3D Printing in VET

2019-1-EL01-KA202-062909

IO3

Curriculum on 3D Printing

Partners contribution:

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Contents

Introduction

Even though 3D printers have been around for almost 30 years, the recent rise of low-cost printers has led some to proclaim the onset of a new industrial revolution. Schools and libraries all over the world are bringing these powerful tools to students in classrooms and dedicated "makerspaces" where they are accompanied by other fabrication tools. For example, China is putting 3D printers in each of its 400,000 elementary schools. In the U.S., are adding 3D printers into schools at a good rate, particularly into CAD programs, but also into traditional art and social studies classrooms and even business programs.

If 3D printing is starting a new industrial revolution, it is well on its way to revolutionizing teaching and learning as well. The result of bringing these tools into classrooms is a rekindling of the powerful pedagogy of hands-on learning. 3D printing leverages hands-on learning to deepen our educational approach to traditional educational subjects. With 3D printers, teachers can literally add another dimension to their classroom practice; can use 3D printed objects to illustrate complex concepts, make abstract and inaccessible objects tangible, improve students' spatial abilities and create a richer, more engaging learning environment.

The overarching goal of the 3DP-VET course is to design a highly innovative, internationally competitive training programme on 3D printing use for teachers and trainers in VET. With this in mind, the 3DP-VET course (3D Printing in Vocational Education and Training) seeks to introduce VET teachers/ educators to the use of 3D Printers in Vocational Education and Training in Europe.

The course is the product of a two-year EU-funded international project (KA2 Erasmus+ project #2019-1-EL01-KA202-062909) with the following partners:

1. Coordinator: **KEKAPER – Department for Lifelong Learning, Education, Employment Vocational Training Centre, Regional Unit of Rethymnon, Region of Crete,** Greece

2. **EELI - European Education and Learning Institute**, Greece
3. **CEIPES – International Centre for the Promotion of Education and Development**, Italy
4. **KIT - Karlsruher Institut fuer Technologie**, Germany
5. **ETIC – School of Technologies, Innovation and Creation**, Portugal
6. **UNINETTUNO - International Telematic University**, Italy
7. **WSEI - University of Economics and Innovation in Lublin**, Poland
8. **Inercia Digital**, Spain

The 3DP-VET curriculum is a detailed plan of the course with a clear definition of learning outcomes and sequence of activities designed to help the participants attain them. The methodology of working out the programme is based on the following principles:

- The curriculum addresses concrete identified needs of VET teachers,
- The programme of learning covers the aspects of 3D Printing which can be easily applied in educational practice,
- The curriculum is open to further input/modifications in the course of the training materials development and its pilot implementation in the 3DP – VET course for VET teachers.

Against this backdrop, the course is divided into six distinct Modules, which could also be studied independently. A certificate is issued only upon completion of all six Modules, including the respective assessments. The duration of study of each Module is approximately 4 - 6 hours. The structure of the course is as follows:

Module 1: Technical Basic/Entering Module *Optional

A. Computer hardware
B. Software
C. Networking Fundamentals

Module 2: Introduction to 3D Printing:

A. History of 3D printing

B. 3D Printing possible applications

Module 3: 3D Printing in education:

A. Potential uses of 3D printing in education (engineering design, architecture, history, graphic design, geography, chemistry, biology, etc.)
B. Examples and best practices
C. Online and Physical Resources for Educators
D. 3D Printing in Education - How to choose the right 3D printer for educational purpose

Module 4: Design and/ or print 3D objects:

For beginner's:

a) Introduction
b) Where can I download 3D Printable files?
c) What software to use?
d) How to print the object?

For advanced learners:

A. Introduction to CAD
B. What software to use?
C. How to print the object?
D. Conclusions and recommendations

Module 5: Overview of CAM Processes:

A. Overview of CAM Processes
B. CAD to CAM Process
C. 3D printing materials

Module 6: Set up a 3D printer:

A. Machine Parts/How built up/ 3D printers setting
B. Maintenance and problem solving

Overview

Data and Methods

The design of the curriculum proceeded in the following stages which involved all partner teams in the elaboration of the programme.

Needs analysis of the target group

Project partners firstly carried out a background research in order to identify and analyse existing international and national training programs on the use of 3D printing in education, and more specifically in VET (IO1). Then partners proceed with a need analysis on the essential skills and competences that educators should have in order to be able to integrate 3D Printing in VET classes (IO2).

These tasks were finalised prior to the curriculum development phase. The survey on trainers' and teachers' needs for training on 3D printing gave an essential preparatory ground for defining the focal points of the curriculum. The findings of the research were presented in "IO1 Research report on 3D Printing Education" and in "IO2 Need Analysis Report".

Based on research activities (IO1 and IO2), partners proceed to the definition of the standard key competencies for VET teachers in the field and to the development of 3DP-VET curriculum (IO3).

Determination of focal points of the curriculum

The focal points which derived from the needs' analysis were translated into the thematic domains of the curriculum. The programme is modularised to permit maximum flexibility in the delivery of the course content. The afore mentioned key areas were identified, which outline the needs for training and the potential impact on VET education, and they are thus discussed in the specific modules of the curriculum.

Definition of learning outcomes

The 3DP-VET course uses a curriculum in which the proposed learning outcomes are clearly stated for each module and inform on the following activities, finally leading to an assessment and possibly certification. The adopted approach has been adopted taking into consideration the European Qualification Framework (EQF) in which learning outcomes are understood as "statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence". All the learning outcomes have been revised as a whole set of expected results of the training to ensure consistency of the 3DP-VET learning experience.

Developing content of specific modules

The curriculum was developed by the core team of the project partners and the task force behind the specific modules is:

Module 1: Technical Basic/Entering Module – KEKAPER

Module 2: Introduction to 3D Printing - ETIC

Module 3: 3D Printing in education – CEIPES and EELI

Module 4: Design and/ or print 3D objects – KIT and UNINETTUNO

Module 5: Overview of CAM Processes - WSEI

Module 6: Set up a 3D printer - INERCIA

All the modules have the same structure; slight differences appear among modules, but still all of them are consistent as parts of one curriculum.

- **Thematic domain of the module:** this chapter provides a brief introduction to the themes to be explored, with a definition of main concepts elaborated in more detail in the course training materials.

- **Aims and learning outcomes:** outline the prospective benefits for the course participants (what they are expected to learn).
- **Teaching and learning methods/approaches:** this section presents a sequence of activities leading to the achievement of the intended learning outcomes elaborated in more detail in the course training materials.
- **Assessment:** this is a specification of evaluation scenarios aligned to the intended learning outcomes.
- **Teaching materials:** this section lists the resources needed to run the trainings.
- **Time/duration:** this part gives approximate time needed to complete the proposed workshop scenarios
- **Bibliography:** the references given are mainly in English, more resources in national languages are listed in the course training materials.

Module 1: Technical Introduction

a) Computer hardware

b) Software

c) Networking Fundamentals

Thematic Domain of the Module:

The thematic domain of the module focuses on basic computer architecture and usage. The module also offers a brief introduction in networking. The module approaches the content with an entry level perspective, as the teachers and educators have to be familiar with the basic usage of computers, in order to be able to work on 3D printing.

The first unit of the thematic domain deals with computer hardware. There is a brief description of the main components that a computer consists of, and the way they communicate with each other. The connectivity of the external peripherals, like a 3D printer, is discussed on this unit.

The following unit deals with the software of a computer. The unit is separated into three parts. The first part deals with the available and most common Operating Systems, including Windows and MacOS. The second part is dedicated to the Windows operating system, with a comprehensive report of the basic tasks a user can do. The last part refers to some common Windows software that are useful in combination with the 3D printing software.

Finally, the last unit provides basic knowledge on computer networking. Through this unit, a computer with its peripherals are connected to the Internet. As an extension, there is a reference to the Internet of Things (IoT), a cutting edge technology.

Aims and Learning Outcomes:

Upon completion of this module, learners/teachers are expected to be able to:

- Understand the fundamental hardware components that make up a computer's hardware and the role of each of components (internal parts of a computer)
- Provide a general overview of the main available external parts of a computer

- Understand the difference between an operating system and an application program, and what each is used for in a computer
- Provide a basic knowledge of using Microsoft Windows operating system
- Describe various communication networks, their main components and the connection option
- Provide a basic knowledge of computer network connectivity technologies

Teaching and Learning Methods/Approaches:

This training methodology will be based on the use of a web platform, specifically created on the project website, which participants have access to with their username and password. The training activity will be realised through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path that will involve, motivate, and encourage participants to use any previous knowledge, provide them with documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback, and constantly monitor the learning level of topics.

Clear instructions that explain the use of platform will be provided, as well as an assistance system that will allow the solution of problems linked to the download of contents and tools of self- evaluation of competences.

The role of the trainer in this methodology is monitoring the training path of the trainees, solving doubts and questions and correcting the evaluation, if applicable.

This module will include three (3) chapters:

1. **Computer Hardware**
   - 1.1. Internal components of a Personal Computer
   - 1.2. PC architecture
   - 1.3. Peripherals and PC connectivity

2. **Software**
   - 2.1. Operating systems

2.2. Windows operating system

2.2.1. Start/Shutdown Computer

2.2.2 Windows Desktop

2.2.3. Files, Folders and Shortcuts

2.3. Other software (notepad, wordpad, calculator, paint etc)

3. Networking Fundamentals

3.1. Networking devices and connections

3.2. Network options (IPv4 settings)

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a selected subject in "3D Printing in education" module. At the end of the module learners are asked to answer a set of questions which reflect the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners' knowledge (about 20 questions). They must get minimum score of 50.

Teaching Materials:

The materials used for this module will be PowerPoint presentations, interactive links combined with the use of a projector.

Time/Duration:

It will take about 3 to 4 hours to read and complete all the materials.

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Module 2: Introduction to 3D Printing

a) History of 3D Printing

b) 3D printing possible applications

Thematic Domain of the Module:

The module provides an overview of the history of 3D printing and manufacturing processes. It is an introduction to what is today called rapid prototyping or 3D printing, which includes 3D modelling, along with printing models on 3D printers. In this way, we intend to establish a connection with a wide range of processes and disciplines that have been around long before the entire new generation of 3D printing.

The module will provide knowledge about the historical evolution and the immense possibilities of applications in 3D printing in our current world. Understanding will be gained about different disciplines and concepts that have been successful for a long time and remain essential for a better evolution of projects and processes. The trainees will learn to use the software indicated to achieve the desired shapes and effects in the best way, always prioritizing the materials and the final utility of each piece.

Aims and Learning Outcomes:

This module provides an overview of the processes used previously to what we now call Speed Prototyping or 3D Printing. Upon completion of this module, learners/teachers are expected to be able to:

- Explain the history of 3D printing
- Recognise what a 3D printer looks like
- Describe where 3D printers are used in society
- Discuss why 3D printers are being widely adopted in society
- Explain the benefits of using a 3D printer to make products
- Identify potential issues with 3D printing materials
- Explain the basic concept of how a 3D printer works

Teaching and Learning Methods/Approaches:

This training methodology will be based on the use of a web platform, specifically created on the project website, where participants can access with their username and password. The training activity will be realized through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path that will involve participants, motivate them, encourage them to use any previous knowledge, provide them with documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback and constantly monitor the learning level of topics.

Clear instructions that explain the use of platform will be provided, as well as an assistance system that will allow the solution of problems linked to the download of contents and tools of self- evaluation of competences.

The role of the trainer in this methodology is monitoring the training path of the trainees, solving doubts and questions and correcting the evaluation, if applicable.

This course aims at training teachers to use 3D printing techniques in several VET subjects. Teachers will be informed about how accurate, complex and fast a 3D printing technology is. For this reason, a deep analysis will take place with a set of parameters that will also include a pricing estimation, complexity of use, application areas and practical examples.

The analysis result will come in the form of suggestions for the best technologies to be used by teachers and educators in the academic environment.

This module will have five (5) chapters divided into:

1. **Introduction**
    - 1.1. Introduction to the concept of 3D printing - History of 3D Printing
    - 1.2. Layout disciplines and processes / methodologies (prior to 3D printing)
    - 1.3. Machine and software process (vectors, modeling, laser and printing)
2. **Machines and Materials**
    - 2.1. Printing Machine Process
    - 2.2. Machines and materials

3. **Printing Possibilities vs Needs**
    - 3.1. Analysis of currently existing needs and materials
    - 3.2. Identification of the main areas of the industry to use 3D printing
    - 3.3. Speed Prototyping laboratory methodology
4. **Realization of Two-Dimensional Piece (layout)**
5. **Conclusion and Presentation**

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a selected subject in "3D Printing in education" module. At the end of the module learners are asked to answer a set of questions which are reflecting the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners' knowledge (about 20 questions). They must get minimum score 50.

Teaching Materials:

The materials used for this module will be; PowerPoint presentations; interactive, practical exercises; texts; images; videos; e-books; and exemplary class scripts.

Time/Duration:

It will take about 6 hours to present, discuss objectives, analyse and research information and produce a completed piece.

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10. https://all3dp.com/2/3d-printed-phone-stand-6-best-curated-models/

Module 3: 3D Printing in Education

a) Potential uses of 3D printing in education (engineering design, architecture, history, graphic design, geography, chemistry, biology, etc.)
b) Examples of best-practices
c) Online and physical resources for educators
d) Choosing the right educational 3D Printer

Thematic Domain of the Module:

3D printing has recently seen a surge in popularity in schools and educators are rushing to use it in their curriculum and classrooms. This course offers advice to educators for integrating 3D printing into their lessons in order to improve student learning.

The first unit of the present Module introduces the numerous uses of 3D printing in VET education, in various academic fields, such as engineering design, architecture, history, graphic design, geography, chemistry, biology, mathematics, physics, etc. 3D printing technology improves learning methods from traditional teaching through books and theory to learning through aids and materials by bringing the subject matter to life; thereby promoting critical thinking and problem solving capabilities. It can also help students improve their skills by modelling and designing something or making a prototype to analyse and enhance.

In addition, this Module's second unit includes useful examples and best practices on the application of 3D printing technology in school subjects. This unit presents best practices for teaching with 3D printing, and examples of projects for school education.

The last two units of the Module have been created in order to help teachers and educators choose the right 3D printing technology for educational purpose. They also offer a collection of free online and physical resources for the target group in question to use them in class/lab and support training staff in the educational process.

The 7 most used 3D printers are compared according to the current technological trends. The analysis is based on 12 different parameters that best help to illuminate the 3D printing world.

In this module the strengths and weaknesses of each technology are explained and there are some important indicators as to their most suitable use.

Thanks to the online and physical resources teachers and educators will have an interactive guide with some OER that will support them in the training process. A list will be available of 3DP providers such as FabLab, hackerspace and 3D printing Shop, to provide a reference of some 3D printing services.

Aims and Learning Outcomes:

Upon completion of this module, learners/teachers are expected to be able to:

- Identify the benefits of applying 3DP technology in their lessons
- Have practical examples of applying 3D printing in various academic fields, such as engineering design, architecture, history, graphic design, chemistry, biology, mathematics, physics, etc.
- Collect online and physical resources for planning lessons, collecting ideas, and materials to support them in learning processes using 3DP
- Understand how different 3D printing technologies work in order to choose the technology that best suits their teaching and students needs in classrooms and labs

Teaching and Learning Methods/Approaches:

This training methodology will be based on the use of a web platform, specifically created on the project website, which participants can access with their username and password. The training activity will be realised through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path. This will involve participants, motivate them, encourage them to use any previous knowledge, provide them with documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback and constantly monitor the learning level of topics.

Clear instructions that explain the use of the platform will be provided, as well as an assistance system that offer solutions to problems linked to the download of content and tools of self-evaluation of competences.

The role of the trainer in this methodology is monitoring the training path of the trainees, solving doubts and questions and correcting the evaluation, if applicable.

This course aims at training teachers to use 3D printing techniques in several VET subjects. Teachers will be informed about how accurate, complex and fast a 3D printing technology is. For this reason, a deep analysis will take place with a set of parameters that will also include a pricing estimation, complexity of use, application areas and practical examples.

The analysis result will come in the form of suggestions for the best technologies to be used by teachers and educators in the academic environment.

This module will include 7 chapters:

1. **Introduction**
    - 1.1. Benefits of 3D Printing in Education
    - 1.2. Potential uses of 3D printing in education
        - 1.2.1. Application of 3D printing in Science (Physics, Chemistry, Biology)
        - 1.2.2. Application of 3D printing in Technology
        - 1.2.3. Application of 3D printing in Engineering
        - 1.2.4. Application of 3D printing in Mathematics
        - 1.2.5. Application of 3D printing in Arts and Graphic design
        - 1.2.6. Application of 3D printing in Architecture
        - 1.2.7. Application of 3D printing in History and Geography
2. **Examples and Good Practices of Application of 3D Printing in Education**
3. **How to Choose the Right 3D Printer for Educational Purposes**
    - 3.1. Purpose of the study
    - 3.2. Comparative table

4. **Presentation of 3D Printers' Types**
   - 4.1. STEREOLITHOGRAPHY (SLA)
     - 4.1.1. Process, Materials and Application Areas
     - 4.1.2. Strength & Weaknesses
   - 4.2. FUSED DEPOSITION MODELING (FDM)
     - 4.2.1. Process, Materials and Application Areas
     - 4.2.2. Strength & Weaknesses
   - 4.3. SELECTIVE LASER SINTERING (SLS)
     - 4.3.1. Process, Materials and Application Areas
     - 4.3.2. Strength & Weaknesses
   - 4.4. SELECTIVE LASER MELTING (SLM)
     - 4.4.1. Process, Materials and Application Areas
     - 4.4.2. Strength & Weaknesses
   - 4.5. ELECTRON BEAM MELTING (EBM)
     - 4.5.1. Process, Materials and Application Areas
     - 4.5.2. Strength & Weaknesses
   - 4.6. PHOTOPOLYMER JETTING (POLYJET)
     - 4.6.1. Process, Materials and Application Areas
     - 4.6.2. Strength & Weaknesses
   - 4.7. ELECTRON BINDER JETTING (EBM)
     - 4.7.1. Process, Materials and Application Areas
     - 4.7.2. Strength & Weaknesses
5. **Emerging Technologies and Latest Trends**
6. **Conclusions and Recommendations**
7. **Resource Index**

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a

selected subject in “3D Printing in education” module. At the end of the module learners are asked to answer a set of questions which are reflecting the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners’ knowledge (about 20 questions). They must get minimum score of 50.

Teaching Materials:

The materials used for this module will be PowerPoint presentations, interactive links, texts, images and videos.

Time/Duration:

It will take about 3 to 4 hours to read and complete all the materials.

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Module 4: Design and/or print 3D objects

For beginner's:

a) Introduction
b) Where can I download 3D Printable files?
c) What software to use?
d) How to print the object?

For advanced learners:

a) Introduction to CAD
b) What software to use?
c) How to print the object?
d) Conclusions and recommendations

Thematic Domain of the Module:

For beginners:

This module aims to give an overview to design and printing process of 3D objects. The user is introduced to available software to 3D print and modelling tools, learns step by step the production process from a 3D model to 3D Print.

For advanced:

The module gives a complete overview of creating complex 3D models. Before the start of the 3D modelling, the main tools of the workspace are analysed, using which will create the geometry of the 3D model. As the created model is chosen with options from a construction, mechanism part or other pre-agreed form. The modelling participant completely creates the geometry of the model and then prints the creation.

Aims and Learning Outcomes:

Upon completion of this module, learners/teachers are expected to be able to:

For beginners:

- Explain the production process of 3D printing
- Identify what is printable or not
- Identify the different types of Software used in 3D printing
- Download pre-modelled, printable files and customize the models
- Acquire basic modelling skills to design simple geometric forms
- Create and render designs with computer aided design (CAD) to make the product design look realistic
- Develop or polish their three-dimensional thinking and operating skills
- Prepare a 3D model ready to be printed using a 3D Printer
- Consider about the economic importance and ways to increase resource efficiency

For advanced:

- Increase skills of using the software to create the models
- Save time to create 3D model
- Create more complicated models with complex geometry
- Create a model by using different tools of software
- Create and print a model independently
- Consider about the economic importance and ways to increase resource efficiency

Teaching and Learning Methods/Approaches:

The training methodology will be based on the use of a web platform, specifically created on the project website, which participants can access with their username and password. The training activity will be realised through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path. It will involve participants,

motivate them, encourage them to use any previous knowledge, provide them with documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback and constantly monitor the learning level of topics.

Clear instructions that explain the use of the platform will be provided, as well as an assistance system that offer solutions to problems linked to the download of content and tools of self-evaluation of competences.

The role of the trainer in this methodology is monitoring the training path of the trainees, solving doubts and questions and correcting the evaluation, if applicable.

This course aims at training teachers to use 3D printing techniques in several VET subjects. Teachers will be informed about how accurate, complex and fast a 3D printing technology is. For this reason, a deep analysis will take place with a set of parameters that will also include a pricing estimation, complexity of use, application areas and practical examples.

The analysis result will come in the form of suggestions for the best technologies to be used by teachers and educators in the academic environment.

This module will have a total of eight chapters, four of them for the beginners, and four more for advanced:

<u>Beginner:</u>

1. **Introduction to CAD**
    1.1. What is CAD
    1.2. Simple modelling steps
    1.3. What are the requirements for a printable model?
2. **Where can I download 3D Printable files?**
3. **What software to use?**
    3.1. Modelling Software
        3.1.1. How to import a model?
        3.1.2. How to modify a model?

3.1.3. How to export a model? Extensions….

3.2. Printing Software

3.2.1. How to import a model?

3.2.2. How to correct a model?

3.2.3. How to export a model? Extensions, support structures…

4. How to print the object?

Advanced:

1. Introduction to CAD

1.1. What do you know about CAD

1.2. What type of model do you want to create

2. What software to use?

2.1. Modeling Software

2.1.1. How to import a model?

2.1.2. How to modify a model?

2.1.3. How to export a model? Extensions…

2.2. Printing Software

2.2.1. How to import a model?

2.2.2. How to correct a model?

2.2.3. How to export a model? Extensions, support structures…

3. How to print the object?

4. Conclusions and Recommendations

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a selected subject in “3D Printing in education” module. At the end of the module learners are asked to answer a set of questions which are reflecting the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There

will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners' knowledge (about 20 questions). They must get minimum score of 50.

Teaching Materials:

The materials used for this module will be PowerPoint presentations, interactive links, texts, images and videos.

Time/Duration:

Every chapter will take 1 hour to complete, which would take four hours for the beginners' course and four more hours to complete the advanced part. In total the module will take eight hours to complete.

Bibliography:

For beginners:

1. SketchUp: A simple, easy to learn CAD program https://www.bgsu.edu/content/dam/BGSU/libraries/documents/collab-lab/Sketchup-Tutorial.pdf
2. Netfabb: It is a software for 3D mesh processing and additive manufacturing. http://edutechwiki.unige.ch/en/Netfabb_Studio_tutorial

Commercial software:

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2. MeshLAB tutorial // http://www.heritagedoc.pt/doc/Meshlab_Tutorial_iitd.pdf
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Module 5: Overview of CAM Processes

a) Overview of CAM Processes

b) CAD to CAM Process

c) 3D printing materials

Thematic Domain of the Module:

The module gives a complete overview of CAM processes. The element of the so-called 'rapid prototyping' is introduced which includes 3D modelling along with the printout of models on 3D printers. Furthermore, the detailed analysis of CAD approach to constructing machine parts using 3D modelling is provided. The Solid Edge program is described, which allows a participant to model parts, create assemblies and generate technological documentation. Subsequently, the scrutiny of the CAM printing techniques of 3D models on 3D printers is provided. Moreover, the examples and usage of various 3D printing materials in the school environment on the basis of the selection of 3D printers and their capabilities are described. At the end of the module, the design process, implementation and examples of a 3D print used in didactics are presented. The procedure is shown on the basis of the 3D printout of the hydrogen fuel cell model where the FDM (Fused Deposition Modeling) technology was used for printing.

The purpose of this course is to train teachers to use CAD, CAM and 3D printing techniques in didactics. In the following module the knowledge assimilation, expository, problem based and activating methods are used. Their aim is to familiarize the participants with new material, ensure consolidation of the acquired knowledge, and enable control and assessment of the degree of knowledge mastery.

In order to achieve a desirable level of knowledge, reading materials that ensure certain and precise information on a given topic are provided. They are supported by video materials and power-point presentations in which the material is more thoroughly explained using examples to better visualize certain concepts. Finally, the interactive exercises in which participants can practice and consolidate their knowledge are provided.

In the materials, concepts are introduced in their simplest form first, then the material gradually progresses from simple to more complex procedures. Thanks to this the participants

will have to work their way through the examples, rather than skip some of them over in order to see the real benefit of the course.

Aims and Learning Outcomes:

Upon completion of this module, learners/teachers are expected to:

- Acquire knowledge about the latest trends in the approach called rapid prototyping i.e. the construction and development of machine and device components using 3D modeling (CAD), CAM and printing on 3D printers
- Learn how to apply 3D modeling in didactics through a number of examples of the use of 3D prints in various areas of life
- Know the basic functions of the Solid Edge program
- Know the types of materials for 3D printing and appropriate printers that allow them to directly create a given element with appropriate technical parameters

Teaching and Learning Methods/Approaches:

The training methodology will be based on the use of a web platform, specifically created on the project website, which participants can access with their username and password. The training activity will be realised through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path. It will involve participants, motivate them, encourage them to use any previous knowledge, provide them with documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback and constantly monitor the learning level of topics.

Clear instructions that explain the use of the platform will be provided, as well as an assistance system that offer solutions to problems linked to the download of content and tools of self-evaluation of competences.

The role of the trainer in this methodology is monitoring the training path of the trainees, solving doubts and questions and correcting the evaluation, if applicable.

This course aims at training teachers to use 3D printing techniques in several VET subjects. Teachers will be informed about how accurate, complex and fast a 3D printing technology is. For this reason, a deep analysis will take place with a set of parameters that will also include a pricing estimation, complexity of use, application areas and practical examples.

The analysis result will come in the form of suggestions for the best technologies to be used by teachers and educators in the academic environment.

This module will include 8 chapters:

1. **Introduction**
    - 1.1. Introduction to quick prototyping
        - 1.1.1. Definitions
        - 1.1.2. Rapid prototyping stages (taking into account industrial design)
2. **3D modeling of machine parts**
    - 2.1. The philosophy of modeling in the three-dimensional space - The origin
    - 2.2. Computer assistance of CAD design
        - 2.2.1. CAD software on the example of Solid Edge - program functions
        - 2.2.2. Constructing 2D
        - 2.2.3. 3D modeling
        - 2.2.4. Create 3D Assemblies
3. **Printouts of machine parts on 3D printers modeling of machine parts**
    - 3.1. 3D Print - genesis
    - 3.2. Rapid Prototyping Laboratory
        - 3.2.1. OBJET 23 printer
        - 3.2.2. EOSIN 26 printer
        - 3.2.3. Other Interesting 3D printers
4. **3D printing materials**
    - 4.1. Examples of Printing for teaching materials
        - 4.1.1. LPG installation components
        - 4.1.2. Didactic toys
5. **3D design and printing of teaching materials**
    - 5.1. Project Objective and Scope

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a selected subject in "3D Printing in education" module. At the end of the module learners are asked to answer a set of questions which are reflecting the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners' knowledge (about 20 questions). They must get minimum score of 50.

Teaching Materials:

The materials used for this module are: Power Point presentations, interactive exercises, texts, images, videos, e-books and scripts of exemplary lessons.

Time/Duration:

It will take about 2.5 hours to read and complete all the materials.

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Module 6: Set up a 3D printer

a) How to build and set up a 3D printer

b) Maintenance and problem solving

Thematic Domain of the Module:

Setting up a 3D printer for the first time – a step-by-step guide on what to do to get a 3D printer ready to print. Learning about a 3D printer's different parts and how settings affect how each part functions and how well the printer performs. This module also covers maintenance aspects and troubleshooting to solve printing problems.

Aims and Learning Outcomes:

Upon completion of this module, learners/teachers are expected to:

- Know the different parts that make up a 3D printing machine
- Be able to differentiate between pre-assembled printing kits and partially-assembled printing kits
- Be able to properly read, understand and follow the setup instructions that come with each 3D printer machine or model
- Know how and when to calibrate to avoid misaligned printouts
- Be able to square and level a 3D printing machine
- Know how and when to lubricate a 3D printer
- Be familiarised with common troubleshooting issues and know how to fix them

Teaching and Learning Methods/Approaches:

The training methodology will be based on the use of a web platform, specifically created on the project website, which participants can access with their username and password. The training activity will be realised through downloading didactic materials elaborated and uploaded on the platform in a structured and intuitive path. It will involve participants, motivate them, encourage them to use any previous knowledge, provide them with

documents and information according to their possibilities and to the characteristics of available tools, offer support and feedback and constantly monitor the learning level of topics.

Clear instructions that explain the use of the platform will be provided, as well as an assistance system that offer solutions to problems linked to the download of content and tools of self-evaluation of competences.

A user's guide or manual on how to set up 3D printing machines with step-by-step instructions accompanied by visual aids to illustrate the different steps involved in setting up a 3D printer. The manual will include an introduction, a brief description of how 3D printing machines are built and will have preliminary chapters going over the different parts, how to recognise each part in a 3D printing machine and what role they play in the printing process. The next chapters will cover the importance of carefully reading each 3D printer's own manual, following instructions and referring back to the original manual when in doubt, assembling parts, connecting wires, balancing the device and securing it. Final chapters will cover calibration, squaring and levelling, lubrication and final checks to carry out before printing for the first time.

At the end there will be a final practical printing exercise to check that a printer has been set up correctly.

Assessment:

The module is planned in such a way as to give participants a clear indication of the level of attainment of the intended learning outcomes. Each activity introduces a specific aspect of a selected subject in "3D Printing in education" module. At the end of the module learners are asked to answer a set of questions which are reflecting the level of understanding of the key concepts in focus. Teachers will be able to assess their learning with a multi-choice test. There will be a self-assessment of 5 to 10 questions at the end of each chapter to test what the teachers have learned. There will also be an evaluation test at the end of the module to evaluate the learners' knowledge (about 20 questions). They must get minimum score of 50.

Teaching Materials:

The materials required for this module include; PDF guide / manual; 3D Printer; PC with required licensed software.

Time/Duration:

This module will take around 4 hours to complete.

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3. https://all3dp.com/2/3d-printing-speed-optimal-settings/
4. https://www.popsci.com/getting-started-with-3d-printing/