Reverse Engineering

Target audience

The scenario is intended for technical teachers working in product design and engineering processes.

Vocational Education and Training at EQF 5 is gaining special attention across Europe and beyond, thanks to its relevance for the labour market and consequent high rates of employability. A concrete example of qualification where to apply this learning scenario is Technician for innovation of metal production processes and products, and in general terms, those professional profiles related to Industry 4.0.

Specialised technicians undertaking this learning path combine highly specialised digital skills with strong metal sector expertise.

Problem to solve - Learning Situation

3D Scanner and Reverse Engineering workflow

The activity plan is articulated around the reverse engineering workflow, which includes scanning objects, technical drawing, properties analysis, metal production.

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During the learning phases, we offer to trainers several insights and concrete proposals to co-develop their own digital skills as well as build foundations of key digital skills among learners.

Overview of scenario

EQF 5 Machining and Metalworking

In this learning scenario we propose a set of interrelated activities aimed at, from one side, developing advanced technical and professional competencies, namely applied reverse engineering for machining and metalworking, and from another side, based on DigCompEdu, fostering key digital skills, among trainers and learners.

IDC Self-Assessment Tool

As a trainer who wishes to develop digital skills for education, we invite you, before integrating this learning scenario in your own teaching practices, to undertake the IDC-VET Self-Assessment tool, which may help you to map your own strengths and weaknesses.

Our ambition is that, once implemented this learning scenario and re-assessed your digital skills with our self-assessment tool, you will be able to observe improvements on the following DigCompEdu dimensions and competencies.

Competencies covered from DigCompEdu

Target level of Digital Skills according to DigCompEdu progression levels

Professional engagement,

1.1 Organisational communication, B1

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To use digital technologies to engage in collaboration with other educators, sharing and exchanging knowledge and experience, and collaboratively innovating pedagogic practices.

- *I use different digital communication channels and tools depending on the content (formative or informative) and the context of usage, for communication with students, colleagues in my institution, companies, and also to the school staff.*

1.3 reflective practice, B1

To individually and collectively reflect on, critically assess and actively develop one's own digital pedagogical practice and that of one's educational community.

- *I experiment with new pedagogical approaches, enabled by digital technologies.*

Digital resources,

2.2 creating & modifying, B2

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.

- *When I adapt digital resources, I integrate in practical exercises, such simulations, case studies from companies and examples from work-based environments, according to the level and learning outcomes of VET learners.*

2.3 managing protecting and sharing - B1

To organise digital content and make it available to learners, parents and other educators. To effectively protect sensitive digital content. To respect and correctly apply privacy and copyright

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rules. To understand the use and creation of open licenses and open educational resources, including their proper attribution.

- *I share technical educational content in collaborative and virtual learning environments such as blogs, slideshare, through the online platform to VET.*

Teaching and learning,

3.3 collaborative learning - B2

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.

- *I can use online (Internet) learning environments to support collaborative learning of the VET students in the classrooms.*

Assessment,

4.2 analysing evidence, - B1

To generate, select, critically analyse and interpret digital evidence on learner activity, performance and progress, in order to inform teaching and learning.

- *I'm using data from different digital sources in order to monitor progress and provide feedback and assistance to my VET learners*

4.3 feedback & planning - A2

To use digital technologies to provide targeted and timely feedback to learners. To adapt teaching strategies and to provide targeted support, based on the evidence generated by the

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digital technologies used. To enable learners and parents to understand the evidence provided by digital technologies and use it for decision-making.

- *I know how to provide detailed feedback to my VET students by using digital tools*

Empowering learners,

5.3 actively engaging learners - B1

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.

- *I can provide the guidance and support for the VET students and apprentices in fostering their active use of digital technologies in the classrooms and practical training environments.*

Facilitating learners' digital competencies,

6.3 content creation - B1

To incorporate learning activities, assignments and assessments which require learners to express themselves through digital means, and to modify and create digital content in different formats. To teach learners how copyright and licenses apply to digital content, how to reference sources and attribute licenses.

- *I implement learning activities in which learners use digital technologies to produce digital content, e.g. in the form of text, photos, other images, videos, etc.*

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Curriculum Construct(s)

In the conception of the learning scenario, we adopt a revised Bloom's Taxonomy (Anderson and Krathwohl, 2001), which offers a simplified structure articulated in 5 areas:

- Remembering: Retrieving, recognizing, and recalling relevant knowledge acquired in the theoretical part of class about the reverse engineering process.

- Understanding: Understanding what are the key steps in the reverse engineering process to achieve results that meet the required specifications.

- Applying: Correctly apply procedures at different levels

- Analyzing: Analyzing step by step the results and obstacles encountered at different stages of the process to identify improvements and optimize the procedure

- Evaluating: Through peer review make critical judgments on the work done by peers in order to consolidate competence on the reverse engineering process

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Scenario description

Reverse engineering in the metal and mechanical sector is used to ascertain design features of products, without specific information on the related production procedures and processes. There are many reasons why reverse engineering has recently gained attention across various sectors, these include understanding technical characteristics of competitor's products, product security analysis and maintenance, as well as product re-design.

The specific added value of this scenario consists in providing concrete and actionable examples to support teachers and trainers in the integration and deployment of digital skills while working on the implementation phases of reverse engineering in the metal and mechanical sector.

Scenario

Objectives

The aim of this learning scenario is to adopt a structured and effective approach on your teaching strategies related to reverse engineering in VET at EQF 5.

More specifically, we have identified the following steps or phases, described in detail in the following section with specific references to DigCompEdu activities and skills:

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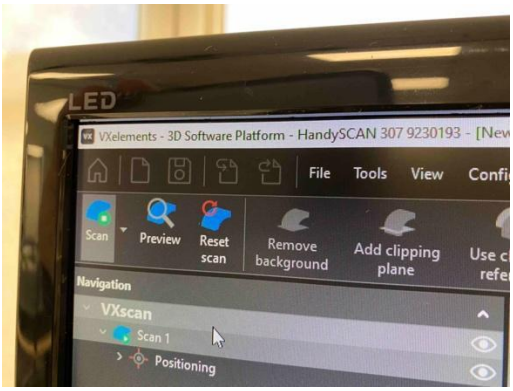
- 3D Scanning
- 3D Modelling
- CAD Technical Drawing
- Analysis & Improvement
- Prototyping
- Production



Requirements

When approaching this learning scenario, it is essential to consider pre-requirements both from the trainers' side, in terms of digital skills, as well as from learners' side, in terms of engineering background knowledge and skills, relevant for VET participants at EQF level 5.

As for the trainers' pre-requirements, we suggest implementing the activities suggested in this learning scenario for those who have already mastered basic digital skills in the DigCompEdu as referenced above.

It is therefore essential to undertake, beforehand, the IDC-VET self-assessment tool, to ensure consistency with this requirement.

Equipment and Support

Reverse engineering is a demanding skill and complex and expensive technologies are involved in the implementation of all processes.

The main technologies required across the multiple phases described above are:

- LMS
- 3D scanner
- 3D modelling software
- CAE and FEM software

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- 3D printer

Outline plan

Activity	3D Scanning
Timing	1 hour
Methods	Peer-learning is adopted by dividing participants in small groups (max 3 learners per group). Each group in this phase receives instructions in order to undertake all subsequent phases of the learning scenario. In this phase the teaching staff configures the learning environment and tools required by the activity and introduces the learning path and activities to the learners
What the tutor is doing	Tutor introduces the overall process and workflow and highlights key evaluation criteria for this phase, based on the activities assigned to each group. Configure LMS for the whole learning scenario: ● Create learners' accounts and groups on LMS ● Create assignments ● Create repository folders ● Create advanced evaluation methods (Rubric) ● Show to learners how to enter the LMS, how to complete assignments, how to upload files
What the learners are doing	Learners in group perform the following activities: ● Generation of digital file via 3D Scanner ● Check correctness and data consistency of file ● File upload on LMS / repository ● Document with short video each of the above activities
Required Resources	Tools and technologies include:

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	• 3D scanner and related software • Computer, mobile device, and internet connection. • LMS
Reference to DigCompEdu	1.3 reflective practice, B1 2.2 creating & modifying, B2 3.3 collaborative learning - B2 5.3 actively engaging learners - B1 6.3 content creation - B1

Activity	3D Modelling
Timing	4 hours
Methods	Individual assignment Each learner is tasked to develop a 3D model
What the tutor is doing	Tutor introduces the evaluation criteria for this phase, based on the activities assigned to each learner. Tutor explains: • Technical requirements of 3D model, by showing an example of 3D model • Evaluation criteria and procedure, by showing grid analysis and sharing a checklist to be used by each learner to evaluate own activity • How to upload 3D model files on LMS
What the learners are doing	Learners individually perform the following activities: • Generate 3D model • Elaborate files with CAD technical drawing • Check correctness and data consistency of file • Fill in checklist provided by tutor • Upload file on LMS / repository • Document with short video each of the above activities • Upload all significant files and resources on the LMS
Required Resources	Tools and technologies include: • 3D model software • Computer, mobile device, and internet connection • LMS

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Reference to DigCompEdu	1.3 reflective practice, B1 2.2 creating & modifying, B2 2.3 managing protecting and sharing - B1 3.3 collaborative learning - B2 4.2 analysing evidence, - B1 4.3 feedback & planning - A2 5.3 actively engaging learners - B1 6.3 content creation - B1

Activity	Analysis & Improvement
Timing	4 hours
Methods	Group assignment Each group is tasked to adopt a structured approach to analyse 3D model and identify areas of improvement, which may include, where applicable, CAE (computer aided engineering, simulation, validation, and optimisation of products and manufacturing tools), FEM (finite element method, for structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential). Multiple dimensions of analysis and improvement may refer to and include the following: ● Design ● Materials ● Safety ● Robustness and solidity
What the tutor is doing	Tutor introduces the evaluation criteria for this phase, based on the activities assigned to each group. Tutor implements the following activities: ● Explains project development techniques, including CAE, FEM, etc. ● Introduces processes to implement technical improvements of the 3D models ● Shares a checklist to be used by each group to do peer-review of another group ● Comment and feedback deliverables by groups

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What the learners are doing	Learners in groups perform the following activities: ● Project analysis and improvements ● Check correctness and data consistency of files ● Upload file on LMS / repository ● Fill in peer-review of other groups ● Document with short video each of the above activities
Required Resources	Tools and technologies include: ● CAE and FEM software where applicable ● Computer, mobile device, and internet connection ● LMS
Reference to DigCompEdu	1.1 Organisational communication, B1 1.3 reflective practice, B1 2.2 creating & modifying, B2 2.3 managing protecting and sharing - B1 3.3 collaborative learning - B2 4.3 feedback & planning - A2 5.3 actively engaging learners - B1 6.3 content creation - B1

Activity	Prototyping
Timing	6 hours
Methods	Group assignment Each group is tasked to produce the prototype of own 3D models via 3D printer. Learners develop the ability to perform 3D prototyping, understanding how iteration of design and manufacturing physical prototypes may be adopted to improve products.
What the tutor is doing	Tutor introduces the evaluation criteria for this phase, based on the activities assigned to each group. Tutor implements the following activities: ● Explains 3D printing and 3D prototyping ● Introduces processes to implement technical

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	improvements of the 3D prototyping • Comment and feedback deliverables by groups
What the learners are doing	Learners in groups perform the following activities: • Produce 3D prototypes • Analyse correctness and consistency of prototypes • Document with short video each of the above activities
Required Resources	Tools and technologies include: • 3D printer • Computer, mobile device, and internet connection • LMS
Reference to DigCompEdu	1.1 Organisational communication, B1 1.3 reflective practice, B1 2.2 creating & modifying, B2 3.3 collaborative learning - B2 4.2 analysing evidence, - B1 4.3 feedback & planning - A2 5.3 actively engaging learners - B1 6.3 content creation - B1

Assessment of/for learning

As outlined above, assessment is implemented at each phase above via different methods and approaches aimed at ensuring both validation of competencies, exploitation of digital tools and skills, engagement of learners and peer-learning.

Tutors are accompanied to exploit digital skills to implement assessment of learning via several methods and tools, including:

- Evidenced-based evaluation
- Peer-review
- Checklist

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- Advanced evaluation method (Rubric)

Our notes from practice

This learning scenario is proven to be very attractive to learners as it proposes multiple hands-on activities which are interconnected. We propose to alternate both groups as well as individual assignments and tasks to improve engagement and retention among learners, as well as to co-develop multiple skills, including the ability to work in teams.

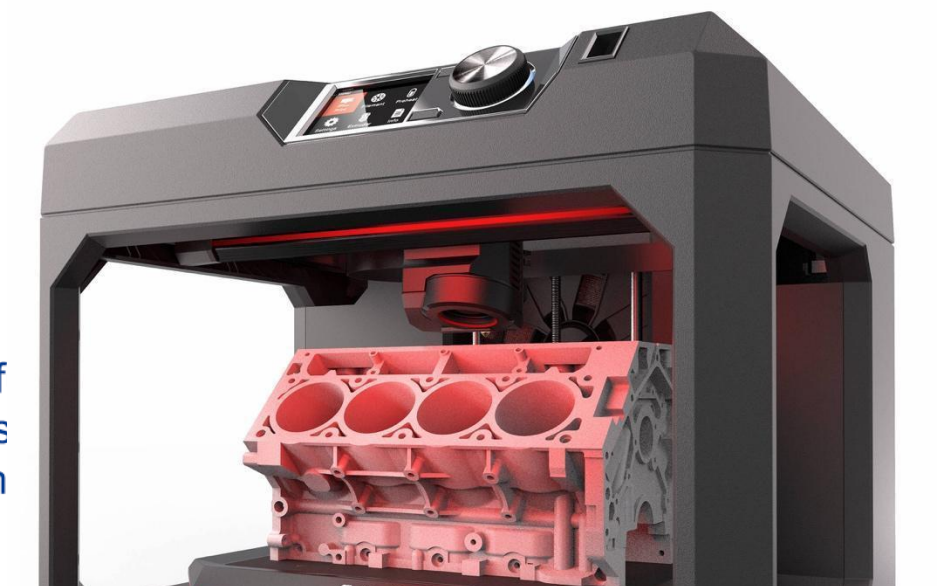
The learning scenario is problem-based and should be focused on identifying and solving technical issues related to concrete products or goods which may appeal to participants.

The key dimension here is how a tutor may blend their own digital skills into their own teaching and assessment strategies.

Resources and more info

Info specific to this learning scenario can be found on the web, via the following links:

- Reverse Engineering explained https://youtu.be/1r8F-BQOy3w
- 3D scanning process https://youtu.be/Y1kKt4WvPbw
- CAD/CAE/CAM Tutorial https://www.youtube.com/user/taufik2000itb



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