

3DP trainer guidelines



www.3d-p.eu

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AN EDUCATOR'S JOURNEY: INTRODUCING 3DP IN THE CLASSROOM

As we have seen, 3D Printing is continuing to make its way in to schools, colleges and universities in every corner of the globe. Even though it is not a very complex technology, there are a number of things to consider before starting. The goal of this handbook is to support and educate teachers and make the introduction of 3D printing in to the classroom a simple process. The possibilities for the students are greater than ever and we believe that 3D printing will play a key part in the careers of the next generation. From engineering and architecture to fashion and art, 3D printing promotes problem solving, creative thinking and 3D design. The following five steps may be useful for introducing the 3D printing methodology in the classroom:

LEARNING

Learning and becoming familiar with the 3D technology is essential for teacher to transmit the knowledge they acquire to their students, and also for being able of finding an innovative usage of the 3D Printers for their subjects. One of the main objectives of the 3DP project is to create an online course which will allow teachers to learn all the basics on how to use a 3D Printer.

Apart from this course, here there are some other ways of expanding knowledge:

- Attend an exhibition
- Visit a 3D printing store
- Check out some online forums
- Read a book
- Watch video tutorials

GETTING HANDS ON

Before starting teaching the lessons, it is crucial to put into practice what the teachers have learnt themselves. It is time to experiment and get hands on. For completely beginners it may be interesting to download free models from the internet so that they can see and analyse the printing process for the first time. By getting familiar with already existing 3D models, teachers may begin to appreciate what generally works and start to understand how best to design.

Once getting familiar with the printing process of the online models, it is time for teachers to start designing by themselves. As we have seen in the previous pages, the designing process is the most crucial part, and something that they should be able to transmit and teach to their students. In the following section of this manual we present different practices and the steps that teachers should follow for teaching them to students. It may be a good chance for the teachers to practice their 3D printing skills by carrying them out before teaching them to students. This way they may also get to know the difficulties and challenges that may arise during their lesson.

PLANNING

Once the teachers have gain some experience in 3D printing it is time to prepare a plan on which strategy should be followed for the introduction of the 3D methodology in the classroom.

It is crucial to really consider the objectives. This will enable teachers to plan the usage of the 3D printers in their subject. It is a good idea to ask a number of questions. What learning outcomes are they trying to convey to their students? 3D design, physics and engineering principles are all fantastic examples and there are many more to consider. How many students will require the use of a 3D printer? What curriculum needs do students have? Are other teachers going to collaborate and work together in the planned strategy? ...

TEACHING

Once the teachers have acquired experience and have planned how they are going to introduce the 3D methodology in their lessons, it is time to start teaching their students. The previous investigation actions will help them because, while watching videos and reading information, they have learnt how to communicate and deliver 3D printing lessons. In the following lines we present 5 tips for teaching 3D printing in the classroom:

1. Let the students handle 3D printers: There is no better way to learn about 3D printing than to get hands-on, and this specially applies to students. Make sure they have access to the printers, let them try to fix any problem that may arise, let them get familiar with the device. However, keep a close eye on the safety aspect, and make sure the students know where the heated elements of the printer are.
2. Organize the time and the printing: Time is probably one of the most important aspects in the journey of introducing the 3D methodology in the classroom. It takes time to learn and plan. We suggest teachers to be organized and to have schedule that includes lesson planning and self-development.
3. Work together with the students: The trenchers should make clear to the students that he/she doesn't know everything about 3D printing. They should work together with them in solving problems and keep lessons open ended. In other words, although lessons should have set criteria and learning outcomes, there is a world of opportunity beyond this when giving students freedom to explore.
4. Don't isolate 3D printing: In modern day industry, it is rare that 3D printing is used as a tool on its own. It compliments other forms of design and manufacturing (3D scanning, CNC machining, etc.) to enhance the outcome. Teacher must make sure that students know of the existence of these other devices and when integrating 3D printing in the curriculum.
5. Be flexible and open to change: Flexibility is as important as having a plan. Things teachers planned at the beginning will be completely different when they start their

lessons. It is part of the development process, so we suggest teachers to keep on learning and testing and to be open minded.

INSPIRE A GENERATION

Now that teachers are ready to start using 3D printing in their lessons, it is time to enjoy it and encourage their students to do the same. 3D printing is an extremely powerful tool to convey theory from a multitude of core subjects, inspire creativity and even spark a debate amongst students on best 3D printing practices. Apart from those models and practices purposed in the next section of this handbook, let the students create and design their own models too; inspire them and make them freedom to expand their creativity. As mentioned before, the 3D printing industry is set to keep growing and growing in the future, so it is crucial that the students get well prepared to face the challenges they are going to come with in their labour life.



CREATING CONDITIONS FOR LEARNING

- Environment
- Equipment needed: PCs, laptops, Internet access
- Software applications

WHAT THE TRAINER MUST DO

At the beginning of the training programme, the trainer should learn about the trainees: who are they, their age, where do they come from, what work they do, what form of schooling have they had.

Trainer will encourage the trainees to talk about themselves and their background, thus allows knowing more about the trainees, but it also allows the trainees to share and compare their experiences.

The trainer should make it clear exactly what the trainees will be expected to learn. At the beginning of the course, **Learning objectives** and **Acquired competences** are presented for informing the trainee what is expected them to know and to be able to do after completing the course.

Trainees must be given repeated opportunities to ask questions and to practice during course for blending the theoretical knowledge with practical skills.

THE CONDITIONS OF LEARNING

In order to facilitate the running of a training course, the trainer will ensure that the classroom has facilities for laptops/PCs and internet access.

EVALUATING THE TRAINEE'S PROGRESS

During course, the trainer will assess using different tasks that the trainees correctly performed the steps involved. She/he will ask questions for checking that trainees acquired the knowledge presented during course.

SPECIFIC REQUIREMENTS

COURSE 1 - INTRODUCTION TO 3D PRINTING

Learning objectives

After studying this unit the student should be able to:

- Understand 3D Printing approach
- Understand the terminology used for the 3D printing technology
- Understand the advantages and limitations of 3D Printing for different applications
- Understand the process steps for obtaining an object using 3D Printing technology
- Understand how 3D printing technology can be applied across a number of application sectors

Training plan

The trainer will have made provision for:

- The availability to demonstrate 3D printer main parts and how it works
- Have several 3D printed items interesting for particular target group
- Computer with Internet connection

The trainer will explain the aim of the training and explain the equipment which will be used. The **Learning objectives** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Have you ever heard of additive manufacturing? What about 3DP?
- What are advantages and disadvantages of 3D printing?
- What do we need before printing the items?
- Where could be used 3D printed items?

How, why when

Explain why and when 3DP is being used nowadays

Explain what is required for 3DP in terms of resources, equipment, software, etc.

Tasks:

1. Read the lecture
2. Watch this video clip
3. Ask them to perform self-evaluation questions

COURSE 2 - AVAILABLE 3D PRINTING TECHNOLOGIES

The overall aim of this unit is to equip students with the basic knowledge on the main 3D Printing processes, their advantages and limitations, basic understanding on materials issues in 3D Printing and with basic knowledge on STL file format.

Learning objectives

More specifically, after studying this unit the student should be able to:

- Acquire knowledge on the main 3D Printing processes together with their advantages and limitations;
- Understand the basics of materials issues in 3D Printing;
- Acquire knowledge on the STL file format.

Training plan

The trainer will have made provision for:

- laptop/PC with Internet connection
- Computer-Aided Design (CAD) System (e.g. *Autodesk Inventor*)
- Free STL file viewer (such as *Open3D Model Viewer*)

The trainer will explain the aim of the training and explain the equipment which will be used. The **Learning objectives** will be outlined. Explain that the first part of the lecture will focus on the type of 3D printing process, whereas in the second part, focus is placed on the STL file.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Have you ever heard of different types of 3DP technologies?
- Do you know on what basis these are classified?
- Do you know their respective, basic principle, main process characteristics, materials used and their advantages and limitations?

How, why when

Explain that a 3DP technology can be classified according to the state of the raw material which is utilised. Highlight that only two types of 3DP processes will be considered in this unit, as these are the most commonly used.

Explain the underlying principles of FDM. Give examples of characteristics associated with FDM, such as build envelope. Stress out the fact that such characteristics are only indicative as these vary from one FDM 3D Printer make and model.

Distinguish between support and build material used in FDM.

Should trainees ask for additional information, prepare some additional physical samples produced by FDM, with/without support material to those included in the lecture content, as shown in Figure 1.

Build material constituting the desired geometry



Support material required for the internal thread

Figure 1 – Sample FDM prototypes with/without support material

If no physical prototypes are not available, prepare some useful *YOUTUBE* links (see an example in Figure 2). Refer the trainees to such links.

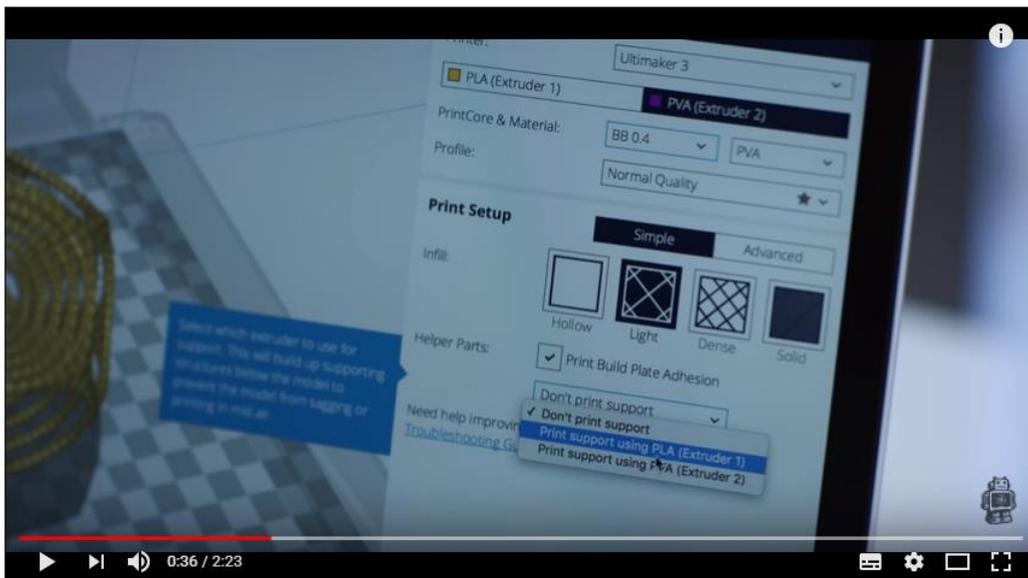




Figure 2 – YOUTUBE video showing pre – and post processing of FDM parts on the *Ultimaker 3D printer*
(Source: <https://www.youtube.com/watch?v=0ENgGkPP94w>)

Follow the same procedure/guidelines for SL.

Explain how a 3D CAD model can be exported to STL file format directly in a CAD package.

Explain how to view the facets and normals of an STL file using a free STL file viewer.

Tasks:

1. Read the lecture slides. Prepare some additional material (e.g. properties of materials used in the two 3DP processes covered).
2. Watch the *YOUTUBE* video clips
3. Download a free STL file viewer (e.g. <http://www.open3mod.com/>).
4. Prepare a simple 3D CAD model (e.g. a vase, similar to the one provided in the slides)
5. Prepare a one-page sheet with step-by-step instructions on how trainees can firstly create an STL file of the model referred to in (4) and secondly view it in a free STL file viewer.
6. Ask trainees to participate in an on-line quiz.

COURSE 3 - 3D PRINTING EQUIPMENT

Learning objectives

After studying this unit the student should be able to:

- Understand the difference between industrial 3D printers, desktop 3D printers and home/hobbyists 3D printers
- Know about RepRap Project and what influence it had for desktop 3D printers
- Understand FDM and FFF process, the main components of a FDM 3D printer

Training plan

The trainer will have made provision for:

- The availability to demonstrate 3D printer
- Computer with Internet connection

The trainer will explain the aim of the training and explain the equipment which will be used. The **Learning objectives** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Have you ever heard about RepRap project?
- Do you know that RepRap is an open design, all of the intellectual property produced by the project is released under a free software license, the GNU General Public License?
- What materials are used by FDM printers?
- Have you ever heard about FDM Home/hobbyist 3D Printers? What could be printed by using those 3D printers?
- Have you ever heard about FDM Desktop 3D Printers? What could be printed by using those 3D printers?
- Have you ever heard about Industrial FDM 3D Printers? What could be printed by using those 3D printers?
- What are main components of FDM 3D printers?

How, why when

Explain about FDM Home/hobbyist, Desktop and Industrial 3D printers. Explain purpose of these printers, when and by whom they are used.

Demonstrate main components of FDM 3D printers, etc.

Tasks:

1. Read the lecture
2. Watch this video clip

3. Ask them to perform self-evaluation questions

COURSE 4 - 3D CAD MODELLING SOFTWARE APPLICATIONS

The overall aim of this unit is to equip students with basic understanding of 3D CAD modelling principles and with basic knowledge on CAD freeware.

Learning objectives

More specifically, after studying this unit the student should be able to:

- understand the basics of 3D CAD modelling
- acquire knowledge on different free 3D CAD applications.

Training plan

The trainer will have made provision for:

- laptop/PC with Internet connection
- sample defective parts produced by Fused Deposition Modelling
- CAD package

The trainer will explain the aim of the training and explain the software which will be used. The **Learning objectives** will be outlined. Explain the link between CAD technology and 3D printing.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Have you ever used a CAD package? Do you know the benefits of CAD technology?
- Do you know how CAD technology is linked to 3D printing?
- Do you know in what sectors CAD technology is used?

How, why when

Define what is meant by Computer-Aided Design. Highlight how CAD technology has nowadays become part and parcel of a design activity in a range of sectors related to vocational training such as architecture, product design, jewellery design and interior design.

Mention that a 3D CAD model can be created using a free/commercial CAD package. Explain that the CAD model is then prepared for 3D printing (e.g. converting it to STL, removing any errors, setting up layer thickness etc.). Ensure that the trainees have background on STL and terms related to 3D printing such as layer thickness etc.

Distinguish between 2D and 3D modelling and why the former is the foundation for 3D modelling. If possible, show a short demonstration on typical commands (e.g. extrude) commonly found used to convert a 2D entity into a 3D model. Use everyday things such as a staircase handle, vase etc. (see Figure 1) to illustrate how these can be modelled in CAD. Ask participants to provide further examples.



Figure 1 – Example of everyday products which can modelled with revolve and sweep in CAD

Refer to a number of popular free CAD modelling software packages are available, such as: *Trimble SketchUp*, *TinkerCAD* and *A360 Fusion*. Highlight that software is always evolving, and hence versions change frequently from time to time.

Use say *Trimble SketchUp* to show how the push/pull tool works.

Give an overview of the basic functions of the *A360 Fusion* software.

Show how *A360 Fusion* software can be downloaded. You can refer to the video referred in Figure 2.

Tasks:

1. Read the lecture slides. Prepare some additional material (e.g. properties of materials used in FDM).
2. Watch the *YOUTUBE* video clips
3. Prepare a simple 3D CAD model (e.g. a simple conical model) so that you can show the difference in the STL resolution and the ensuing consequences in 3D printing.
4. Prepare a one-page sheet with step-by-step instructions on how trainees can download a free CAD software package – such as *Trimble SketchUp* or *A360 Fusion*.
5. Prepare a one-page sheet with step-by-step instructions on how trainees can generate a simple CAD model using *Trimble SketchUp*.

6. Ask trainees to participate in an on-line quiz.

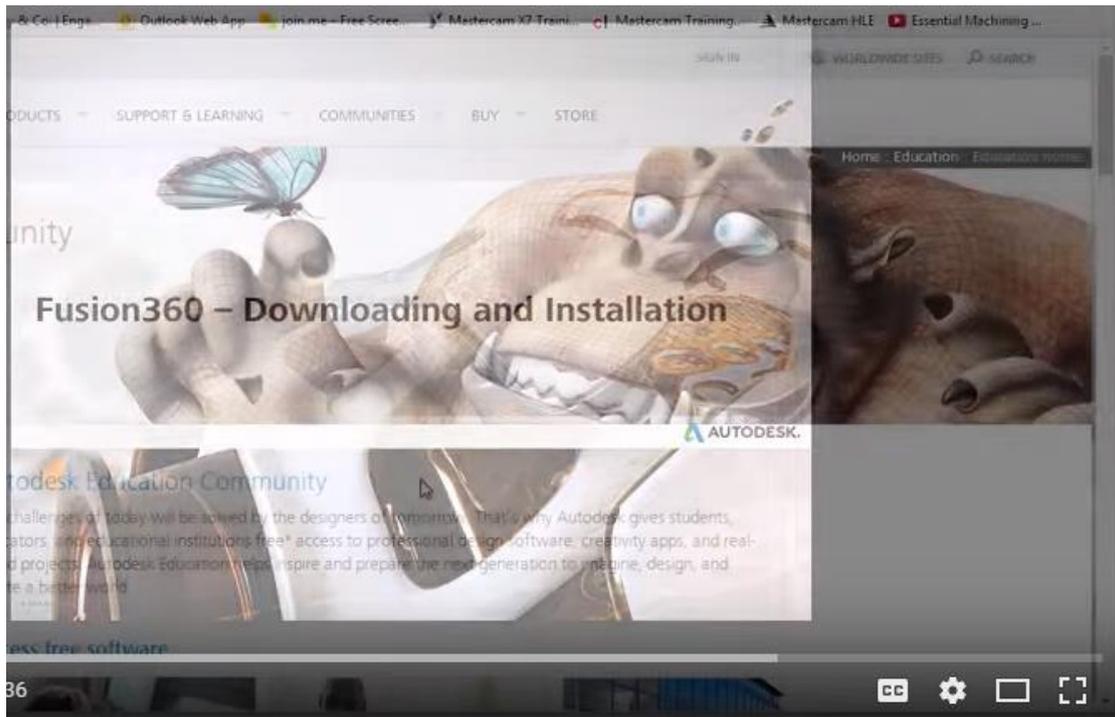


Figure 2 – YOUTUBE video showing downloading and installing Fusion 360 (Source: <https://www.youtube.com/watch?v=EyuMN2pWpvk>)

COURSE 5 - 3D CAD MODELLING USING AUTODESK FUSION 360

Learning objectives

After studying this unit the student should be able to:

- 3D model an object from scratch using Autodesk Fusion 360 software
- Generate STL files from Autodesk Fusion 360

Training plan

The trainer will have made provision for:

- The availability of computers according to system requirements for Autodesk Fusion 360 (for updated requirements see <https://knowledge.autodesk.com/support/fusion-360/learn-explore/caas/sfdcarticles/sfdcarticles/System-requirements-for-Autodesk-Fusion-360.html>)
- The availability of internet access for Fusion 360 application

The trainer will explain the aim of the training and explain the software which will be used. The **Learning objectives** and **acquired competences** will be outlined. Explain the link between CAD technology and 3D printing.

Finding out what the trainee already knows

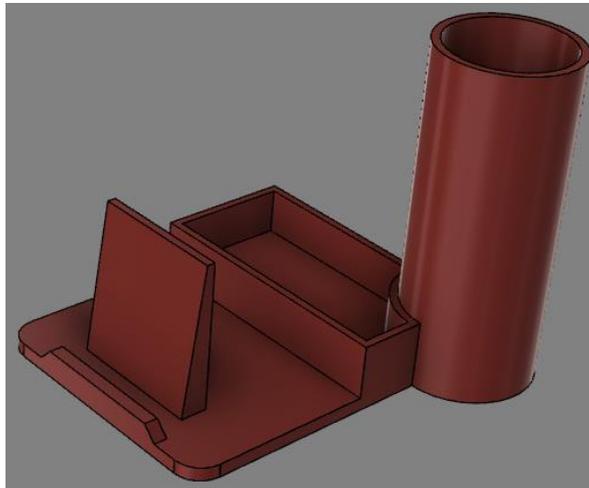
Find out the answers to the following questions:

- Have you ever used a CAD package? Do you know the benefits of CAD technology?
- What do you know about Autodesk Fusion 360?
- Have you ever used Autodesk Fusion 360?
- Do you know how CAD technology is linked to 3D printing?
- Do you know what a STL file is?

How, why, when

Explain how Fusion 360 can be used for preparing models for 3D printing.

Present the 3D printable desk organizer used during the course (bellow figure).



Explain why it is important to design the models keeping in mind the particularities of 3D printing.

Tasks:

1. Read the lecture
2. Prepare a one-page sheet with step-by-step instructions on how trainees can obtain an Autodesk ID and download *Fusion 360*
3. Ask trainees to participate in an on-line quiz

COURSE 6 - SELECT A STL MODEL FROM ONLINE REPOSITORIES

Learning objectives

After studying this unit the student should be able to:

- Understand the difference between repositories, search engines and marketplaces for STL models/files
- Understand the workflow for 3D printing a STL model from an online repository/search engine/marketplace
- Acquire practical skills on how to access online resources for STL files/models
- Understand the main steps which should be performed when using the most common STL models online resources (Thingiverse, GrabCAD, Pinshape, etc.)

Training plan

The trainer will have made provision for:

- The availability of user account for repositories, search engines or marketplaces requiring registration.
- Laptop with Internet connection
- Software for unzipping files downloaded from Internet (winrar, winzip)

The trainer will explain the aim of the training and explain the equipment and software which will be used. The Learning objectives and acquired competences will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Do you know what STL means?
- Do you know what type of STL file formats can be used in 3D printing process?
- Do you know how to use unzipping applications?

How, why, when

Explain that there are online resources, free or paid, for downloading STL models required for 3D printing process

Explain what it is required for accessing the online resources for STL models

Explain the difference between repositories, search engines and marketplaces for STL models

Present students the most common online resources of STL models

Explain the workflow for 3D printing a STL model from an online repository/search engine/marketplace

Explain that some online resources allow downloading 3D models in other formats, but for 3D printing process online STL files can be used, other format requiring processing for being transformed in STL format

Give examples on how to find STL models in different online resources by using keywords or categories

Explain that some online resources for STL models offer information on 3D printing materials, process parameters etc. Exemplify.

Explain that some STL models online resources require creating user accounts and exemplify

Show students how to download STL models from different online resources

Tasks:

1. Read the lecture

2. Ask them questions about how to browse online resources for finding a certain STL model, and on the workflow for 3D printing a STL model from an online repository/search engine/marketplace

3. Ask students to access online resources for STL models, to search different models and to download them

COURSE 7 - CHECK AND CORRECT STL FILES USING DEDICATED SOFTWARE

Learning objectives

After studying this unit the student should be able to:

- Understand how to use different software for checking and repairing STL files: Netfabb, MeshLab, MiniMagics
- Understand what are the most common problems of STL models
- Know how to use automated tools/commands for checking and correcting STL models
- Know how to use manual tools/commands for correcting STL models

Training plan

The trainer will have made provision for:

- The availability of internet access for MiniMagics/3DPrint Cloud application
- The availability of each student computer of Netfabb and MeshLab software applications (free licenses)

The trainer will explain the aim of the training and explain the equipment and software which will be used. The **Learning objectives** and **acquired competences** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

Do you know what STL means? Do you know how a 3D model is transformed into a tessellated STL model? Do you know the difference between ASCII and Binary STL formats?

How, why, when

Explain that are the most common problems (errors) which can be encountered in STL models

Explain why it is important to verify and correct STL files before sending them to the 3D printer

Explain what it is required for accessing the online resources for STL models

Present Netfabb application, its interface, tools, data exchange formats

Present the most common tools used for automatic and manual checking and repair in Netfabb

Give a practical example on how to check and repair wrong/damaged STL files using Netfabb

Present MeshLab application, its interface, data exchange formats and tools

Present the most common tools and methods used for checking and repair in MeshLab

Give a practical example on how to check and repair wrong/damaged STL files using MeshLab

Present MiniMagics/3DPrint Cloud application, its interface, characteristics and repair tools

Give a practical example on how to use MiniMagics/3DPrint Cloud

Tasks:

1. Read the lecture
2. Ask them questions about how to check and repair STL models using different the presented dedicated applications
3. Ask students to check and repair wrong STL files for practicing the present

COURSE 8 - Obtain the physical model using services offered by 3D Printing providers

Learning objectives

After studying this unit the student should be able to:

- Understand how to access online service bureaus or platforms offering 3D printing services: 3DHubs, Sculpteo, Shapeways, i.Materialise, Ponoko
- Understand the basic workflow of using online 3D printing services
- Understand how to upload STL model, select material, 3D Printing process and 3D printer
- Understand how to evaluate cost, delivery time and access other information provided by producers/platforms

Training plan

The trainer will have made provision for:

- The availability of internet access
- Laptops, PCs

The trainer will explain the aim of the training and explain the equipment and applications which will be used. The **Learning objectives** and **acquired competences** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Do you know what STL means?
- Do you know how a 3D model is transformed into a tessellated STL model?
- Do you know the difference between ASCII and Binary STL formats?
- Do you know what are the most used 3D printing processes and their working principle?

How, why, when

Present and discuss the file formats accepted by the most used 3D printing online services

Present the general workflow for 3D printing an object using the online services provided by different platforms and producers

Present the following platforms: 3DHubs, Sculpteo, Shapeways, i.Materialise, Ponoko

Present the working steps (uploading model, selecting material, selecting process and 3D printer, providers) and characteristics of each of the above mentioned online 3D printing platforms

Show how to orient object in different online applications/platforms

Present case studies in each platform for showing how to obtain information on cost, delivery time and access other information provided by producers/platforms

Tasks:

1. Read the lecture
2. Ask students questions about how to select material, producers and 3D printing process in different online platforms offering 3D printing services
3. Ask students to use different 3D printing online services platforms and obtain info on cost and delivery time

COURSE 9 - 3D PRINTING AN OBJECT ON A LOW-COST FILAMENT DEPOSITION BASED PRINTER

Learning objectives

After studying this unit the student should be able to:

- Understand how to set the building orientation, process parameters and build an object on a low-cost 3D printer, as well as with knowledge on 3D printer software
- Understand how to 3D print an object using Z-suite for Zortrax 3D printers
- Understand how to 3D print an object using Cura for Ultimaker printers
- Understand how to 3D print an object using Slic3r software for RepRap 3D printers
- Understand how to 3D print an object using ReplicatorG for RepRap 3D printers, Makerbot Replicator, Thing-O-Matic printers

Training plan

The trainer will have made provision for:

- The availability of internet access
- Laptops, PCs
- Software applications
- STL models

The trainer will explain the aim of the training and explain the equipment and applications which will be used. The **Learning objectives** and **acquired competences** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Do you know what STL means?
- Do you know how the building orientation is influencing 3D printed parts' characteristics?

- Do you know what are the main process parameters in the 3D printing based on filament deposition?

How, why, when

Present and discuss the interface and main characteristics of Z-Suite software

Present and discuss the interface and main characteristics of Cura software

Present and discuss the interface and main characteristics of Slic3r software

Present and discuss the interface and main characteristics of ReplicatorG software

Present the modalities of setting building orientation in each of the above mentioned software applications

Present the settings for material and process parameters available on each of the above mentioned software applications

Present case studies for each software applications using different type of STL models

Tasks:

1. Read the lecture
2. Ask students questions about the process parameters that can be set in different software applications for 3D printers based on filament deposition process
3. Ask students to use different 3D printing software application for low-cost 3D printers based on filament deposition process

COURSE 10 – 3DP AND ENTREPRENEURSHIP

Learning objectives

After studying this unit you should be able to:

- Know the opportunities offered by 3D printing in entrepreneurship
- Understand the requirements of a 3D printing business

Training plan

The trainer will have made provision for:

- The availability of internet access
- Laptops, PCs

The trainer will explain the aim of the training and explain the equipment and applications which will be used. The **Learning objectives** and **acquired competences** will be outlined.

Finding out what the trainee already knows.

Find out the answers to the following questions:

Have you ever heard of additive manufacturing? What about 3DP?

How, why when

- Give examples of 3D businesses and start-ups
- Provide a brief summary of possible funding sources
- Browse skills required for a 3DP based business
- Detail opportunities for freelancers in 3D printing

Tasks:

1. Read the lecture
2. Ask students questions about examples of 3D printing businesses and 3D printing services
3. Ask students questions about funding sources and freelance opportunities
4. Ask students questions about the skills required in 3D printing

COURSE 11 - DESIGN WITH 3D PRINTING IN MIND

The overall aim of this unit is to equip students with the basic knowledge on defects typically encountered in 3D printed parts and 3D printing design rules for parts and assemblies in order to minimise the occurrence of such defects.

Learning objectives

More specifically, after studying this unit the student should be able to:

- acquire knowledge on defects associated with 3D printed parts fabricated by FDM
- understand the influence of building orientation over parts' quality and mechanical properties
- acquire knowledge on 3D Printing design rules for parts and assemblies.

Training plan

The trainer will have made provision for:

- laptop/PC with Internet connection
- sample defective parts produced by Fused Deposition Modelling
- software which interfaces with a 3D printer (e.g. *Catalyst* used with *Dimension 1200* FDM printer)
- CAD package

The trainer will explain the aim of the training and explain the equipment which will be used. The **Learning objectives** will be outlined. Explain that the first part of the lecture will focus on the type of defects one can encounter in 3D printed parts, whereas in the second part, focus is placed on a set of guidelines aimed at reducing the occurrence of such defects.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Have you ever encountered defective parts produced by FDM?
- Do you know the cause(s) of such defects?
- Do you know how to reduce such defects?
- Do you apply design for 3D printing principles when preparing 3D models for prototyping?

How, why when

Explain that causes of defects are classified according to the stage in which they happen. Highlight that only FDM technology is taken as a case study.

Explain the various causes which may lead to defects in 3D printed parts. If possible, try to vary the resolution of a STL file to show that even data preparation can lead to defects. Show how the resolution of *STL* files can be controlled during their generation in a 3D CAD system.

Highlight the role of build orientation on the final quality of FDM parts. If possible, provide a live demonstration using the Catalyst software to show how orientation impacts the amount of support material employed and the structural integrity of the part.

Should trainees ask for additional information, prepare some additional physical samples produced by FDM, with/without defects to those included in the lecture content, as shown in Figure 1.

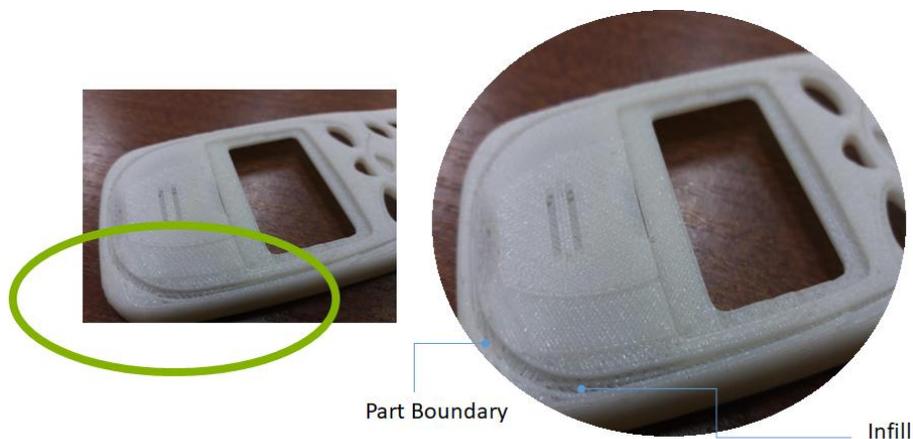


Figure 1 – Sample FDM prototypes with defects

If no physical prototypes are not available, prepare some useful *YOUTUBE* links (see an example in Figure 2). Refer the trainees to such links.



Figure 2 – YOUTUBE video showing 3DPrinting Tips & Tricks Delamination of layers due to poor extrusion
(Source: https://www.youtube.com/results?search_query=defects+fdm+printer)

Explain how the proposed guidelines can reduce the occurrence of such defects.

Tasks:

1. Read the lecture slides. Prepare some additional material (e.g. properties of materials used in FDM).
2. Watch the *YOUTUBE* video clips
3. Prepare a simple 3D CAD model (e.g. a simple conical model) so that you can show the difference in the STL resolution and the ensuing consequences in 3D printing.
4. Prepare a one-page sheet with step-by-step instructions on how trainees can prepare a simple conical CAD model so as to reduce as much as possible consumption of support material and hence building time, whilst maintaining structural integrity of the part.
5. Ask trainees to participate in an on-line quiz.

COURSE 12 – Case studies in the industry to show the potential for boosting entrepreneurial spirit, creativity and innovation

Learning objectives

After studying this unit the student should be able to:

- Understanding the impact of 3D printing technology in various businesses
- Acquiring knowledge of how to make or contribute to a start-up in 3D printing business

Training plan

The trainer will have made provision for:

- The availability of internet access for search and understand other case studies models

The trainer will explain the aim of the training and explain the equipment and software which will be used. **Aim** and **Learning Outcomes** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Do you know what 3D Printers business are in your country?
- What is the impact of using 3D printers in different businesses?
- How business development influences them?

How, why when

- Explain that are the most common problems in implementing a 3D printing business
- Explain why it is important to develop and increase using 3D printer in business
- Present the most common business that use 3D printing and make profit
- Give a practical example on how to discover a new domain/business for using 3D printing
- Present a 3D printing business
- Give a practical example on how to use 3D Printers in business

Tasks:

1. Read the lecture
2. Ask them questions about how to find existing business that use 3D Printers
3. Ask students to find new ideas of 3D Printing business and how to implement them

COURSE 13 - FUTURE OF 3D PRINTING TECHNOLOGIES

Learning objectives

After studying this unit the student should be able to:

- Understand the potential risks and regulations related to 3D printing technologies
- Acquire knowledge on 3D printing trends and developments

Training plan

The trainer will have made provision for:

- The availability of internet access
- Laptops, PCs

The trainer will explain the aim of the training and explain the equipment which will be used. The **Learning objectives** and **acquired competences** will be outlined.

Finding out what the trainee already knows

Find out the answers to the following questions:

- Do you know some myths about 3D printing?
- How do you think the 3D printing will evolve in the future?
- What do you think are the bigger risks related with 3D printing?

How, why when

Explain that there are many different 3DP technologies and they are evolving very fast.

Explain the main advantages of 3D printing technologies and their potential to change the world.

Highlight the importance of regulations in the 3D printing technologies field.

Tasks:

1. Read the lecture
2. Prepare some useful *YOUTUBE* links to demonstrate interesting applications of 3D printing.
3. Ask trainees to participate in an on-line quiz
4. Ask students to find new ideas of 3D Printing applications