

CNC Milling Machine

Target audience

The mechanical engineering sector requires strong specialist skills spread over at least three EQF levels: 3, 4, 5.

The scenario is addressed to participants involved in training activities at level 3 and 4, both in VET and technical schools.



Problem to solve - Learning Situation

Produce mechanical parts from 2D drawing

The activity plan is articulated around the CNC workflow, which includes 2D drawing conversion to 3D model, 3D model importing to CAM software, define the working strategies by the CAM software, post process the CNC program file, prepare the milling machine to start working, execute and monitoring the CNC job.

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 3-4 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.

The differences in the scenario between the 3rd and 4th eqf levels are only based on the characteristics of the technical workflow: the activities proposed for the 3rd eqf level are more practical while those proposed for the 4th level give more space to planning and analysis; but there are no differences from the point of view of the digital competences that will be developed.

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

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 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 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.*



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 production of mechanical parts from 2D drawing by using CNC milling machines.
- Understanding: Understanding what are the key steps in the CAD - CAM 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 production of mechanical parts by using CNC milling machines.

Scenario description

One of the main activities of the mechanical engineering industry is to produce mechanical parts from drawings made by designers. Over time, the quality of these parts has increased,



both in terms of the materials used and in terms of dimensional accuracy, and the drive to reduce costs has created great pressure to reduce machining times and reduce scrap.

This requires a great deal of technological know-how on the part of the technicians in charge of operating the CNC machines.

In addition to technological skills, transversal skills have grown, such as problem solving and creativity, which enable original solutions to production problems and provide a competitive advantage over competitors.

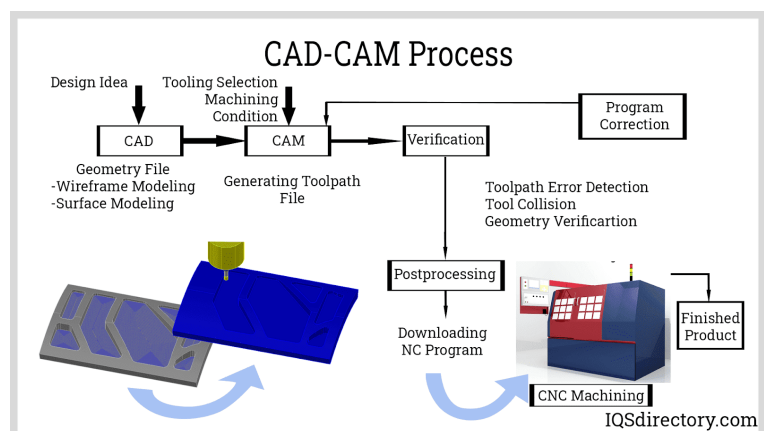
The specific added value of this scenario consists in providing concrete and actionable examples to support teachers and trainers in the integration and deployment of digital skills while working on the implementation phases of reverse engineering in the metal and mechanical sector.

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 3 and 4.

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:

- 2D digital drawing analysis
- 3D model realisation
- Processing the model with technological features



- Definition of machining strategy
- Construction of the toolpath
- Production of program file
- Program simulation and validation
- Machine set-up
- Execution of machining program
- Process control
- Final inspection and process validation

Requirements

In order to realise this scenario, it is necessary that students are already prepared from a theoretical point of view, and that they possess adequate digital skills. In this way, specialist skills can be integrated into the overall process and transversal skills can be developed, thanks to a problem-based approach, collaborative work and feedback from teachers and peer groups.

Students involved should be able to:

- use 3D modeling techniques
- use CAM software
- create the work cycle for making a mechanical part
- use a CNC machine

The mechanical part to be produced should not be too complex, so that the pedagogical focus does not shift from digital and transversal skills to technical ones.

As for the trainers' pre-requirements, we suggest to implement the activities suggested in this learning scenarios to those who already master 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

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

Main technologies required across the multiple phases described above are:

- LMS
- 3D model software
- CAM software
- CNC machine
- Set of machining tools
- Set of measuring instruments

Outline plan

Activity	2D digital drawing analysis and 3D modelling
Timing	2 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	<p>Tutor introduces the overall process and workflow and highlights key evaluation criteria for this phase, based on the activities assigned to each group.</p> <p>Configure LMS for the whole learning scenario:</p> <ul style="list-style-type: none"> • 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	<p>Learners in group perform the following activities:</p> <ul style="list-style-type: none"> • Open the 2D CAD file • Analyse the shape and dimension of the mechanical part • Convert 2D drawing into 3D model • Validate the correctness of the model
Required Resources	<p>Tools and technologies include:</p> <ul style="list-style-type: none"> • CAD 2D/3D software • Computer, mobile device, and internet connection. • LMS
Reference to DigCompEdu	<p>1.1 Organisational communication, B1 1.3 reflective practice, B1 3.3 collaborative learning - B2 4.2 analysing evidence, - B1 4.3 feedback & planning - A2 5.3 actively engaging learners - B1</p>

Activity	CAM processing
Timing	3 hours
Methods	<p>Individual assignment</p> <p>Each learner is tasked to process the 3D model in the CAM software</p>
What the tutor is doing	Tutor introduces the evaluation criteria for this phase, based

	<p>on the activities assigned to each learner. Tutor explains:</p> <ul style="list-style-type: none"> • Technical requirements of the CAM processing and output to produce • Evaluation criteria and procedure, by showing grid analysis and sharing a checklist to be used by each learner to evaluate own activity • Technical data to upload on the LMS
What the learners are doing	<p>Learners individually perform the following activities:</p> <ul style="list-style-type: none"> • Import 3D model in the CAM software • Create the technological features to associate to the model • Define working strategy and toolpath • Identify the tools required • Set working parameters • Post process the program file for the specific CNC machine • Upload the program file and all significant files and resources on the LMS
Required Resources	<p>Tools and technologies include:</p> <ul style="list-style-type: none"> • CAM software • Machine post processor • Set of machining tool data sheets • LMS
Reference to DigCompEdu	<p>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</p>

Activity	Manufacturing execution
Timing	3 hours

<p>Methods</p>	<p>Group assignment</p> <p>Each group is tasked to select the best program produced in the previous step.</p> <p>The program file produced individually in the previous phase is examined and evaluated by the working group, through tool path simulation and performance measurement.</p> <p>The best programme is adopted by the group for execution and is further subjected to an improvement session.</p> <p>After the final modifications and additions, the team validates the final program to be executed and loads it into the machine.</p> <p>The aim of this phase is to optimise the machining programme as much as possible, highlighting the impact of the technological choices made on product quality and process efficiency.</p> <p>.</p> <p>Multiple dimensions of analysis and improvement may refer to and include the following:</p> <ul style="list-style-type: none"> ● Working time ● Tools adopted ● Material consumption ● Maintaining quality standards
<p>What the tutor is doing</p>	<p>Tutor introduces the evaluation criteria for this phase, based on the activities assigned to each group.</p> <p>Tutor implements the following activities:</p> <ul style="list-style-type: none"> ● Introduces processes to implement technical improvements of the program file ● Illustrates the key points that need to be addressed to generate a good CNC programme, by showcasing examples from CAM software. ● Presents the group working methods to be followed.
<p>What the learners are doing</p>	<p>Learners in groups perform the following activities:</p> <ul style="list-style-type: none"> ● Analyse individual results ● They choose the best of the individual works, giving reasons for their choice. ● Apply further improvements to optimise the result ● Simulate processing and validate the programme ● Set up the machine for machining according to the chosen program ● They carry out the machining to obtain the finished

	part
Required Resources	<p>Tools and technologies include:</p> <ul style="list-style-type: none"> ● CAM software ● Machine post processor ● Set of machining tool ● Set of measuring instruments ● CNC Machine ● LMS
Reference to DigCompEdu	<p>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</p>

Activity	Analizing & improvement
Timing	2 hours
Methods	<p>Group assignment Each team is responsible for testing the part produced and certifying its conformity. The group then analyses all production data relating to the process to identify any opportunities for improvement. Finally, the process is validated for series production.</p>
What the tutor is doing	<p>Tutor introduces the evaluation criteria for this phase, based on the activities assigned to each group. Tutor implements the following activities:</p> <ul style="list-style-type: none"> ● Explains the testing procedure ● Explain which elements to include in the final validation report ● Comment and feedback deliverables by groups
What the learners are doing	Learners in groups perform the following activities:

	<ul style="list-style-type: none"> • Carry out the test procedure and record the data collected • They write the final report indicating the reasons for the validation of the production process. • Document with short video each of the above activities
Required Resources	<p>Tools and technologies include:</p> <ul style="list-style-type: none"> • Set of measuring instruments or 3D testing machine • Computer, mobile device, and internet connection • LMS
Reference to DigCompEdu	<p>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 4.2 analysing evidence, - B1 4.3 feedback & planning - A2 5.3 actively engaging learners - B1 6.3 content creation - B1</p>

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
- Advanced evaluation method (Rubric)

Our notes from practice

This learning scenario is proven to be very attractive to learners as it propose multiple hands-on activities which are interconnected. We propose to alternate both group as well as individual assignments and tasks as 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 the tutor may blend own digital skills into 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:

- CNC Workflow <https://www.youtube.com/watch?v=t7FMDJciA5U>
- 5 AXIS metalworking process <https://www.youtube.com/watch?v=YhefBROYIAo>

