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

Project no. 2020-1-IT01-KA202-008555

"Innovation Garage of Garages"

IO2 – Intellectual Output 2

Training programme on the first assembly and installation of new vehicle electrification technologies, based on work-based situated learning methodology within the innovation garage

Output Type: Open / online / digital education

OER – Open Educational Resource

The project is funded by ERASMUS+ Programme of the European Union. The content of this material does not reflect the official opinion of the European Union, the European Commission and National Agencies. Responsibility for the information and views expressed in this material lies entirely with the author(s). Project number: 2020-1-IT01-KA202-008555

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

Training Program on HEV/EV installation & assembly

Language: English

Author:

Innovation Garage of Garages Partnership

Coordinator: Cisita Parma scarl, Italy

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

Innovation Garage of Garages

Index of Contents

Intro: the learning model

Since VET providers maintain close cooperation with the industrial sectors, especially within the automotive field, workplace training is the most valuable asset that educational institutions hold to develop job-related skills, facilitating the learners' transition into the labour market.

In this view, the "Innovation Garage of Garages" project (named "IG2" below), holds the purpose to bring VET providers and automotive companies together (either construction houses, OEMs manufacturers, dealers, car-repair workshops) to co-design training paths & learning environments suitable for the development of green mobility skills, in terms of:

a-learning goals & contents;

b-layout of the training workplace;

c-tools, machinery and equipment.

According to the panorama of the green skills and job profiles within the Automotive sector, identified in the IO1 paper, the main 5 work processes that IG2 project deals with are:

IO2: Installation & Assembly of EV/HEV engines

IO3: Maintenance of EV/HEV engines

IO4: Configuration & calibration of Avionics systems in e-vehicles

IO5: Maintenance of Avionics systems in e-vehicles

IO6: After-sales assistance & safety issues related to EVs/HEVs

The training environment should make practical learning accessible and inclusive, and students should learn from work processes and organizational structure, as well as use technological assets that are the closest possible to the real workplace layout.

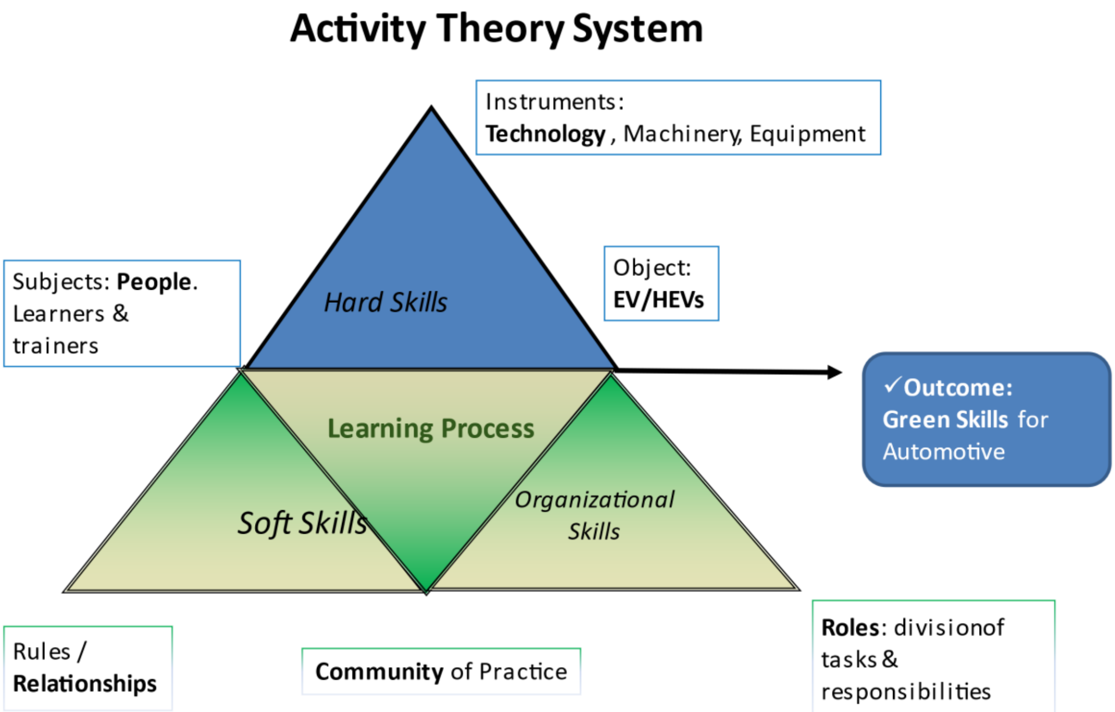
This is what IG2 partnership agreed to call "situated learning", identifying the dynamics of a training environment equipped with technological tools, where learners are immersed into a productive process governed by supervisors performing a mentoring and leading role, aimed at manufacturing a given product.

The learning model inspiring the project methodology is the "Activity Theory" framework by Yrjö Engeström (1987/2015), representing the third generation of academic researchers studying the topic, after the contributions of cultural-historical psychology from the Russian Vygotsky to Leontyev.[1]

---

[1] For a very introductory documentation over the "Activity Theory" system please see:

- Andy Blunden "Engeström Activity Theory and Social System", 2015



According to such model, the overall learning process is composed of two main dimensions: the immersive experience of actually doing some activity or of producing a real product within a given environment, such as the school lab or the training facility, or workplace itself. This is the dimension where the e-mobility hard skills are being developed, thanks to the interaction of 3 main elements: people (learners & trainers) as *subject* of the process; tools (such as technology, equipment and machinery) as *instruments* making the learning process come true; the *electric/hybrid vehicle* or one or more of its components, as the *object* of the learning process itself. The outcome of the interaction of such 3 elements is the expected learning goal itself for the relevant testing, or, more generally, the green skills for the automotive sector.

Underneath the upper triangle, the Activity Theory puts the hidden or intangible part of the learning process, which is related to the development of all the soft skills implied by interacting within a complex organisation of people. This is what happens to workers in a company, but workplace learning or workplace simulation actually reflects the very same dynamics. As a matter of fact, within an automotive production site or within a car repair workshop, for example, workers are assigned different roles, responsibilities and tasks which actually shape the interpersonal relationship happening over there. VET learners, either in their initial training at school, or involved in lifelong and continuous training at work, are immersed in a community of

- Oliver Ding, Yrjö Engeström: the Activity System Model, 2021 practice, where knowledge, skills & behaviours are shared, promoted, rewarded or even confuted or rejected.

IG2 project, by bringing together VET providers and companies, aims at co-designing learning experiences for the development of e-mobility skills, keeping in mind such behavioral and organizational learning model.

1. Referencing Output 2 e-mobility skills to the current job qualification frameworks

Output 2 of the IG2 project is focused on the development of skills related to the first **assembly** and/or installation of **EV/HEV engines** or of relevant **sub-components**.

According to IG2 partners, such tasks can range from simple and basic ones, attainable from EQF 3 operators or even lower, e.g. C-VET operators achieving EQF2 vocational qualifications, to technical or supervisory roles (EQF 4 - EQF 5).

Output 1, outlining the train-the-trainers program for VET teachers willing to introduce e-mobility in their didactic courses, collects the job qualifications in the automotive sector according to the ESCO framework and from the job-profiles and skills card classified by the Erasmus+ Sector Skills Alliances DRIVES 591988-EPP-1-2017-1-CZ-EPPKA2-SSA-B (for the general automotive sector) & ALBATTS 612675-EPP-1-2019-1-SE-EPPKA2-SSA-B (specifically for the battery sector).

According to such classifications, Output 2 refers to the following job roles matching the EV/HEV engine assembly operations:

	DRIVES Development and Research on Innovative Vocational Education Skills	albatts
Motor vehicle assembler		EV Automotive Repair and Inspection Personnel
Automotive Electrician		
Electrical Cable Assembler		
Electrical Equipment Assembler		
Electrical Equipment Inspector		

Electrical Mechanic		
Electrical Supervisor		
Automotive Battery Technician		
Battery Test Technician		Battery Quality Technician
Electronic Equipment Inspector	Robotic Technician	
Vehicle Electronics Assembler		

Among all the e-mobility related job qualifications that ESCO, DRIVES and ALBATTS put together, the one listed above are the ones that are at least partly relatable to the training programs that were designed and tested by the IG2 VET providers' consortium, and that will be described in the chapters below.

2. Designing, testing and evaluating results of training programs about EV/HV engines assembly

During the Pilot Phase of IG2 project (Output 1), partners agreed that the basic structure of any topic-specific program about e-mobility should start with a joint business-VET design phase, including:

– identifying learning objectives,

– setting knowledge or skills entry requisites for VET learners,

– identifying the work procedures to implement,

– setting the training workplace layout and necessary tools/equipment,

– deciding on the expected outcomes of the troubleshooting,

– establishing supervisory and tutoring roles

VET providers were not assigned prescriptive rules about which relevant topic should be chosen for a training program about EV/HEV engine assembly or installation. Multiple reasons usually affect the choice of the specific topic to focus on, and the following criteria should be taken into consideration while evaluating the potential options:

a) whether or not the VET provider is already including specific training modules or contents about EVs/HEVs in the institutional offer;

b) the EQF level of the training course where e-mobility should be taught or introduced for the first time;

c) the general level of technical knowledge & skills of the target learners as well as their behavioural / communication skills and/or their potential fewer opportunities profile

With regards to point a), this is absolutely the most significant and diriment criterion that should guide the choice of VET trainers: are learners already trained about safety precautions around HV batteries and electric or hybrid engines? Are learners already able to read the electrical schemes of the car? Are they already familiar with the structure and components of internal combustion engines whatsoever?

If this is case, it is probably a good choice to delve into EV/HEV engines specific topics such as electrical insulation or HV battery modules checks, or power unit maintenance. On the opposite side, learners who are not trained about electrical risks must never work hands-on with HV batteries. This happens with upper secondary education courses at EQF 3 or EQF 4 levels, where students work just on the mechanical part of engines. In this case, in the first place mandatory electrical safety courses must be attended from students, and demo classes about HV batteries where trainers show the correct battery management procedures without students being involved, or using electronical panels simulating the engine mechanism or the switches of sensors regulating the circuits of the car, are good examples of introductory activities.

Furthermore, VET trainers should take into consideration the general profile of the target learners involved:

-EQF level of the training course and previous knowledge & skills gained by students

-the age of the learners: is it young people in initial learning or is it workers engaged in an upskilling or re-skilling course within C-VET training paths?

-the general life long background of the students involved: is there any type of potential disadvantage represented in the learning group?

This might range from physical or cognitive disabilities, to migrant background or language barriers preventing students from a full exploitation of the learning opportunities, or even age barriers, in the case of underqualified over-50 workers in need of a skill upscale to prevent job loss. In any of such cases, special arrangements should be envisaged by trainers in order to choose the most inclusive and barrier-free training environment possible. In case any learner has a physical disability, the workplace should be designed in a way that the learner is safe throughout the testing, yet he or she can either see the work procedures or operate some of them according to both the work safety procedures and to what the medical conditions allow. In case the learner has a mild cognitive disability, VET trainers should design the experimentation assigning tasks to small students' teams with an appointed leader with a distributed share of duties, so that everybody can be involved in the experimentation with different level of difficulty or responsibilities.

Team work and practical learning is especially recommended and effective in case of migrant learners with little command of the local language, as graphic or synthetic work procedures help understand topics or tasks quicker than a theoretical frontal class.

Evaluation. As a part of O1 train-the-trainer program results, IG2 project partners established a protocol for the evaluation of the work-based testing, to assess to which extent the program itself was successful for VET learners to develop e-mobility skills. Such assessment is a simple form with questions addressed both to VET teachers or trainers, and to business technicians, since the workplace training should be co-designed on both parts.

Teachers or trainers should assess:

– whether or not the learning goals have been met,

– whether or not the work-based testing delivered the expected outcomes,

– to which extent the expected knowledge and skills have been gained by the students or not,

– whether or not the diagnostic tools were used properly,

– whether or not the supervisory and tutoring activities were adequate to provide learners with the guidance they needed.

When relevant, teachers might also provide additional information about the main difficulties overcome, which tasks were missing or not correctly performed during the experimentation, as well as suggestions on how potentially making the experimentation easier or harder according to the learners' profiles.

On the other hand, business technicians should assess to which extent the knowledge and skills that students developed thanks to such a training experience are indeed useful and transferable to the job market. Furthermore, business technicians might as well provide further examples of troubleshooting and diagnostics experimentations on similar topics, that they believe might help learners develop missing skills about working on EVs/HEVs at different EQF levels.

Let's see examples of the training programs that each country team participating in IG2 project designed & tested.

Option 1 - Safety protocols on EV/HEV

The training program was designed & tested by ROC Midden Nederland (VET provider) and Innovam (company), and is targeting VET students attending the following courses:

- First Car Technician (EQF 3)
- First Truck Technician (EQF 3)
- Technical Specialist Car Technology (EQF 4)
- Technical Specialist Truck Technology (EQF 4)

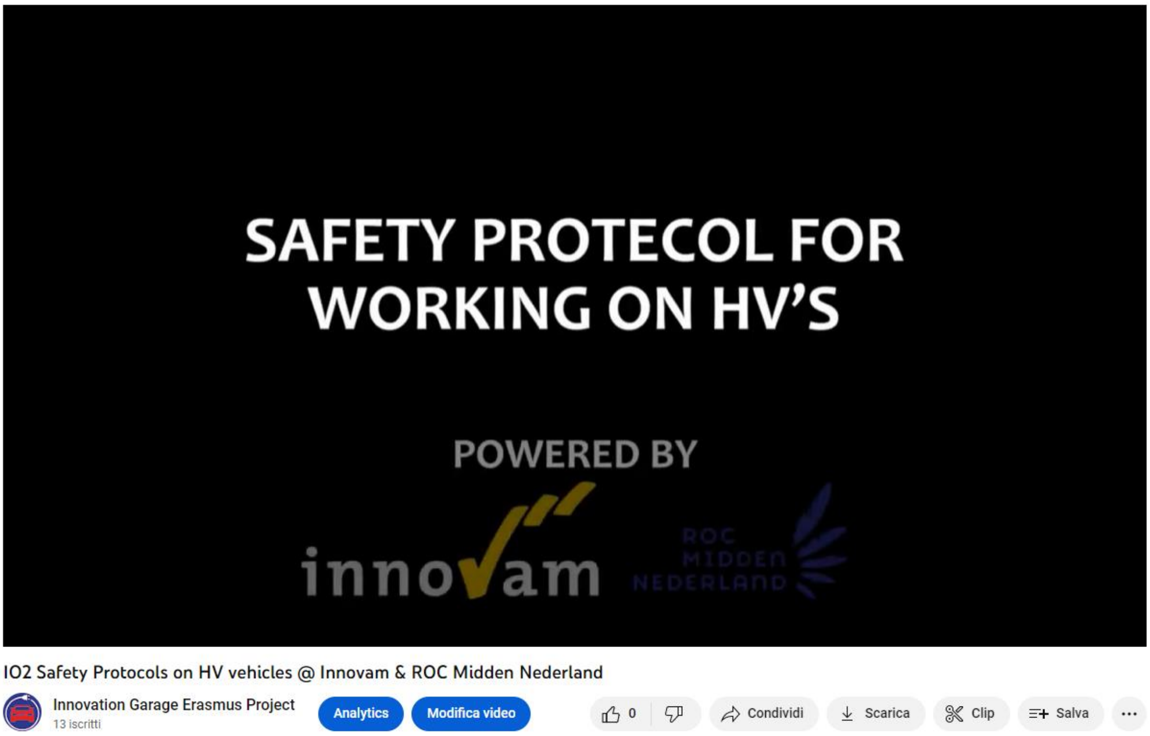
All of them already include, in the regular training paths, teaching contents about the following units:

- Hybrid and electrical drivetrain
- Electric engines
- NEN9140 (EU regulation about electrical works)
- Charging Systems
- Inverter/Converter Battery Management

Nonetheless, the program might be optionable even for trainers with no previous hands-on or theoretical classes about EV/HEV engines, when used as an introductory unit about electrical safety applied to electric or hybrid vehicles. As a matter of fact, ROC Midden Nederland and Innovam do include such topics in a short one-day modular course for students and workers called "Safe working on e-vehicles basics" (see Output 1).

DESIGN FORM	
Task	***Work safe on an e-vehicle***
Learning Objectives	Being able to disconnect the HV-system from the HV-battery. Making sure the system is de-energized and safe to work on.
Entry Level Knowledge (Theoretical)	EQF level 2 Students must be able to recognize all different HV components and their purpose.
Hard Skills involved	Being able to operate a diagnostic tool. Being able to use a two-pole voltage metre. Knowing how to use Personal Protective Equipment
Soft Skills Involved	Being able to read and understand procedures in workshop manuals and diagnostic tools
Equipment & Tools to be used	Personal Protective Equipment Diagnostic tool Two-pole voltage metre
Other Professional Roles involved	An EV responsible employee (EV-nominated person) must be present during execution of the tasks performed by students
Supervision & Tutoring Activities	The teacher must be an EV-nominated person who will guide the students through all the steps to disconnect the HV-system.
Expected Results / Solution	The vehicle is safe to work on after verification that the HV-system is successfully disconnected (HV-system is dead).

Testing with relevant work procedures is portrayed in the instructional video available on IG2 project's official YouTube Channel @innovationgarageerasmuspro1264:



Procedure:

-Inspecting if the vehicle is safe to work with: walk around the car and look for any potential damage

-Checking HV wiring for damage under the hood

-Checking car dashboard for errors

-Connecting laptop and checking battery management system for errors

-Securing and blocking the car, marking vehicle with HV signs so any operator in the garage knows HV work is going on

-Securing the car ignition key at least five meters away from it to prevent accidental activation

-Disconnecting HV battery from HV system: removing 12V negative battery cable from 12V battery terminal

-Checking and wearing rubber insulation gloves (class 0)

-Removing service plug from HV battery to disconnect it from HV system

-Waiting 10 minutes for de-charge

-After 10 minutes, remove protection from HV battery terminals and use a multimeter to check no voltage is left

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

EVALUATION FORM

VET Teachers & Trainers	
Learning Outcomes How to make the procedure easier How to make procedure harder	Achieved Breaking it down into separate parts Letting students find the procedures for safeguarding themselves
Expected results	Achieved
Entry level knowledge and skills of the students Preparation	Adequate level to engage in the experimentation. A training session, partly online partly on-site, was delivered beforehand, about working safe on HV-systems, upfront
Equipment & Tools	Used properly
Supervision & Tutoring Preparation	Effective Making sure all the information about safe working are delivered and clearly understood by learners
Business Technicians	
Extent of transferability of the developed skills to the job market	Complete

Suggestion for further development	A graduate or worker entering the job market must be equipped with the right Personal Protection Equipment (PPE).

Option 2 - Charging an HV battery in a hybrid car

This program was designed and tested by the Lithuanian Team, composed by the VET provider **VAVM - Vilniaus Automechanikos ir Verslo Mokykla** and **Moller Auto Lietuva**, Volkswagen & Audi national dealer, both based in Vilnius.

At VAVM - Vilniaus Automechanikos ir Verslo Mokykla there are two main specialization running on:

-Automotive Mechanic (EQF 4)

-Automotive Electric Equipment Repairer (EQF 4)

Courses do not currently provide a specialisation in HEVs/EVs or avionics circuits, yet work-based training also include maintenance and diagnostics operations on hybrid or electric vehicles. Training modules include contents, knowledge and skills suitable to become the starting point which further e-mobility training can be based upon. Such topics include the following modules:

-Engines technical maintenance

-Transmission technical maintenance

-Automobile electrical equipment repair

-Engines electrical equipment

-Transmission electrical equipment

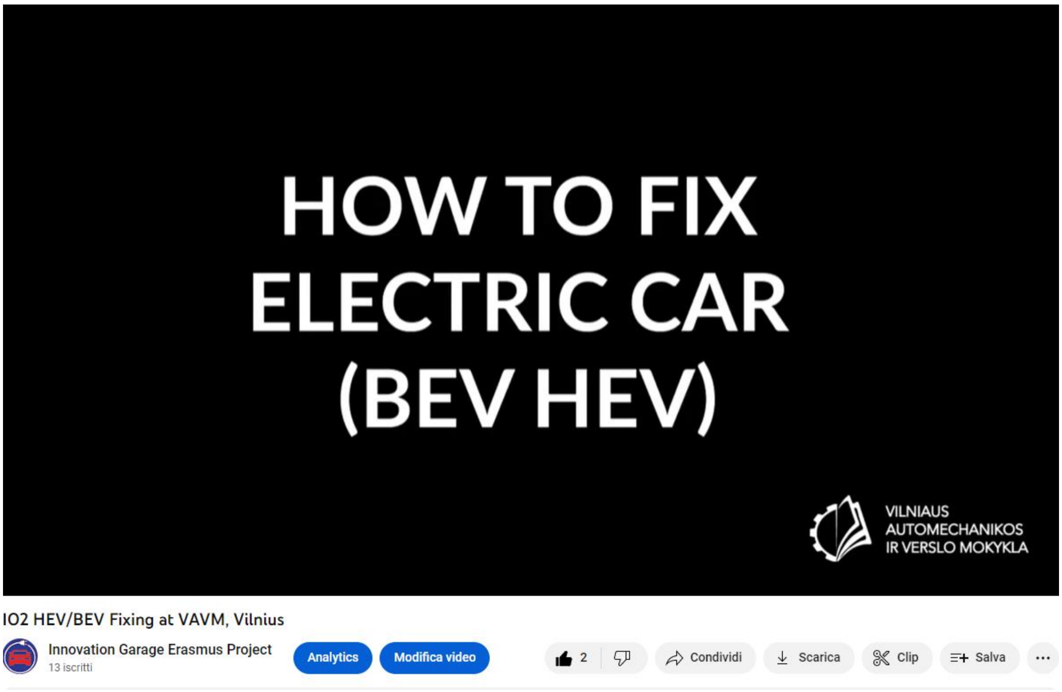
-Automobile comfort and safety electrical equipment

DESIGN FORM	
Task	***Safety precautions around BEV/HEV*** ***Charging an HV battery***
Learning Objectives	Safe handling of high voltage energy sources in HEV/BEV. Safe HV battery charging.

Entry Level Knowledge (Theoretical)	Basic knowledge of mechanics and electronics
Hard Skills involved	Correct way of using mechanical and safety tools (Multimeter, high voltage resistant gloves, and other specific tools)
Soft Skills Involved	English language
Activities & Procedure required at EQF level (forecast)	EQF 3 level
Equipment & Tools to be used	Multimeter, high voltage resistant gloves and carpet, protective glasses, safety sign, security fence
Other Professional Roles involved	BEV/HEV Specialist/supervisor
Supervision & Tutoring Activities	Overview of processes during theoretical lessons

The training program includes a complete set of operations guiding the learner through a safe preparation of the workplace to operate with an EV/HEV, to measure the charge status of an HV battery and then to provide a full charge. For this reason, the program is targeting learners with previous knowledge and skills about the electrical equipment and safety rules about engines and transmission.

Testing with relevant work procedures is portrayed in the instructional video available on IG2 project's official YouTube Channel @innovationgarageerasmuspro1264:



The video illustrates a number of different steps:

1-Preparing a safe workplace and wearing individual safety tools to operate on a EV/HEV

-Setting up a safety zone

-Putting an isolating bumper protection on the back of the car, close to the HV battery

-Putting safety signs with the name of the operator working on the car

-Wearing rubber air tight gloves and protective glasses

2-HV battery charge

-Removing the circuit breaker

-Checking for current in the HV battery with the multimeter: at 0.0 V, the car is safe to start working

-Measuring charge (do not use socket multipliers): the indicator beeps error code and then light is off.

-Measuring charge with a battery break box (with an HV battery plugs lowered to 10:1 for safe training reasons). Measuring is repeated with with HV battery 10:1 plugs - charger DC 10:1 plugs - charger AC 10.1 plugs - inverter/converter 10:1 plugs. Charge is 0 V.

-Re-inserting the circuit breaker

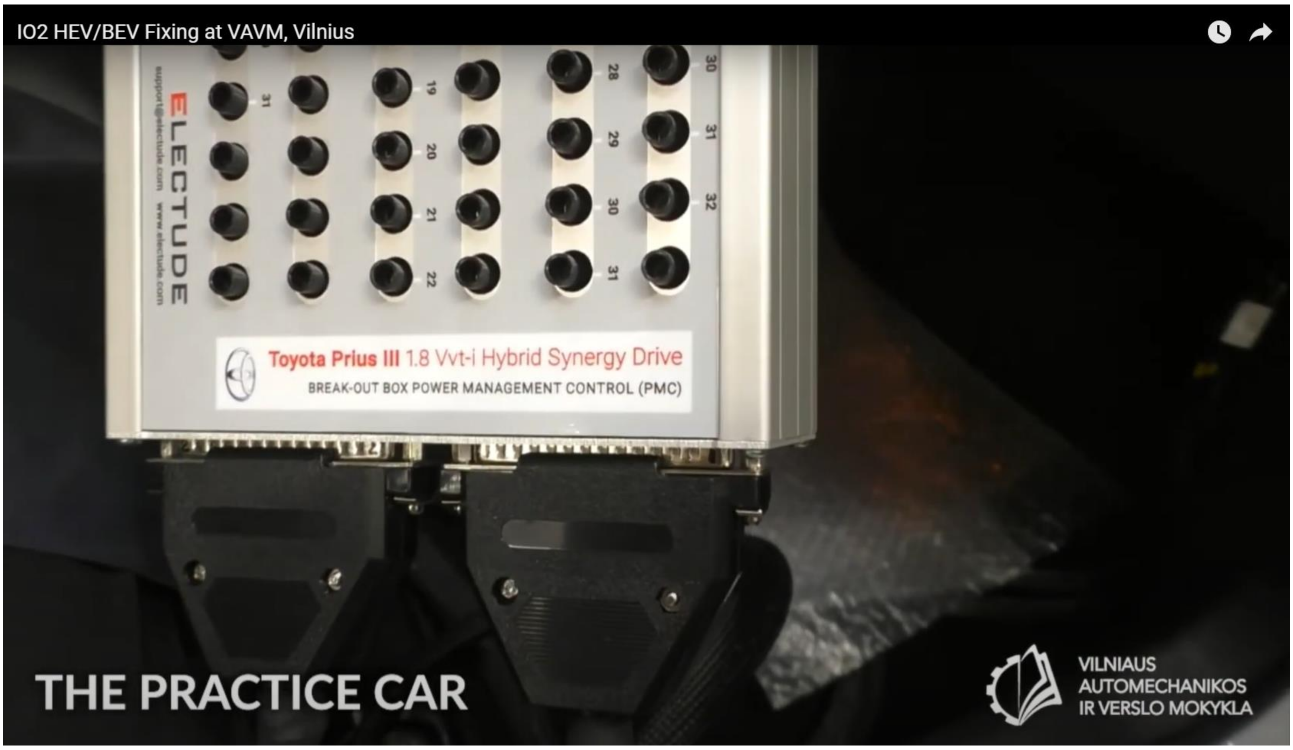
-Insert socket in the charger

-The indicator shows that charging works again

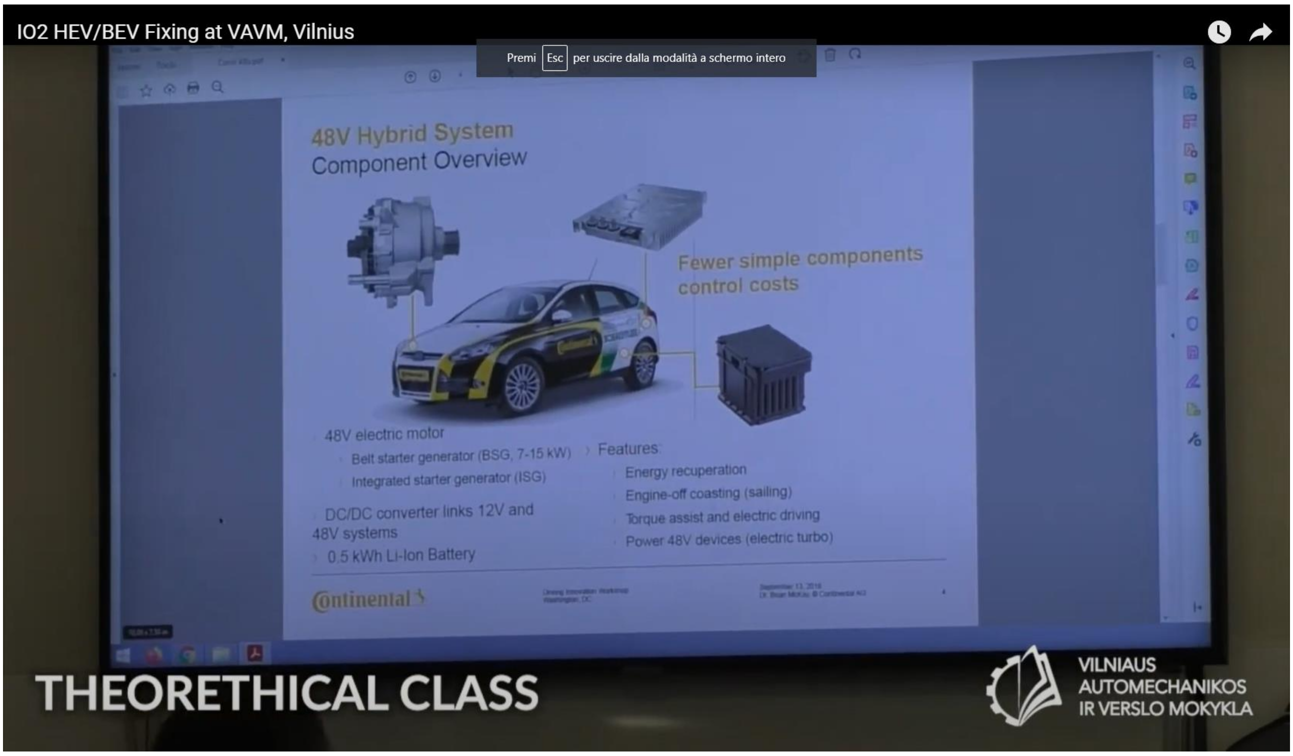
-Measuring charge again with the DC 10:1 battery breakout box: charge is 20.9 V*

The charge is finally on

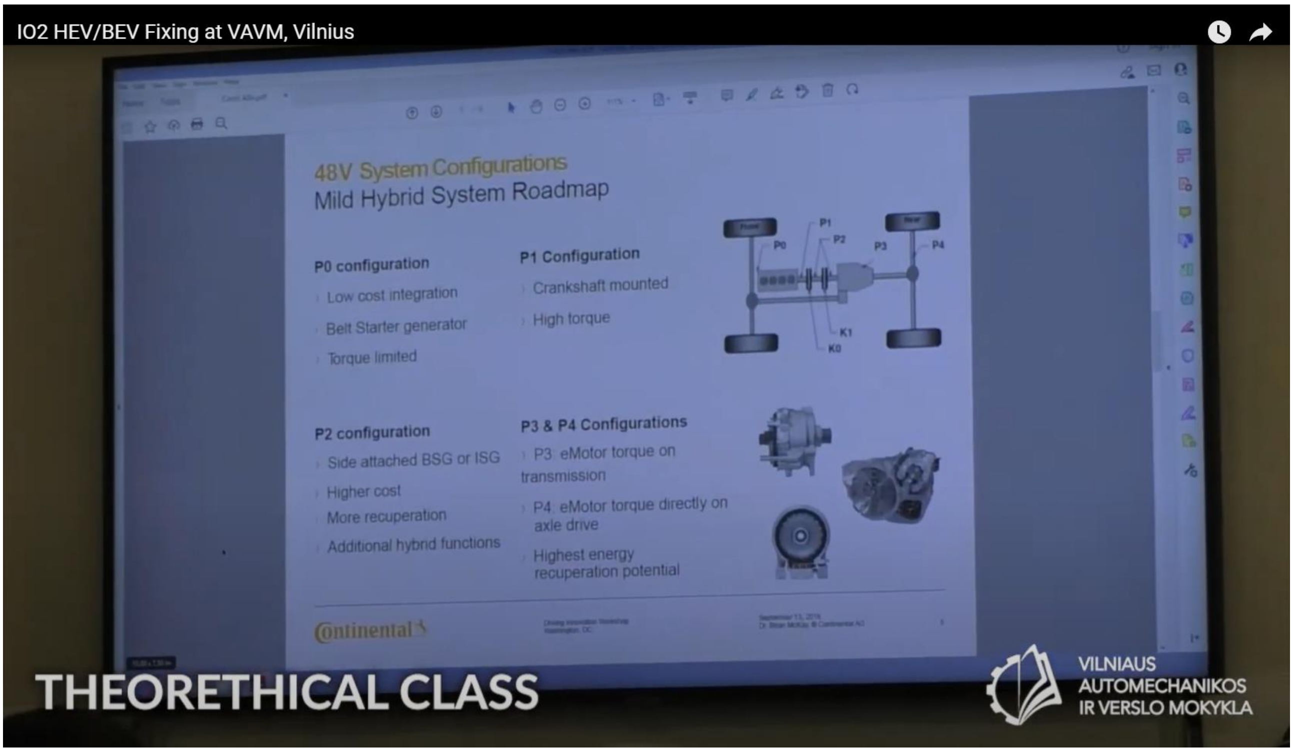
*VAVM uses the Electude Toyota Prius III 1.8 Vvt-i hybrid synergy drive - break out box power management control, further equipped with a separate switch box. The break out box is also equipped with a battery cell + /- unit and a battery module +/- unit



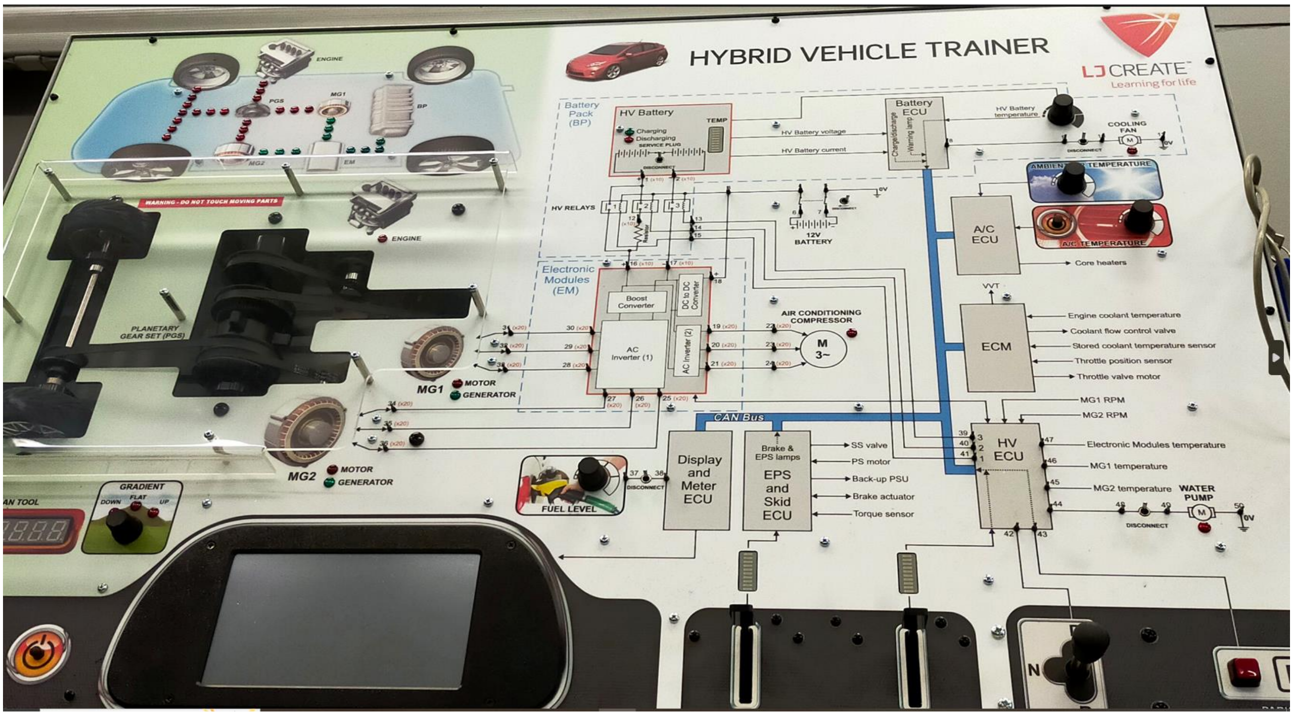
The video is also showing the main topics about electrical transmission that are taught during theoretical classes as a preparatory activity. The first one is battery system component overview.



The second one is system configuration:



Training activities can also benefit from an EV simulation stand with an electronical panel with switches and sensors simulating all the components of an hybrid vehicle, as well as softwares for monitoring the simulation.



EVALUATION FORM	
VET Teachers & Trainers	
Learning Outcomes	Achieved
How to make the procedure easier	Teachers preparing the workplace and all the necessary instruments/tools in advance
How to make procedure harder	Letting students find all the necessary instruments/tools by themselves according to the task requirements
Expected results	Achieved

Entry level knowledge and skills of the students What is missing	Partly adequate level to engage in the experimentation. Multi-brand diagnostic software knowledge
Equipment & Tools	Used properly
Supervision & Tutoring Potential Improvements	Effective Reducing the number of students in groups
Business Technicians	
Extent of transferability of the developed skills to the job market	Complete
Suggestion for further development	A deeper knowledge of brand diagnostic software is useful
Further examples of topic-related troubleshooting problems	
EQF level 3	Charging/discharging HV system
EQF level 4	Checking HV battery leaks
EQF level 5	Checking HV battery control units inside HV battery

Option 3 - Power Unit Operations in an hybrid car

Such a program was run by the EQF 5 level courses within the Fondazione ITS Maker, based in Bologna, training Higher Technicians in advanced technology, mechatronics and automotive fields.

Within IG2 project implementation, there are namely two courses with e-mobility related contents:

- Higher Technician in Hybrid, Electric and Endothermic Engines (EQF 5)
- Higher Technician in Electric & Connected Car and Assisted Driving (EQF 5)

Since both profiles envisage high specialisation standards, attainable with a tertiary education course after the general upper secondary certificate (EQF 4), the current IO2 program is only targeting VET learners with prior knowledge and skills about:

- Electrical schemes of vehicle circuits
- Electrical and electronic technologies and applications
- Installation and maintenance technologies and techniques

The IO2 task run by the Fondazione ITS Maker course in hybrid, electric and endothermic engines was about diagnosis and replacement of the output protection fuse to the auxiliary battery.

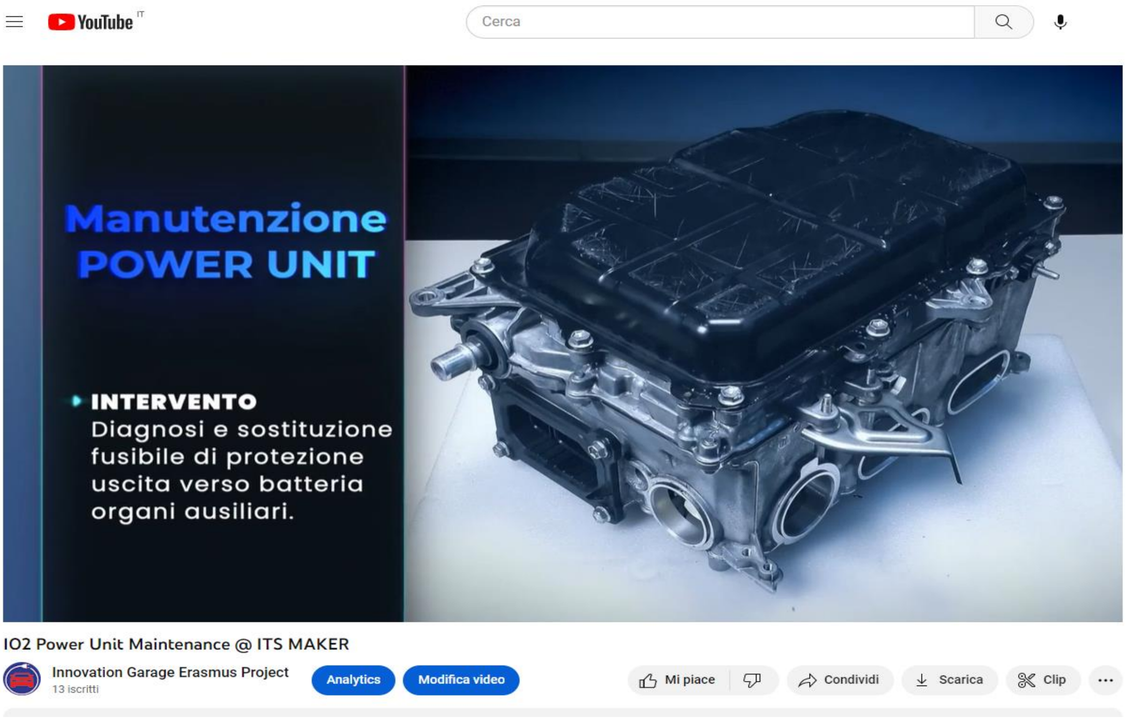
Technical features: water-cooled Toyota power unit with interlock safety sockets. In the event of accidental disconnection of the cables, the batteries are automatically disconnected.

DESIGN FORM	
Task	***Power unit maintenance: diagnosis intervention and replacement of output protection fuse to auxiliary device battery***
Learning Objectives	Knowledge of the main components that run hybrid and electric vehicles in order to carry out repair work

Entry Level Knowledge (Theoretical)	Principle of electricity and electric power
Hard Skills involved	Holding a secondary education qualification or certificate, minimum experience in the car repair sector
Soft Skills Involved	Being vigilant in the workplace, having a responsible attitude when performing a job
Activities & Procedures required at EQF level (forecast)	Component analysis and repair of damaged parts
Equipment & Tools to be used	Vehicle diagnostic tools, multimeter measuring instruments, dielectric equipment
Other Professional Roles involved	Vehicle recovery technicians and car wreckers
Supervision & Tutoring Activities	Correct use of individual protection tools and correct execution of the steps as mandated in the technical data sheets
Expected Results / Solution	Correct use of protective equipment and measuring instruments, as well as acquiring a certain degree of proficiency in carrying out repair work

The testing was performed according to the technical procedure portrayed by the following video available on the IG2 Official YouTube Channel @innovationgarageerasmuspro1264:

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



Procedure:

1. Power unit check

-using the multimeter, preliminary checks are carried out to assess the status and any residual voltage

2. Cover disassembly

-using a socket spanner, dismantle and remove all 10 screws that hold the case closed

-heat the edge of the cover with a jet of hot air to facilitate detachment

-use a screwdriver to remove the cover

3. Diagnosis

-use the voltmeter to check which component is possibly damaged

-the absence of continuity of current shows that the protection fuse has failed

4. Component replacement

-with a socket spanner, unscrew the two screws that block the faulty component and remove it

-the functionality of the new component is checked with the multimeter,

-proceed to position and secure the new component

5. Closing the cover

-before positioning the cover, sealant is applied to the edge of the cover

-screw and tighten the 10 tightening screws

EVALUATION FORM	
VET Teachers & Trainers	
Learning Outcomes How to make the procedure easier How to make procedure harder	Achieved Teachers preparing the workplace and all the necessary instruments/tools in advance No need to make it harder, since the operation is already quite complicated
Expected results	Achieved
Entry level knowledge and skills of the students What is missing	Adequate level to engage in the experimentation. Diagnostic skills on vehicles
Equipment & Tools	Used properly
Supervision & Tutoring Potential Improvements	Effective Even more accurate use of safety protection tools when working with high voltage devices.

Business Technicians	
Extent of transferability of the developed skills to the job market	Complete
Suggestion for further development	A deeper knowledge and skills on repair and maintenance operations
Further examples of topic-related troubleshooting problems	
EQF level 3	Assembly / disassembly of accumulators
EQF level 4	
EQF level 5	

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

Option 4 - Performing electrical insulation

Such a program identifies a preliminary operation that must be executed anytime an operator is performing an electrical task. Despite being a preliminary task, it should be executed only by instructed people because it involves electrical insulation.

For these reasons, at Göteborgs Tekniska College electrical insulation measurements should be performed by learners attending the e-mobility training suite, which is composed by the following units:

Module Title	Duration	Contents
EV Awareness	4 hours (theory)	• Environmental Issues & Constraints • Market development • Total cost of ownership • Technology involved
Battery System Overview	8 hours (theory and practice)	• Battery Technology • Electric Safety • Battery Management • Usage • Durability
Lithium-Ion battery system	16 hours (theory and practice)	• Cell Formats • Physical Chemistry • Supply Chain • System Design • Production
EV charging and power supply	12 hours (theory and practice)	• Modes • Behaviour • Infrastructure • Business Model • Power Components
Electrical machines and transmission	16 hours (theory and practice)	• Drives overview • Hybrid powertrain typologies • Circuit theory

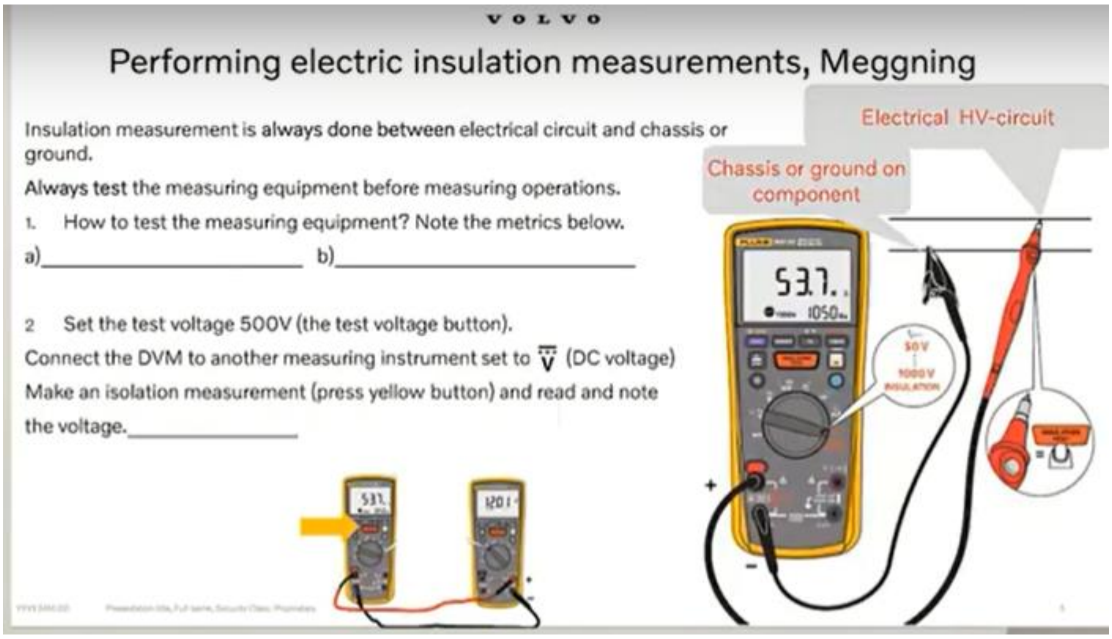
Task: performing electrical insulation measurements on an HV circuit

First thing, the multimeter has to be tested to make sure measurement metrics are fine before proceeding to measure the HV system. The video is showing the correct procedure to make sure electrical insulation is measured in the correct way.

DESIGN FORM	
Task	***Electrical insulation measurements***
Learning Objectives	Knowledge of the use of measuring equipment for HV Knowledge of electrical HV-circuits Knowledge of isolation measurements
Entry Level Knowledge (Theoretical)	EQF level 3
Hard Skills involved	The electric system DC Voltage Operating the equipment involved for measuring Connecting and disconnecting in a safe manner Reading the voltage
Soft Skills Involved	Communicating to team members Understanding manuals
Equipment & Tools to be used	Electrical test equipment (DVM) HV connectors

Other Professional Roles involved	EV responsible employee
Supervision & Tutoring Activities	The EV responsible employee supervision and guiding through the steps of the training activity
Expected Results / Solution	The isolation measurements completed without faulty signals and/or results

The testing was performed according to the technical procedure portrayed by the following video available on the IG2 Official YouTube Channel @innovationgarageerasmuspro1264:



EVALUATION FORM	
VET Teachers & Trainers	
Learning Outcomes	Achieved
How to make the procedure easier	Separating the tasks of measuring into different sections/areas depending on level of education
How to make procedure harder	Using the exercise with measurements in one complete flow with more autonomous work
Expected results	Achieved
Entry level knowledge and skills of the students	Adequate level to engage in the experimentation.
What could be improved	Depending on the students level of previous courses, electrical safety and regulations (EQF 3-4) concerning the actual tasks
Equipment & Tools	Used properly
Supervision & Tutoring	Effective
Potential Improvements	As always, communication between students and tutor regarding HV safety applies in all above cases and has a constant aim for improvement (5s and Lean)
Business Technicians	
Extent of transferability of the developed skills to the job market	Complete

Suggestion for further development	Depending on level of training (EQF 3 or 4) more HV safety courses apply

Option 5 - Performing electrical diagnosis on vehicle simulation panels

Such tasks were performed by students attending the technical and vocational courses (EQF 4) at IIS "A. Ferrari" in Maranello (Modena, Italy).

Based on the learning objectives of the project - getting students familiar with the electric and hybrid vehicles, batteries and engines, the following study courses were identified as most suitable to run IG2 project's experimentation:

- Maintenance and Technical Assistance (EQF 4)
- Technician for the Construction of Transportation Means - Road Vehicles (EQF 4)

At such a level students attend mandatory work safety courses - both general safety recommendation at work and specific mechanic and electrical risk training, but, given their young age, they are not usually trained as EiP (electrically instructed person) and they cannot work with high voltage batteries or circuits. Because of those restrictions, it is not possible to have students work at power circuits, electrical insulation of EV/HEV, at HV batteries or at e-vehicle charging or de-charging.

On the other hand, electrical simulation panels for specific didactic or training purposes can be used to manage control units in cars through a system of sensors and switches.

IO2 task: managing engine control in traditional ICE engine cars through electrical simulation panels

As an introductory activity to electrical circuits in cars, simulation panels will help students manage the central control unit equipped with sensors regulating different functionalities of the vehicle.

DESIGN FORM	
Task	***Management of control units in vehicles***
Learning Objectives	Correct interpretation of the normal operation of an automotive ICE engine

Entry Level Knowledge (Theoretical)	Basic knowledge of static and kinematic physics and of mechanical principles
Hard Skills involved	Knowledge of the components of an automotive engine
Soft Skills Involved	Autonomy, flexibility, adaptability
Activities and procedure required	Basic diagnostic activities
Equipment & Tools to be used	Electrical simulation panels
Other Professional Roles involved	EV responsible employee
Supervision & Tutoring Activities	Teacher of Mechanics
Expected Results / Solution	Correct interpretation of signals from the standard operation of an automotive ICE engine

Since no hands-on training about HV batteries or EV/HEV circuits is done at this level, theoretical knowledge about electrical powertrain, FMEA (failure modes and effects analysis) and onboard diagnostics can be introduced as an extension to the curricular program.

Additional lecture notes are available in the Training Documentation Folder of IG2 project digital archive.

The testing was performed according to the technical procedure portrayed by the following video available on the IG2 Official YouTube Channel @innovationgarageerasmuspro1264:

Topics:

1. Four-channel ABS system. ABS is a braking system. With two sensors we can simulate the whole braking system:

-controlling wheel speed and brake pressure

-operating the various hydraulic valves

-simulating a low battery charge

-simulating an ABS fluid leak

-performing an ABS auto-diagnosis

-measuring the brake fluid level

2. Classic four-stroke engine

The car is controlled by the electronic control unit that controls the fuel injector and injection time, as well as various sensors such as:

-air mass sensor;

-air temperature sensor;

-two lambda sensors, one upstream and one downstream, which monitor the temperature of the exhaust gases. When there is something wrong the control unit then adjusts all the other sensors to fix the whole process.

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

EVALUATION FORM	
VET Teachers & Trainers	
Learning Outcomes How to make the procedure easier How to make procedure harder	Achieved Increasing time for practical exercises to become familiar with the diagnostic tools /
Expected results	Achieved
Entry level knowledge and skills of the students What is missing	Adequate level to engage in the experimentation. Basic knowledge of mechanics
Equipment & Tools	Used properly
Supervision & Tutoring Potential Improvements	Effective Peer to peer didactic methods could be suggested. Reduce student number in groups
Business Technicians	
Extent of transferability of the developed skills to the job market	Complete

Suggestion for further development	A deeper knowledge of brand-specific diagnostic software
Further examples of topic-related troubleshooting problems	
EQF level 3	Charging/discharging HV system (theoretical knowledge)
EQF level 4	Checking HV battery leaks (theoretical knowledge)
EQF level 5	Checking HV battery control units inside HV battery (theoretical knowledge)

3. Collecting VET learners' feedback

As stated in the IO1 paper about designing a pilot Train-the-Trainers program about e-mobility, a relevant part of the program itself relies into collecting the learners' feedback about both their appreciation and their self-evaluation about the training experience.

Questions might vary according to the learning objectives of the experimentation and the EQF level of the VET provider, but on a general rule the following criteria should be met in order to administer feedback questionnaires to measure the impact of the training activities:

-forms should be collected anonymously to make sure respondents are free to express their sincere and honest feedback about the training program, either on a paper or digital format;

-questions might be multiple-choice or on a scale, but, in any case, some room for further comments or remarks should be left;

-the extent to which the training workplace helped students develop e-mobility skills should be assessed;

-the effectiveness of the mentoring or supervisory activities should be assessed;

-the extent to which prior knowledge and skills were allowed learners to make the most out of the training program should be assessed;

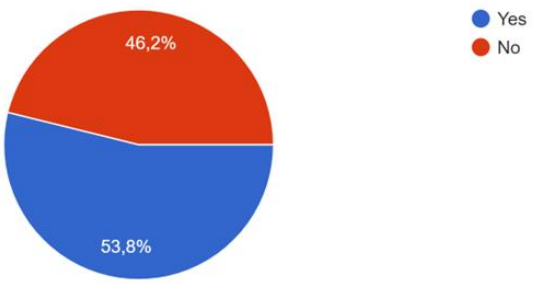
-the perception, on the learners' side, of actual development of e-mobility skills should be assessed;

-the extent to which learners think to be suitably prepared to transition to the job market.

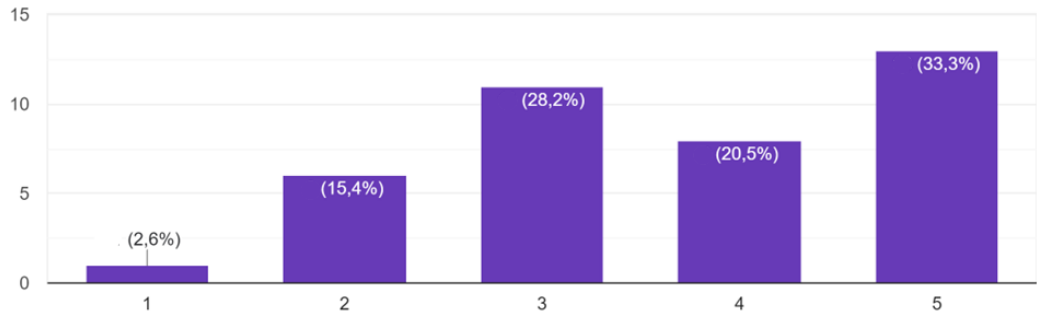
Examples of the collected feedback can be seen from the charts below, which report genderless aggregate data from all the countries and EQF levels involved.

Answers with scale from 1 to 5 mean that respondents were asked to rate the sentence in the questions with a score from 1 (absolutely not) to 5 (absolutely yes).

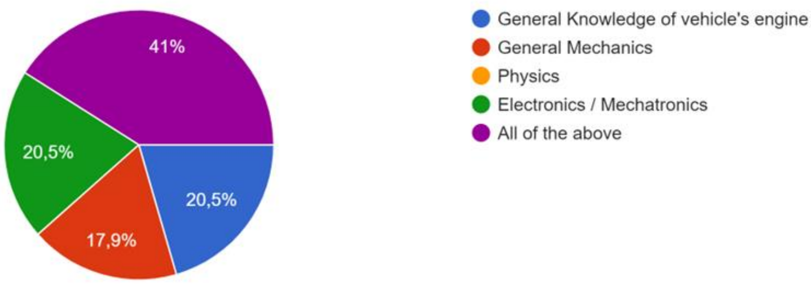
I already took classes in electro-mobility or HEV/BEV before participating in the project



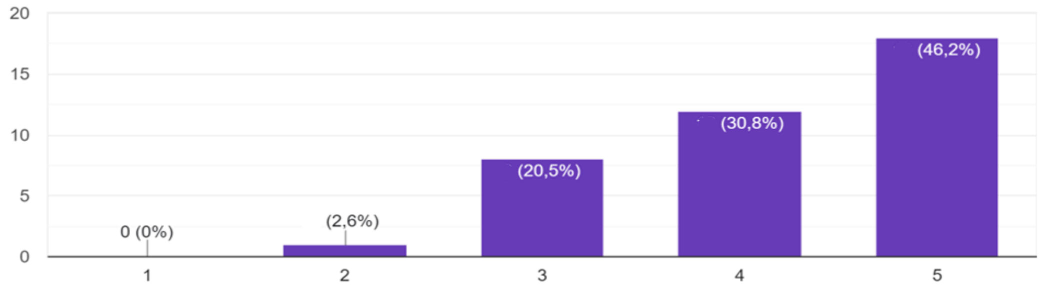
I think my previous knowledge & skills level was enough for me to take part in HEV/BEV testing



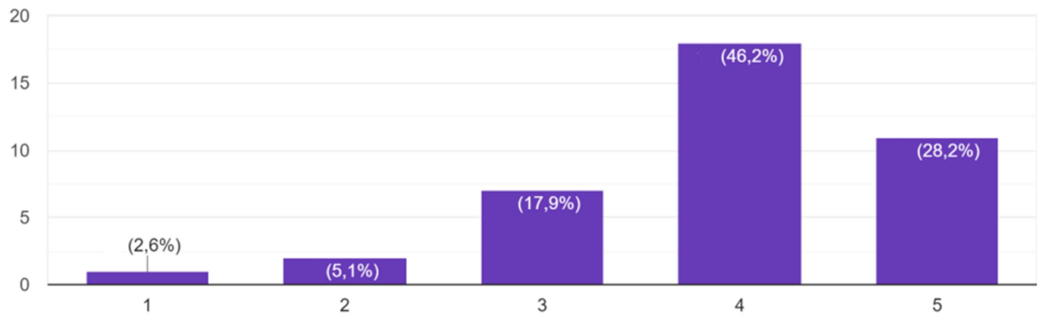
Which of the following was most helpful for you to make the most out of the HEV/BEV testing?



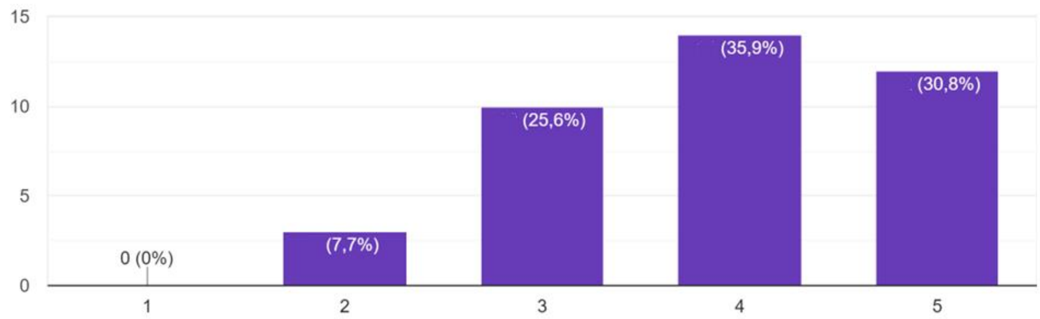
After the testing, I think I developed knowledge and skills about how a to work safely on an HEV/BEV vehicle



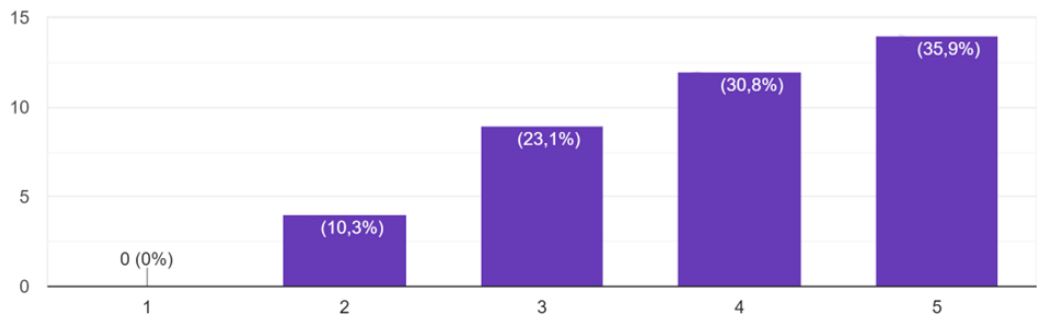
After the testing, I think I developed knowledge and skills about how to perform electrical insulation in a HEV/BEV vehicle



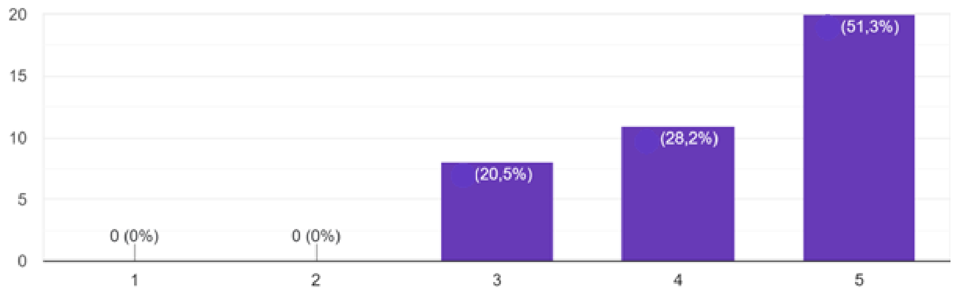
I think I am able to repeat by myself the procedures and work sequences I learned during the testing



I think I was properly trained and supervised during the testing



Thanks to the work-based learning or workplace testing, I think I am better prepared for the automotive job market



Conclusion: who is this paper for?

This paper represents the outcome of Intellectual Output 2 of “Innovation Garage of Garages” Erasmus+ project, aiming at developing green skills for the automotive sector at VET level.

The specific goal of such a paper is to provide guidelines for VET teachers and trainers willing to introduce hybrid or electric engines, high voltage and their components as a modular or integrated path within mechanics or automotive courses.

Multiple actors co-designing the training contents, the workplace layout and tools, as well as the organisational details of the didactic methodology (roles of trainers, facilitators, evaluation and assessment criteria, is the special footprint of the project. Since “Innovation Garage” is a worldwide methodology to introduce bottom-up multi-stakeholders innovation over the workplace premises, what this project is aiming at is renovating the way which “workshops” or “garage” training is usually performed.

So, this is just a proposal that needs to be customised with specific contents according to the target learners and the regular training courses within a VET organisation.

IO2 paper is suitable both for teachers and trainers at I-VET level (schools, training centres for young people or adults) from EQF levels 3-4, or even for H-VET at EQF 5 level (tertiary education other than university level). Nonetheless, e-mobility training can involve managers, technicians or trainers at company level - either at production houses, or repair workshops, or dealers, whenever workers need to develop or upgrade their skills about the management and maintenance of HV batteries, of HEV/EV vehicles and their components.