemented in the VET School of Espinho, the participation of students in local/national/EU/international mobilities has highly increased, mainly in Robotics competitions. Since 2004, groups of students have been sent to compete in the name of the school and/or to join the Portuguese delegation in various national and international Robotics Junior Leagues, in various categories (e.g., Rescue, Rescue Maze, Soccer). The school team has won the National Robotics Championship seven times in three different categories. They were 7th in the RoboCup 2014 Junior League, the *World Cup* of Robotics, in João Pessoa (PB), Brazil, and have participated in eight other International RoboCup competitions[4], and their participation so far has been remarkable. Additionally, they have been winning many "additional prizes" within their participation in international tournaments (e.g., "Best Team Spirit" – RoboCup 2018; "Best Presentation" – RoboCup 2016 and "Best Hardware Design" – RoboCup 2015).

Figure 1 *– ESPE students were part of the Portuguese Delegation in RoboCup 2014, João Pessoa (PB) – Brazil (**Source**: http://robocup-portugal.sprobotica.pt/Images/Portugueses_2014.jpg)*

[4] https://espe.pt/premios-e-certificacoes/

Figure 2 *– ESPE students also participated in RoboCup 2015, in Hefei – China (**Source**: http://robocup-portugal.sprobotica.pt/Images/Portugueses_2015.JPG)*

In this way, through the students' participation in national and international robotics competitions, the teaching community of the Escola Profissional de Espinho has started to notice dramatic improvements not only in their hard skills but also in their soft skills. Moreover, the participating students have also become citizens who are more open to professional mobility, thus acquiring numerous gains: greater cultural tolerance, improved language skills, better ability to work in a team and improved knowledge of the world around them. This was the main reason for including mobilities in the project's work plan .

Once the project was approved and the partnership began to work, it was time to start creating the Robotics training modules…

4. The creation of the training modules and its resources

Since the research phase (IO1) of the project did not take place because the National Agency considered that there was already a lot of research material related to the scope of the project, the first set of activities to be implemented were the creation of the project's training modules and respective training resources. These activities were coordinated by the knowledge providers CEPROF and Ovar Forma, who presented an outline of the modules to be created in the first transnational meeting in Paris, France, on the 28th and 29th of February 2019. All partners were invited to provide inputs to the materials presented.

Figure 3 *– Presentation of the training modules' outline in the LbC project's Kick-Off meeting (Paris, 2019)*

The partnership oversaw the development of four training modules on Robotics from basic to advanced level, available online in an e-learning format and free of charge. The modules would, therefore, be tested within three mobility flows to allow participation in three competitions.

The process of gathering the final structure of the four modules (to be introduced in the KoM) was gathered through the implementation of meetings (f2f and virtual) between APSU, CEPROF and Ovar Forma Robotics experts, who also coordinated Intellectual Output 2. Since the LbC project training modules were also based on the ones built upon the project ROTeNA, in which CEPROF had been actively involved, a basic structure was already created, and this lessened the process. ROTeNA has received a Good Practice badge[5], so the technical staff involved in both projects played a vital role in replicating the same successful strategy for building the most suitable and comprehensive training modules.

The four modules are the following:

Module 1 – Assembly of a Robot (basic level) – this module is focused on explaining the parts that compose the robot as well as what they are for and how they work. The assembly of the robot is explained, as well as the first steps to enable all trainees to perform simple programming operations;

Module 2 – Line-Tracking Robot (intermediate level) – focus on the line follower sensor and its function and use in this robot. This sensor is the basis of this module so that the students can program the robot to follow a line.

Module 3 – Ultrasonic Following Robot (upper intermediate level) – focus on the ultrasonic sensor and its function and use in this robot. By the end of the module, students should be able to measure the distance between the robot and the sensor and use this information in a circuit.

Module 4 – Remote Control of the Robot (advanced level) – the last module is focused on controlling the robot remotely. To do this, the students will learn about communication protocols such as Infrared and Bluetooth

[5] https://erasmus-plus.ec.europa.eu/projects/search/details/2016-1-UK01-KA202-024437

communication and how to implement them, with the help of the knowledge acquired in the previous modules.

The general objectives of the modules are:

Module 1 – Assembly of a Robot	**Module 2 – Line-Tracking Robot**	**Module 3 – Ultrasonic Following Robot**	**Module 4 – Remote Control of the Robot**
• Identify the various components that compose the robot; • Recognize the function of each component of the Robot; • Identify the main characteristics of a microcontroller; • Perform the assembly of the Robot; • Recognize the functionality of the data input and output ports; • Connect the microcontroller to the virtual system;	• Apply code rules defined by the programming language; • Implement programming so that the robot follows a line; • Implement programming so that the robot can complete a circuit; • Implement test programs for the robot; • Detect assembly and programming errors; • Apply procedures for solving tasks and problems.	• Identify the materials needed to assemble an Ultrasonic Following robot; • Understand how the Ultrasonic sensor works; • Use the Mbit Software to program the robot so that the ultrasonic sensor can follow an obstacle.	• Identify the materials needed to communicate thru Infrared and Bluetooth; • Understand how the communication protocol works; • Use the Mbit Software to program the robot to be controlled by IR remote controller; • Program the robot to be controlled by Bluetooth using the Android or iOS Smartphone.

• Implement basic programming in the robot so that it can move; • Implement basic programming in the robot so that it displays a number on the LED panel.			

Table 2 *– The general objectives of the LbC training modules*

The structure has been organised as follows:

Module 1 – Assembly of a Robot	**Module 2 – Line-Tracking Robot**	**Module 3 – Ultrasonic Following Robot**	**Module 4 – Remote Control of the Robot**
1. Components of the robot to be assembled; 2. Assembly of the robot; 3. Micro:bit software interface 4. Moving the robot – main commands 5. Program the robot to perform a circuit 6. Programming a robot to show a number	1. List of components 2. Line follower sensor 3. The process of colour-tracking 4. The "If" condition 5. Build an "If" condition 6. Tracking line code 7. The global code	1. List of materials 2. The ultrasonic sensor – a key element 3. Programming the robot to follow an object	1. List of materials 2. IR Remote Controller 3. Bluetooth Communication 4. Programming the robot to use IR Remote 5. Programming the robot to use Bluetooth 6. How to use the App to control the robot

Table 3 *– The structure of the LbC training modules*

This structure was the basis for developing the four training modules, its resources, and all the training materials in the context of "Learning by Competing". After its approval by the Consortium, CEPROF, Ovar Forma, and APSU started to produce the four training modules and corresponding resources related to challenge, intergroup competition and mobility of VET trainees in Robotics.

During the idealization of this output, the responsible partners expected it to have a great impact on VET trainees, as they are open to learning differently in the current digital era. They are familiar with all sorts of electronic gadgets, and they like to combine them as well. That is why a simple, yet multifaceted robot model was chosen to integrate all the modules' activities, from the start, until the most difficult stages: the **Yahboom micro:bit smart robot car bitbot with IR and APP for Micro:bit V2/V1.5**. This gadget is equipped with all the features needed to provide the most complete training within the context of "Learning by Competing", as it is controlled by a mobile App remote controller connecting with Micro:bit onboard Bluetooth.

Figure 4 *– The Yahboom micro:bit smart robot car bitbot with IR and APP for Micro:bit V2/V1.5 (**Source**: https://category.yahboom.net/products/bitbot)*

Likewise, the knowledge providers produced the four written modules based on the robot model shown above. The written version of the modules contains detailed information about each chapter (of each module). Through a practical approach and language, a step-by-step tutorial was developed, with descriptions and illustrations of the electronic and mechanical materials needed, instructions for their assembly and programming, recommended software, and hardware and some maintenance considerations for the final product, which will be a robot ready to perform simple actions, using low-complexity commands, such as rotations in several directions.

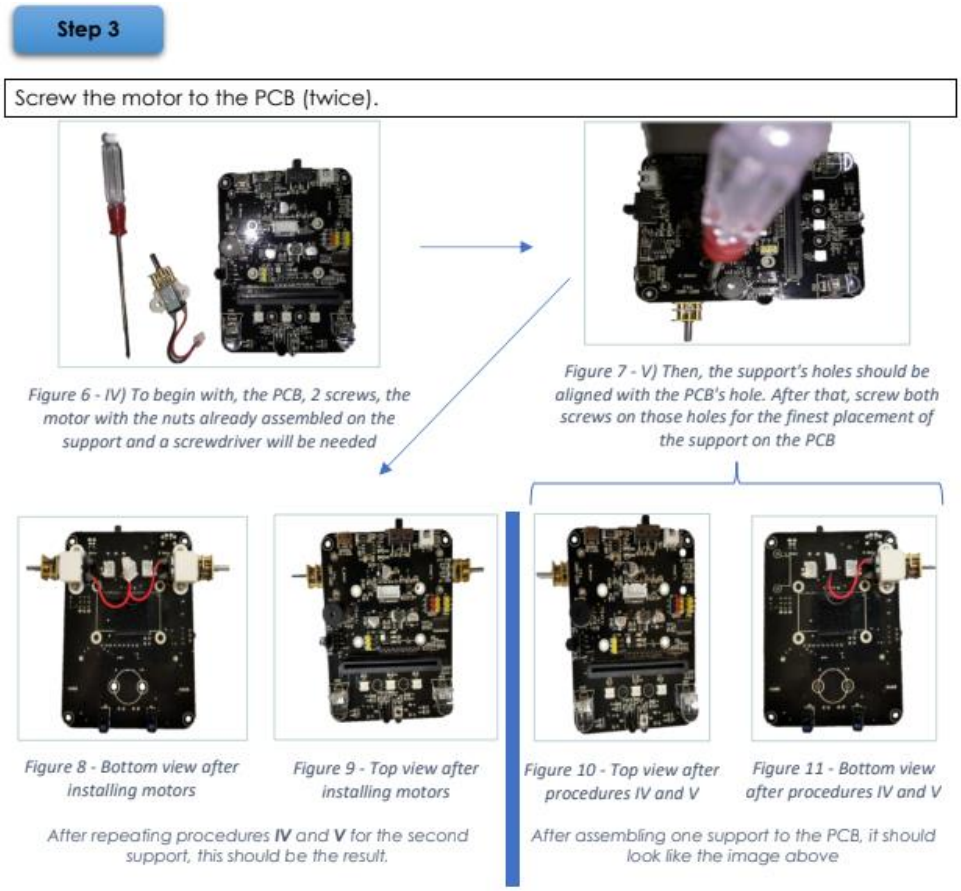

Figure 5 *– Step-by-step approach of LbC written training modules (**Source**: Learning by Competing Training Module 1)*

Added to the written modules, the partners also composed the corresponding additional training resources. They aimed at helping and reinforcing the contents of each module. Using a "do-it-yourself" approach, they proposed a

series of exercises that must be carried out sequentially as a way of complementing and consolidating the algorithmic and programming logic used in robotics. Each exercise contains a blank space below in case trainees need to take notes or to note down new tricks discovered along the way. In the last pages of the training resources documents, there are solutions for the resolution of each exercise, in case there are any doubts left. As an illustrative example, in Module 1 Training Resources, students are challenged to explore, with the help of the basic programming blocks, their algorithmic and logical skills to make the robot perform simple actions. Going forward, going back, left, and right and combining these movements to create a square are some examples of these challenges.

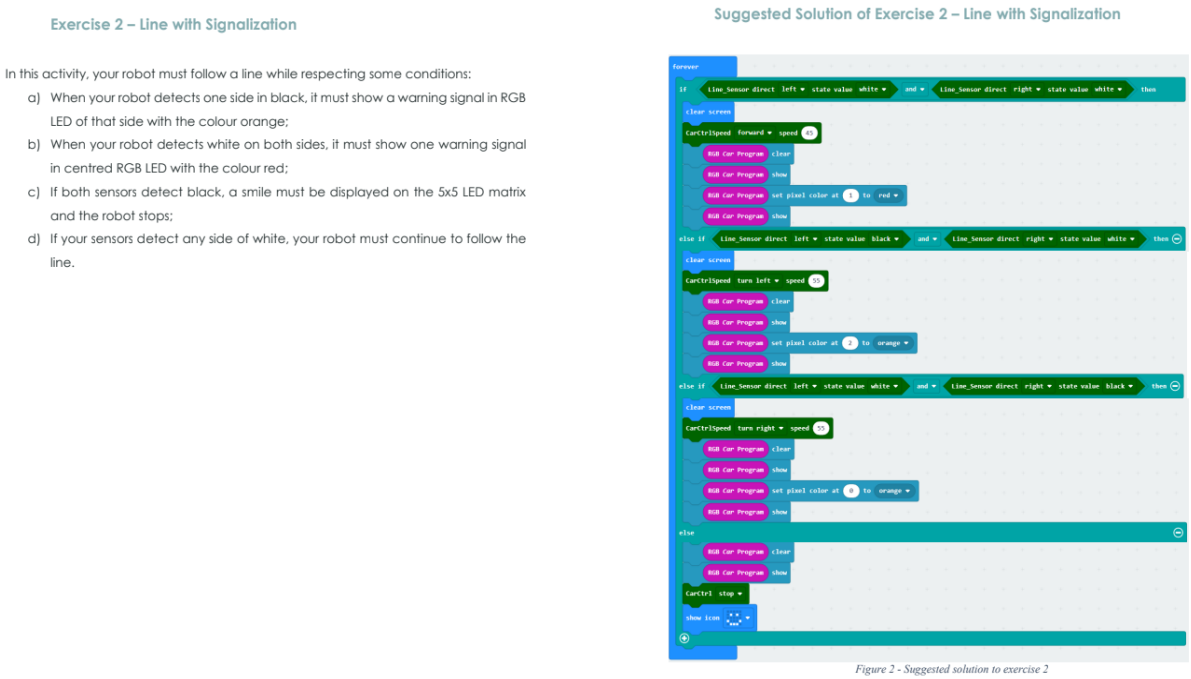

Figure 6 *– Training Resources for Module 1 – Exercise 2 (**Source**: Learning by Competing Training Module 1)*

From the start of the process until the end of the project lifetime, partners worked on a continuous improvement of the modules (as well as of the training platform to be detailed in the next section). This was especially useful for detecting and correcting bugs, adding new and/or more suitable instructions,

improving the user-friendliness experience and embedding all the materials, certificates, modules, texts, videos, etc.

5. The training platform

Right from the start, the partnership worked on developing a MOOC platform, free of charge, available in all the partnership's national languages (English, Portuguese, Spanish, Italian and French). It was meant to receive all kinds of visitors (with a special focus on VET trainees), therefore it is possible to create a free account and enrol in one of the courses (one language – one course).

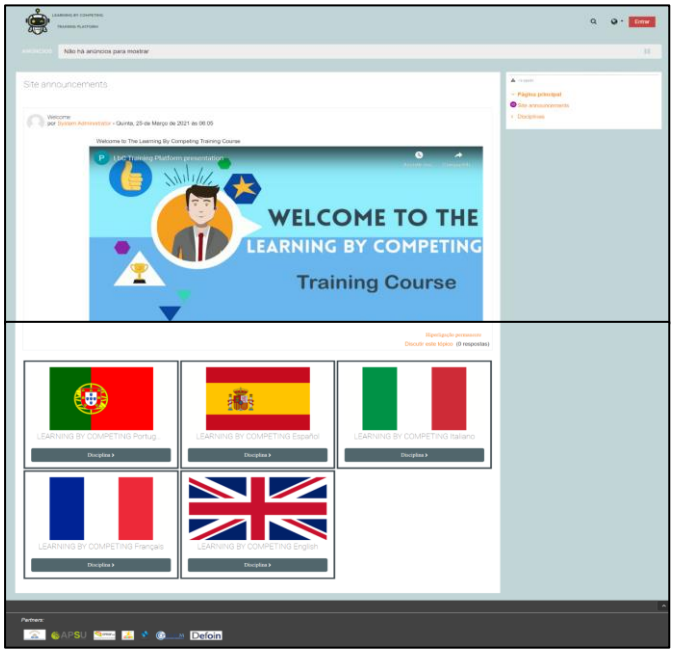

Figure 7 *– After logging in, this is the platform's main page* ***Source****: Author*

Each course is composed of four training modules.

Once the user begins with the Learning by Competing Training Course, he/she should begin with Module 0 (zero), in which the functioning of the platform is explained.

Módulo 0 – Introdução, como usar a plataforma

Bem-Vindo/a à plataforma Learning by Competing!

No módulo zero, procuramos proporcionar toda a informação necessária à compreensão acerca do funcionamento da plataforma.

Tem em consideração os seguintes aspectos:

- Este curso é composto por quatro módulos;
- Cada módulo terá vários passos que deverás seguir.
- Após ver o vídeo de um determinado passo, terás alguns exercícios que deves fazer para avançar para o passo seguinte. Para correctas.
- Após todos os passos dentro de um módulo, terás uma avaliação final.
- Só após esta avaliação, terá acesso à certificação da conclusão do módulo.
- Nos menus acima, encontrará os seguintes menus: Home, Dashboard, Events My courses e, This course;
- menu Home permite-lhe ir para a página principal;
- menu Dashboard permitirá escolher a língua do curso;
- menu Events permitir-lhe-á ver se há algum evento a ser feito relativamente ao curso;
- No menu This Courses tem acesso a todos os cursos em que está inscrito;
- Finalmente, na secção "This courses" podes escolher várias subsecções:
  - "Sections" - Nesta parte, pode ir directamente a um módulo específico;
  - "Participants" - Pode ver todas as pessoas inscritas no curso;
  - "Grades" - Pode aceder aos seus resultados;
  - "Quizzes" - Poderá ver todos os quizzes desenvolvidos no Moodle;
  - "Resouces" - Poderá ver todos os recursos desenvolvidos no Moodle.

Desfruta do teu tempo na plataforma Learning by Competing.

Em caso de qualquer dúvida, envia-nos um e-mail para: apsuprojectmanagement@gmail.com

Figure 8 *– Module 0, in which the platform is explained (**Source**: Author)*

After the thoughtful reading of the Module 0 instructions, users start their path along the various modules. As stated before, the modules are progressive (from the easiest to the hardest), and they all contain the written version of the module, as well as the additional training resources with all the exercises and proposed solutions. These materials are available for download at the beginning of each module; however, users can not move to the next module until all the tasks are completed. These tasks comprise the visualisation of informative step-by-step videos, in which users are provided with a comprehensive demonstration of all the steps required to perform the given tasks (e.g., how to assemble the robot – materials required, ways of assembling, safety procedures, etc.). These videos include a summary of what is described in the picture.

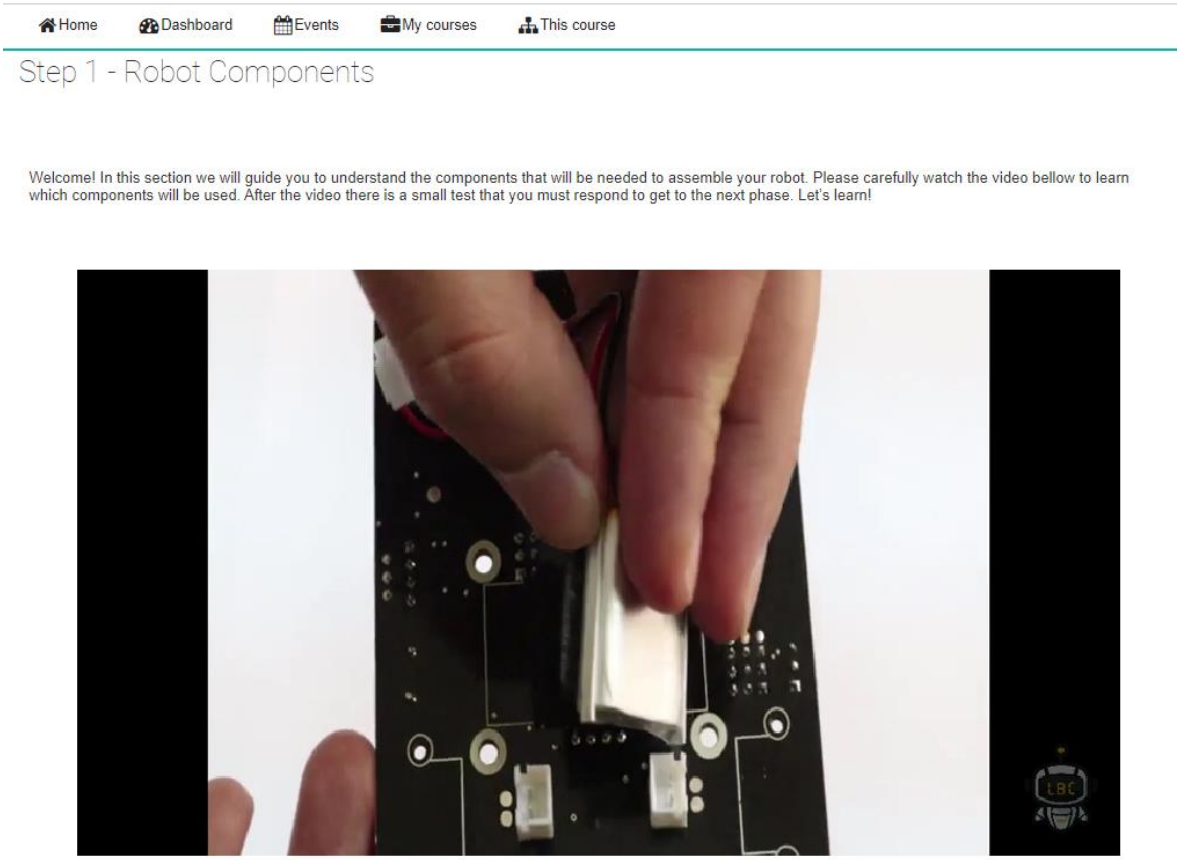

***Figure 9** – Example of a step-by-step video and its description (**Source**: Author)*

After each video, there is a quiz related to the video's contents to be completed by the users. They should have more than 80% of the answers correct in order to move to the next video.

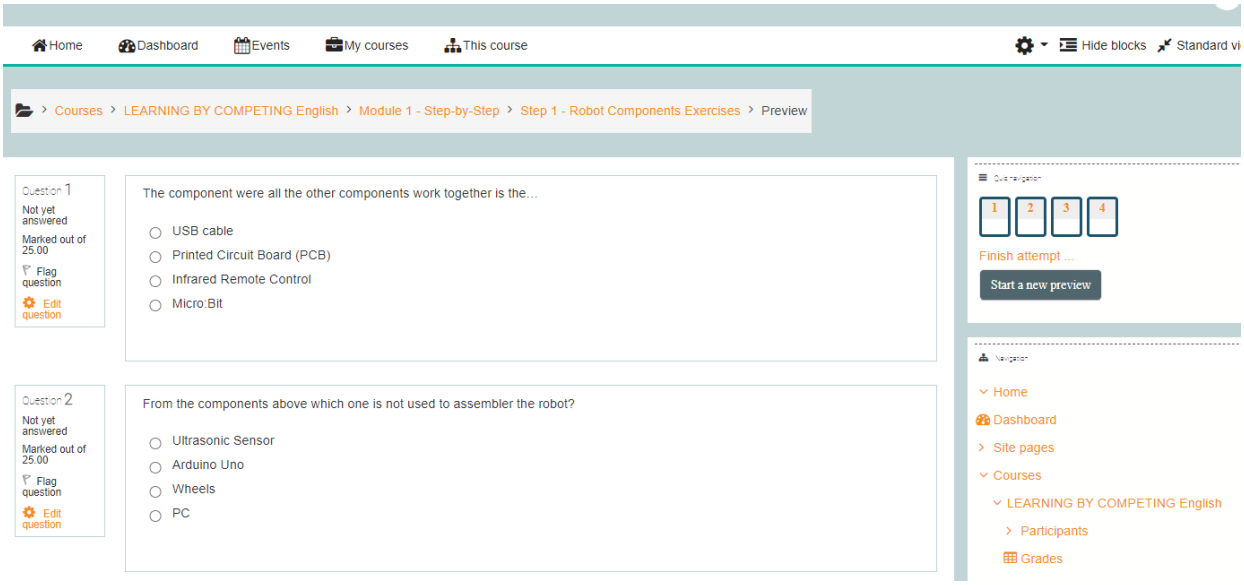

Figure 10 *– Example of quiz available in-between the step-by-step videos (**Source**: Author)*

After users watch all the module's videos and complete the corresponding quizzes, they have to pass the final evaluation quiz. Once again, to move to the next module, they should answer at least 80% of the answers correctly. Its visual aspects look just like the in-between quizzes.

Once users complete the final evaluation quiz, they can download a certificate of the module's completion. In this certificate, users can complete a blank space with their names, and the competencies gained after the completion of the corresponding module are described, as follows:

Figure 11 *– Certificate template for the completion of Module 1 (**Source**: Author)*

6. Pilot-testing and mobility for competition

Undoubtedly, the small-scale pilot test through a period of mobility for the competition is a crucial output regarding the achievement of the objectives of LbC, as only through that, can we draw substantial conclusions about several points: the quality of the materials produced and their receptivity by VET students and VET trainers; the influence of mobilities and competition on the participants' hard and soft skills; the innovation elements associated with mobility for competition – methodology of a challenge, intergroup competition and mobility in the learning process of VET courses, to encourage VET trainees to find the right motivation for learning and successful educational performance).

The main aim of the pilot-testing stage has been to test and transfer the "Learning by Competing" pedagogic approach to other VET Schools in partner countries (France, Spain and Italy). In this regard, three mobilities were organised: the first one in Espinho, Portugal, from the 24th to the 28th of January; the second in Madrid, Spain, from the 14th to the 18th of March 2022 and the third one in Paris, France, from the 16th to the 20th of May 2022.

The methodology adopted for the mobility period

Since the methodology adopted for the entire period of the project implementation has been results-oriented, the partnership worked on preparing the target groups to participate in the three mobility flows, having as main goals the assembling and programming of a small robot with different purposes, depending on the level of difficulty and module addressed.

Before the mobilities took place, VET teachers in all the implementing countries met online in order to arrange all the logistic, technical and pedagogical aspects for the best small-scale pilot-testing of the training modules and the

corresponding competition. They discussed several aspects regarding the implementation of the mobilities:

- Introduction of the project (context, goals, results and activities);
- Selection, registration, profile and preparation of the participants;
- Rules of the competition, access to the Moodle platform and further needed adjustments/corrections;
- eTwinning as a communication platform to be used;
- Materials needed, including software and hardware requirements;
- Logistical aspects (travelling to the host country, agenda, documentation needed, and other practicalities);
- Evaluation procedures.

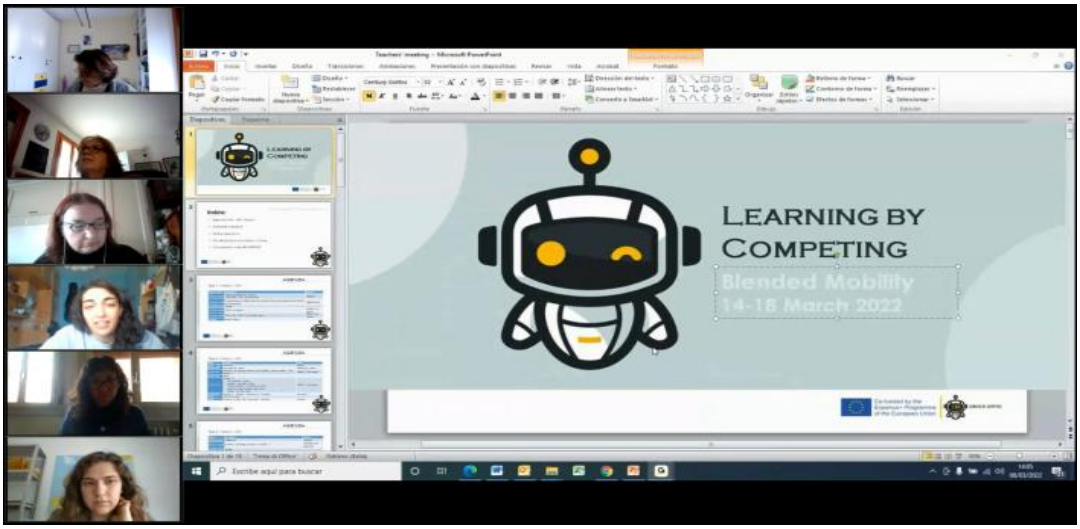

Figure 12 – *LbC teacher's meeting before the 2nd mobility (**Source:** Author)*

The three mobilities had three different structures, since the first and second ones, due to COVID-19 restrictions, were structured in a hybrid format, as some of the delegations did not attend the mobility in person. The third one was the only one that took place face-to-face. Consequently, the host countries followed two different paths for the organisation and implementation of the face-to-face and hybrid modalities.

The agenda for the mobilities followed a similar structure, which included the following activities (divided by five days):

- Opening ceremony session: introduction to the blended mobility and ground rules;
- Presentation of the participants;
- Ice breaking game;
- Technical presentation of the work to be developed (and clarification of any further doubts) along the module(s);
- Assembly and programming of the robot – technical tasks;
- Resolution of the corresponding Moodle quizzes and evaluation tests;
- Study visits (f2f format) in the context of the project scope/activities or online activities with special guests, mainly experts linked to the scope of the project;
- Preparation for the competition;
- Competition;
- Jury evaluation and announcement of the winners;
- Delivery of the certificates;
- Evaluation of the mobility (for all participants, including teachers).

For the first and second mobilities, and since they were held in a hybrid format, the workload was divided between synchronous and asynchronous tasks.

The project team made an effort in order to make all the activities synchronous. Therefore, the technical tasks were performed in an asynchronous way, even though participants from the same team and their teachers were working together. Nonetheless, the remaining staff (from the project and/or other teams) was always available online (via E-Twinning and Google Meet). As for the asynchronous activities, those were basically for the accomplishment of the practical exercises, including the step-by-step assembly and programming of the robot. The students were accompanied by trainers who were there to

clarify any doubts and help them through the whole process. If there was any question they could not elucidate, the eTwinning platform was available for reporting unclarities and clarifying questions.

Regarding the materials and logistic requirements needed to hold the mobilities, from the start of the mobility period, all participants were expected to attend a Google Meet chatroom and Zoom (in the second mobility) in order to be online at the same time. This was the first requirement for implementing the mobility: **a computer with access to the internet, equipped with a webcam**. For a better harmonisation of the process, students and teachers who could not attend the mobilities in person developed the tasks in the same (physical) space, in which the other materials required (e.g., the small robot and all the necessary components to be assembled, the tools needed for its assembly, the tracks provided by the modules' builders and/or IO2 knowledge providers for the realization of the drills and competitions, the printed version of the modules, and its additional resources) were fully available for the participants.

Figure 13 – *Synchronous sessions took place in the first mobility (**Source:** Author)*

Moreover, online resources were available: access to the project's Moodle platform and all the training resources contained therein for the completion of the robot assembly and programming activities; the mobility and competition

rulebook; access to eTwinning to access a support chat; and evaluation forms built on Google Forms to assess the mobility.

Comparing the hybrid mobilities with the third mobility, which was fully face-to-face, the only difference was logistical, as the host partner gathered all the

participants in the same physical space and carried out all the activities synchronously. This time, no online tools were utilized apart from the Moodle platform since all the actors (students and teachers) were together in the same space.

Regarding the competition periods, each one of them had a different purpose, directly linked to the subject addressed in each module. In the first mobility, the competition objective was to make the robot perform a circuit following one black line drawn on the track (Modules 1 and 2); in the second mobility, the main goal was to programme the robot to perform 3 different challenges using ultrasonic sensors as the main component (Module 3); finally, the third mobility comprised of 3 different challenges using remote control tools (Module 4). For each of them, a rule book was delivered and a jury board was appointed.

The preparation for the competitions started way before they took place. Partners had to apply the main goal of each module to a challenging set of drills to be accomplished by the teams. For that to happen, the project's team of experts from the knowledge providers had to agree on a common idea on what tracks, exercises, and competencies had to be implemented during the competition period. With this in mind, the rule book embraces various helpful sections:

- Description of the track;
- The field;
- Rules for the teams;
- Rules for the competition;
- Punctuation and ranking;

- Penalties;
- The Jury;
- Materials needed.

Before each competition, the agenda comprised some time for the teams to prepare themselves. This was the ideal moment for them to combine the knowledge learned in all modules with any new concepts, to improve their coding and assembly skills.

During the competitions in hybrid format, the team in action was recorded by a webcam in order to be followed by the judging panel and the other teams. In the face-to-face competition, the same happened under the watchful eye of the jury.

Figure 14 – *Competition time in the third mobility – Paris, France (**Source:** Author)*

Evaluation of the mobilities

C1 – Espinho, Portugal (pilot-testing of Modules 1 and 2 + 1st Competition)

In summary, the experience was evaluated as positive and beneficial for the target group involved, even though it took place in a hybrid format. Some of the participants stated that the methodology applied would be more fruitful in a face-to-face environment. Nonetheless, the majority of the respondents considered their motivation levels to participate in the project activities improved within their performance during the mobility. Most of the students felt committed to the training activities, even though many of them have never participated in such an event. It must be stated that most of the participants started the competitions with the same level of practical and theoretical knowledge in the scope of the project.

There were **some general recommendations for the upcoming mobilities**:

- Clearness in scheduling synchronous and asynchronous activities;
- Use a simpler language in regard to the evaluation forms;
- Enlarge the scope of the video call, making it available for all the participants, in order to improve the communication stream.

In general, all the target groups were satisfied with their participation during this first mobility. It was an opportunity to participate in an enriching international experience, and everyone noticed i**mprovements in technical and social skills**.

C2 – Madrid, Spain (pilot-testing of Module 3 + 2nd Competition)

Overall, the participants' experience was positive and beneficial for their learning experience. Most of the respondents stated that they were happy about their mobility, although there is always room for improvement. The partnership tried to apply the recommendations mentioned in the previous

mobility, and an effort to ensure better communication software among all participants was made.

As for students' feedback, when asked to comment on the most valuable aspect of the training programme, most of the trainees stated that they found the aspects important, and one of them stated something that was very rewarding for the partnership: "**The [improved] capacity of thinking. I use the ICT method of thinking for other subjects**". This feedback ended up being meaningful to the project staff, as it worked as proof of a successful implementation of the "Learning by Competing" methodology. This statement was reaffirmed when the trainees were asked if they would put into practice what they have learned. 83% of the trainees answered "Yes".

Nevertheless, when asked about **how the programme could be improved**, some trainees pointed out the lack of time to complete all the tasks should be one of the most important aspects to be worked on; they stated as well some communication issues; the need for a more detailed explanation regarding the Micro:bit software; and more time to practice before the competition.

C3 – Paris, France (pilot-testing of Module 4 + 3rd Competition)

The third and last LbC mobility was an ambivalent success, as shown by the assessment results. The fact that this was the first mobility taking place completely face-to-face significantly improved the assessment results on behalf of all actors: trainees, trainers, and participating VET schools. Even though the previous mobilities' assessment results were positive, the feedback gathered within C3 showed that the full f2f format generated more bonding and engagement with the tasks to perform and with the social goals of such encounters.

As for recommendations to consider, the participants underlined the following aspects:

- The team working on the organisation and implementation of the mobility should provide comprehensive, yet simple information about several aspects of the training programme and the competition, as this was considered one of the points to be worked on in the three mobility flows;
- The balance between genders should be more equal, as there were more male participants in all the mobilities;
- The duration of all tasks should be thoroughly analysed before the mobility periods, as some tasks took longer than needed and other tasks were short in time.
- It was also noted that the agenda should comprise activities to be done by all the teams together, as this is a key factor to improve the participants' social skills and intercultural perceptions.

7. Conclusions / Lessons learned

It is not always easy to transport a methodological approach to contexts different from the original one. The concept of transferability addresses several challenges. The "Learning by Competing" project proved it, not only by the challenging nature of the objectives it set itself but, above all, because of the difficulties that appeared along the way. From a pandemic that marked the daily life of the planet, affecting the entire planning of the project right after its approval, to the expectable idiosyncrasies of the cultural differences that enrich the European territory, the project partnership was always faced with new, unpredictable, and difficult challenges, but showed a willingness to find viable solutions to complex problems. This is the first point that institutions willing to adopt this methodology should consider - in a world of constant change, there is no room only for "Plan A". A persevering attitude must be adopted, going through the alphabet of contingency plans up to the letter Z.

The second point to keep in mind is the need to be receptive to change, whether technological, circumstantial, or any other change. The educational action teams need to understand that robotics, as science in constant development, brings with its constant updates, and it is essential to know how to adapt it to the methodology we propose. Furthermore, and despite the four training modules of the project having been constructed in such a way as to be discovered without major thorns along the way, we must be aware that we are implementing this methodology in a young population, often unprepared and lacking in concepts that educators may understand as being "basic" and "obvious". There is no such thing as "too much information" in the Learning by Competing approach. There must be long, easy-to-understand explanations in simple language adapted to the new generations, always accompanied by demonstrative examples that can be reproduced by most lay learners, whether in videos, textbooks, activity books - all formative and pedagogical materials. This approach to communication does not stop at the teacher-learner circuit, but also extends to communication between implementation partners (educational institutions, governing bodies, and other stakeholders). It is essential to find a unanimous plan, understandable and extensible to all realities.

Through implementing the mobilities and competitions, the project team realised that the Learning by Competing methodology can have a positive and holistic effect on the trainee's curricular and, more importantly, life path. The contact with other realities, teamwork, logical and critical thinking, brushed with a constant invitation to innovation and creativity, will make the trainees not only better students, but also better future workers and citizens. It is, therefore, vital that educational professionals do not deprive them of socializing and teamwork - and here there is a special warning - they should never allow competition to turn into a duel of egos. Unity is strength.

Last but not least, it is important to ensure equity in gender distribution among teams. Science, innovation, development and, crucially, healthy growth and opportunities should be attainable by everyone, regardless of their gender, ethnicity, sexual orientation, and social background. The main goal of all educational projects should be common and extend to all of them: the building of attentive, supportive, respectful citizens. Let us not miss the opportunity to do so by implementing such an innovative and attractive project.