Scenario title

Teaching circular economy skills in the VET programmes related to welding.

Target audience

VET teachers working with the VET programmes of welding

Problem to solve - Learning Situation

The skills related to “circular” performance in the field of welding (economy of materials, consumables, reduction, collecting and recycling of rests, working with energy saving welding regimes, using of digital solutions in planning the cutting of parts from the metal sheets, etc.) very often are downplayed in the training curriculum. This scenario seeks to show how such skills can be better integrated in everyday training activities.

Overview of scenario

EQF levels 3 and 4

This scenario of VET teacher training deals with the problem of how to fill in the gaps of VET students abilities and skills to apply the principles of the ‘circular’ performance in welding operations (preparation of materials and parts, adjusting of the welding regimes, reduction of rests, consumables and exhausts) by applying different digital and ICT-based solutions.

Competencies covered from DigCompEdu

Innovating digital strategies for active learning.

Target level of Digital Skills according to DigCompEdu progression levels

01	**Professional Engagement**		
1.3	Reflective practice	To individually and collectively reflect on, critically assess and actively develop one's own digital pedagogical practice and that of one's educational community.	
	B2 Expert	Using a range of resources to develop one's individual digital and pedagogic practices.	*I actively seek out good practices for VET, courses or other advice to improve my own digital pedagogies and wider digital competences.*
			I evaluate and reflect on how to use digital technologies to improve my educational practice.

02	**Digital resources**

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	2.2 Creating and modifying digital resources	To modify and build on existing openly-licensed resources and other resources where this is permitted. To create or cocreate new digital educational resources. To consider the specific learning objective, context, pedagogical approach, and learner group, when designing digital resources and planning their use.	
	C1 Leader	Creating, co-creating and modifying resources according to the learning context, using a range of advanced strategies.	*I create and modify digital resources and activities adapted to the learning context and the group of trainees, using innovative strategies such as online assessment sheets, online surveys, thematic games, collaborative platforms.*
			I use tools like h5p, Padlet, Mentimeter, Kahoot, and others to create interactive activities for my graduates.

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03	**Teaching and Learning**		
	3.1 Teaching	To plan for and implement digital devices and resources in the teaching process, so as to enhance the effectiveness of teaching interventions. To appropriately manage and orchestrate digital teaching interventions. To experiment with and develop new formats and pedagogical methods for instruction.	
	B1 Integrator	Integrating available digital technologies meaningfully into the teaching process	*I can integrate the use of several different digital technologies and tools in the theoretical lesson and in supporting the independent learning of students.*
			I can integrate several different digital technologies and tools in practical training and work based-learning environments.

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	3.3 Collaborative Learning	To use digital technologies to foster and enhance learner collaboration. To enable learners to use digital technologies as part of collaborative assignments, as a means of enhancing communication, collaboration and collaborative knowledge creation.	
	B2 Expert	Using digital environments to support collaborative learning	*I can use online (Internet) learning environments to support collaborative learning of the VET students in the classrooms.*
			I can apply digital environments used for the collaboration and communication in the work processes for the purposes of collaborative learning.

05	**Empowering Learners**

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	5.3 Actively engaging learners	To use digital technologies to foster learners' active and creative engagement with a subject matter. To use digital technologies within pedagogic strategies that foster learners' transversal skills, deep thinking and creative expression. To open up learning to new, real-world contexts, which involve learners themselves in hands-on activities, scientific investigation or complex problem solving, or in other ways increase learners' active involvement in complex subject matters.	
	B2 Expert	Using digital technologies for learners' active engagement with the subject matter.	*I can explain and demonstrate to VET students and apprentices the advantages of using digital technologies for the active and effective acquisition of vocational knowledge, skills and transversal skills in the classrooms and practical training environments.*

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			I can initiate and implement the training projects which involve using of digital technologies for the active engagement of the VET students and apprentices in the acquisition of vocational knowledge, skills and competence.
	C2 Pioneer	Innovating digital strategies for active learning.	*I can design the new methodical-organizational approach of active learning for the VET students and apprentices based on the application of digital technologies.*
			I can develop new technological solutions of digital applications for the active learning for the VET students and apprentices.

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Curriculum Construct(s)

According to Revised Bloom's Taxonomy (Anderson and Krathwohl, 2001)

https://www.researchgate.net/publication/264675976_Transitioning_from_Teaching_Lean_Tools_To_Teaching_Lean_Transformation/figures?lo=1

Level	Description	Coverage
Creating	Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing	FL
Evaluating	Making judgments based on criteria and standards through checking and	FL
Analyzing	Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through	FL

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Applying	Carrying out or using a procedure through executing or implementing	LP
Understanding	Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining	LP
Remembering	Retrieving, recognizing, and recalling relevant knowledge from long-term memory	LP
LP = Learning Prerequisites, FL = Focus of the Learning Scenario		
Source: Anderson & Krathwohl (2001)		

Scenario description

VET teachers today deal withy important changes of curricula and training processes related to the provision of knowledge, skills and competencies needed for the “circular” handling of the work processes, in applying the principles of circular economy by saving materials and

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consumables, reducing the consumption of energy and resulting emissions, minimizing the volume of rests and their re-usage or recycling. These competencies include both theoretical knowledge and practical know-how, highly developed practical skills which ensure smooth and flawless production process (avoiding of non-conformities), good understanding of the circulation of materials and consumables in the work processes, as well as holistic view to the whole production process and profound understanding of the role and place of concrete workplace in this process. Besides, it requires active engagement and motivation of the operator to follow the 'circular' approach of working. Implementation of 'circular' approach to work in the field of welding is highly important, when considering the environmental impacts of metalworking and metal production industry (including the huge impact to the climate change), as well as fast depletion of the main raw materials used in this sector. The role of welder and welding operator in implementing and following 'circular' principles of work is significant, despite very intensive regulation, prescriptiveness and standardization of this occupational field. Including of circular economy related knowledge and skills in the training programmes of welding could be challenging for VET teachers because of the strict regulation and prescriptiveness of the technological processes of welding and strong attachment to the traditional work methods oriented to the maximization of the output and productivity, especially in the practical training. Digital solutions, especially digital simulations of the welding processes can be highly effective measures in such training.

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Scenario Objectives

This scenario seeks to develop the subject and methodological competences of vocational teachers needed to teach the “circular” performance knowledge and skills in the field of welding:

- explaining the principles of “circular” performance in the different work processes of welding;
- helping to notice and to understand the environmental and economic impact of the application of ‘circular’ principles in welding;
- preparing and implementation of digital teaching and training materials for the development of ‘circular’ performance skills and competencies in welding.

Requirements

Teaching/learning infrastructure and technology: equipped welding workshop / laboratory with welding equipment (TIG, MIG, MAG, etc.), metal sheet cutting equipment (CNC), computers, CAD-CAM or equivalent software, Internet.

Requirements from the learners (VET teachers) side: being aware of the key principles of circular economy and their application in the technological work processes; awareness of the environmental impacts of welding on the level of workplace, local and global ecosystems, awareness of the measures and instruments of environment protection, management of rest and waste applied in the welding processes by enterprises.

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Outline plan

Activity 1	Presentation and discussion of the 'circular' performance of the welding processes.
Timing	8 hours
Methods	Lecturing, presentations, questions-answers, execution of independent/group tasks.
What the tutor is doing	The tutor presents to teachers the training strategy on how to explain to the students the principles of circular performance in the work processes of welding: 1) preparation of the materials and parts (cutting and surface preparation), 2) executing of the welding joints; 3) quality control, 4) finishing of welds. The presentation is based on the demonstration of the videos of correct "circular" welding operations and explanation of the impacts of this performance. Then the tutor supervises how teachers prepare the practical training tasks for students which facilitate the development of the skills and competencies needed for the 'circular' performance in welding work processes.
What the learners are doing	The VET teachers prepare the training units/modules for the development of circular performance skills and competencies in welding with the help of the digital instruments and test these modules in their teaching practice. The training units should consist of the theoretical part, where students are interactively introduced the principles of circular

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	performance in welding and the practical part for training and demonstration of the relevant practical skills by using digitalized / numerically operated technological solutions. Special attention is paid to the development of competencies needed for the reading of drawings and schemes and prevention of the non-conformities and faults. This training activity also involves reflection of students on the application of circular performance principles in executing the welding tasks and its environmental, ergonomic and economic impacts.
Equipment and Support	Welding laboratory / workshop equipped with computers, CAD-CAM or equivalent software, welding drawings and schemes.
Reference to DigCompEdu	01 Professional Engagement - 1.3 Reflective practice 02 Digital resources - 2.2 Creating and modifying digital resources 03 Teaching and Learning - 3.1 Teaching 03 Teaching and Learning - 3.3 Collaborative Learning 05 Empowering Learners - 5.3 Actively engaging learners
Assessment of/for learning	Tutors observe the teaching process and communication between the VET teachers and students and provide the feedback to teachers and trainers.
Resources/links/relevant content/Examples	Digital/online learning resources in the field of welding (videos, tutorials).

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Activity 2	Presentation and discussion of the work processes and operations of welding by explaining their environmental impacts and the potential of the application of circular performance principles. Use of video materials, digital models and schemes. Can be performed online.
Timing	3 hours
Methods	Demonstration, presentation, lecture, discussion.
What the tutor is doing	Discusses with the VET teacher the execution of training activity and observes the process of training.
What the learners are doing	The VET teacher prepares the video/online materials for presentation of the welding processes, as well as tasks for students (tests, open tasks of discussion). The students independently (with the teacher's help/advice if necessary) suggest ways of implementing circular performance principles in welding work processes and operations.
Equipment and Support	Classroom equipped with computers, CAD-CAM or equivalent software.
Reference to DigCompEdu	02 Digital resources - 2.2 Creating and modifying digital resources 03 Teaching and Learning - 3.1 Teaching

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	03 Teaching and Learning - 3.1 Collaborative Learning
Assessment of/for learning	Methods used to assess learning outcomes: - Theoretical testing of knowledge (tests with multiple choice answers, etc.) - Practical test of knowledge. Computer aided design of the drawing provided and printing of the model.
Resources/links/relevant content/Examples	Materials of the Erasmus+ project CEMIVET: Circular Economy in Metal Industries VET (to be provided)

Activity 3	Executing the practical tasks of welding by applying identified principles of circular performance and using digitalized technological solutions.
Timing	4 hours
Methods	Demonstration, independent execution of tasks
What the tutor is doing	Prepares and discusses with VET teachers the plan of a practical training module /unit focused on the circular performance in welding by using digitalized solutions (welding simulators, numerical control applications for cutting of metal sheets, software for programming automated welding operations etc.).
What the learners are doing	The VET teacher explains and demonstrates to students how to apply the digitalized technological solutions in welding for the

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	optimization of the welding operations in terms of saving of materials and welding consumables (including materials and consumables for surface preparation and finishing of welds, energy consumption), reducing rests, tracing, collecting, sorting, reusing or recycling of rests. VET students perform the welding operations by applying circular performance principles and using digital technological solutions in this process.
Equipment and Support	A welding workshop/ laboratory equipped with welding machines (semi-automatic, automatic) computers, CAD-CAM or equivalent software.
Reference to DigCompEdu	02 Digital resources - 2.2 Creating and modifying digital resources 03 Teaching and Learning - 3.1 Teaching 03 Teaching and Learning - 3.1 Collaborative Learning
Assessment of/for learning	Methods used to assess learning outcomes: - Cumulative. Cumulative grading is a convenient way to motivate students by monitoring and recording their motivation, initiative and progress, as well as their independent learning. Cumulative assessment is used throughout the process. - Formal assessment can be used to assess the results achieved. Formal assessment is used at the end of each of the following two stages (one mark for the first two activities and a second mark for the third activity): a mark for performing the

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	digitalized work process / operation of welding by following circular performance principles, a mark for reflection on the environmental/economic impact of such performance and possibilities of its scaling-up.
Resources/links/relevant content/Examples	Materials of the Erasmus+ project CEMIVET: Circular Economy in Metal Industries VET (to be provided)

Our notes from practice

The learning scenario could focus on the development of the following competencies identified in the Erasmus+ project CEMIVET: Circular Economy in Metal Industries VET:

1. **Competence area:** Following the design and maintenance of sustainable work process and products.

Competence development steps	**Qualifications**
1.1. To read the drawings and understand the symbols and technological information in order to avoid mistakes and non-conformities.	Welders and welding operators (EQF

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1.2. To clarify the technological requirements and possible practices of sustainable technological work regimes (using of materials, applying welding regimes, preparation of materials) with designers and engineers. To discuss possible, from the welder's and his shop's point of view, sustainable resource use practices by arguing one's proposals properly.	3-4)
1.3. To apply the instructions and suggestions of sustainable usage of materials and consumables in the welding practice.	

2. **Competence area:** Sustainable and circular preparation, maintenance and design of the workplaces in welding

Competence development steps	**Qualifications**

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2.1. To keep the workplace tidy (e.g. putting scrap metal in the designated place).	Welders and welding operators (EQF 2 - 4)
2.2. To verify the parameters of the dust extraction system (the condition of the welding station) and the performance of the welding source (and its changes) by following internal regulations and rules of the enterprise, using control sheets of filtering systems.	Welders and welding operators (EQF 3 - 4)
2.3. To sort and dispose of the waste at the workplace according to defined waste management procedures and systems (ISO etc.), internal rules of waste management, environmental guides.	
2.4. To evaluate each waste produced at the workplace and its suitability for further use.	
2.5. To execute and ensure the traceability of the used materials in ensuring economic usage of the main materials (metal sheets) by moving the remaining materials to the warehouse and using them in further production (when it is a part of work delegated to the welder/welding operator).	

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2.6. To evaluate the welding position and to apply the possible countermeasures, evaluating the risk of failures or poor welding regimes.	

3. **Competence area:** Sustainable and circular execution of the technological operations in the field of welding.

Competence development steps	**Qualifications**
3.1. To develop practical skills of welding by using a simulator before executing the real operations, practicing; to use test equipment of the alternative methods, e.g. safety-relevant bolting, tightening torques and bolted connections by hand.	Welders, welding operators (EQF 3-4)
3.2. To execute quality control of the materials and executed welds: reading and checking the markings of the material to be welded and welding consumables, visual control of the metal sheets and workpieces before the welding in order to spot and remove dirt, slags, rust and other deficiencies potentially having harmful effect on quality and volume of used materials; to execute the self-inspection of weld by using inspection gauges, as prevention of non-conformities.	

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3.3. To apply savy procedures of the preparation of raw materials for welding permitting to save on the surface treatment operations after welding (metal and sand blasting); to follow the technological requirements and guidelines for selecting and fine-tuning of the composition of welding consumables : shielding gases, welding wire, electrodes etc.; to execute the preparation of the surface and edges of the workpieces and sheets before welding by using cutters, grinding plates instead of abrasive materials (where possible); to execute the edge preparation in the ways which help to optimize the volume and intensiveness of the welding /joining and to minimize the zones of weld area.	
3.4. To strictly follow quality management procedures, requirements of the WPS and welding instructions; visually assess the quality of weld; to evaluate the effect of changing welding parameters on the quality of weld.	
3.5. To ensure proper quality of cleaning of surface after welding (remaining slags before pickling requires additional pickling operations with negative environmental implications); to follow strictly the requirements of the need of the volume of paint and other surface surface treatment materials by referring to the corrosiveness of the environment of product usage.	

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3.6. To apply a higher pace in executing welding operations in seeking to use fewer materials and save emissions (only for highly experienced welders, not compromising the quality).	Welders, welding operators (EQF 4)
3.7. To apply possible changes in the welding process parameters to optimize the welding process; to apply technological solutions of welding regimes that allow for the reduction of subsequent work expenditure on cleaning the connection; while executing welds to keep within the limits of thermal impact defined in the welding procedure; to execute welds in applying savy regimes, such as pulse regime helping to control the thermal input and to regulate the volume of energy, using of synergetic regimes of welding which help to control and optimise the energy consumption; to apply submerged-arc welding or combination of welding regimes with submerged arc welding for the welding of high thickness metal sheets, what permits to reduce the number of welding passes; to apply contact welding (point welding) instead of full joint welding, where possible; to use the CNC machines (plasma cutters, lasers) in seeking to limit the harmful impact of welding processes on the operation of other stations (machining in a closed machine space).	Welders, welding operators (EQF 4)

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4. **Competence area:** Sustainable and circular digitalization of the work processes in the field of welding.

Competence development steps	**Qualifications**
To apply the automated welding processes (welding robots, CNC laser cutters used in repeatable processes leading to the reduction of defects).	Welders, welding operators (EQF 4)

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