Output 4: Modules Materials

- Activity 1 -

Training of Trainers

PARTICIPANT ORGANIZATIONS

Karlsruhe Institute of Technology

CETEM

CEIPES

STYRIAN TECHNOLOGY PARK
Regional Centre for Technology Development
Business Support Centre and Incubator

TRAINING OF TRAINERS

O4-A1: Training of Trainers: Content Editors

This activity will enable both teachers and content developers to improve their teaching skills and standardize methodologies and share teaching methods*, pedagogical approaches and tools among teachers and content developers so that students can perceive a unified team and an only one work methodology. KIT in charge.*

A disclaimer notice:

[1] E3D+ - Erasmus 3D Plus

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ERASMUS3D+

Training material for developing 3D printers.

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Karlsruhe Institute of Technology

Technical Research Centre of Furniture and Wood of the Region of Murcia

CEIPES

Styrian Technology Park
Regional Centre for Technology Development
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1. Presentation of the project. What is E3D+?

The main objective of this project is to address the need to feed an industry that is in high growth as is the 3d printing of its "target group", students, users, experts and professionals of current sectors, by developing a thorough VET tool that provides new skills in the "learning pillars" and "promoting entrepreneurship".

From this main objective, several specific objectives are defined:

SO1. Capacity Building in new sectors: Promoting ACTIVE COOPERATION and partnership between Higher education institutions (KIT), VET providers (CETEM, CEIPE, STP) and partners from outside academia: enterprises (STP,CETEM), professional organisations (CETEM), and local/Regional Bodies (CETEM, STP) in order to obtain an impact on the modernisation and internationalisation of VET education in the 3D Printing sector.

SO2. Create a FLEXIBLE LEARNING PATHWAY able to provide HE students and graduates the most important competences and skills, such as learning internationalization and growing use of digital learning. This new learning pathway will also include validation of prior learning and will aim to improve the level of both sector specific and transversal competences and skills, with particular regard to those relevant for the labour market in the 3D Printing, such as management, entrepreneurship, language competences and leadership and their contribution to a cohesive society, in particular through increased opportunities for learning mobility and through strengthened cooperation between HE, VET, and the world of work in our specific sector.

SO3. A joint curriculum that will define and analyze the most suitable training paths addressing the Skills and Capacities gaps and needs.

SO4. To develop a Multilingual eLearning Platform (Website/APP) for teaching the remote learning part. This will maximize the impact and dissemination of the project during its funding period and future life.

SO5. To involve VET policy makers and other stakeholders that will help disseminate and exploit the project outcomes, and that will recognize it as a standard VET model, which will ensure a high impact on VET policies.

2. Objective. Training of Trainers.

Training of Trainers is a guide to standardize teaching methodology and pedagogical strategies in the teaching of new technologies such as additive manufacturing.

Through this training program, you will gain expertise in how to plan, design, and facilitate an effective training course aimed for students who will be following the course of E3D+.

By the end of this training, you will:

- Develop effective strategies for teaching.
- Gain better understanding of the desired learning outcomes.
- Get familiarized with the rationale and course content of the teacher-training pack prepared by the consortium especially for E3D+.
- Learn how to introduce the learning and teaching methods and cultivate these methodologies within the course material using suggested approaches.
- Know the E3D + project and its objectives.

In the next point, you will see the four modules of the curriculum of this course summarized. The objectives and the main skills are detailed so that the reader gets an overall idea of the content of the whole course before going deeper into it.

Later we will talk about the teaching methodology. The instructor, after the advice and suggestions presented in this guide, will be able to adapt and apply the acquired knowledge to teach the contents of this course.

3. Learning outputs.

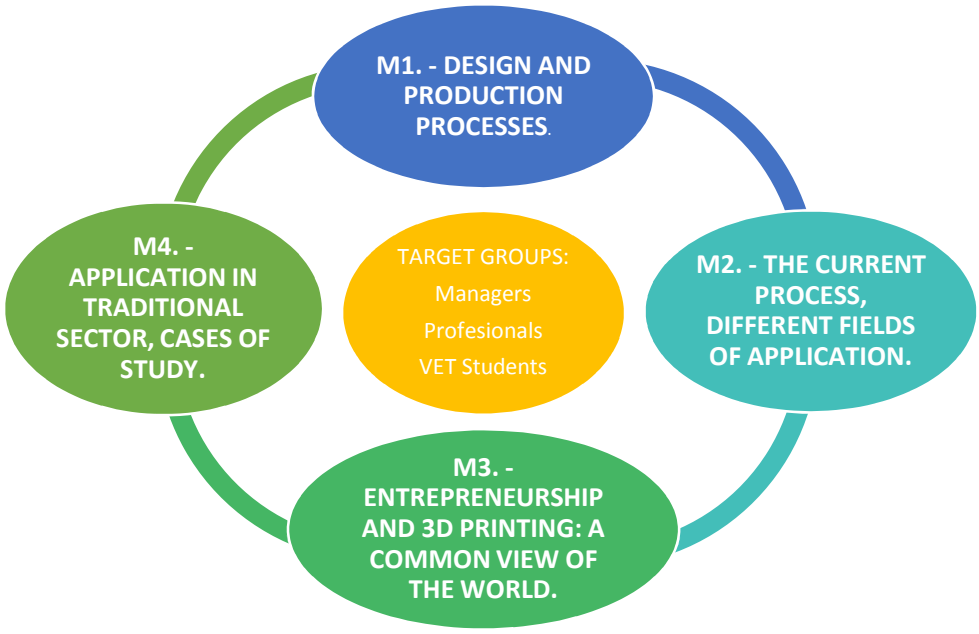
The learning outputs expected after the completion of this course, as well as the curriculum can be divided into four parts.

In the first module, *"Design and production processes"* the user will learn the origin of additive manufacturing, the production process from obtaining the 3D design to the printed piece, which softwares are necessary for this process, the most common materials and will get basic knowledge about different 3D printing technologies.

In the second module, *"The current process, different fields of application"* the most used technologies are explored; the user will have a more complete vision of what technology to use and how to use it based on their materials, limitations, etc. In addition, the user will know different fields of application of additive manufacturing.

In the third module, *"Entrepreneurship and 3D printing"* the user will know the most important theories about entrepreneurship, the qualities that an entrepreneur must have and learn how to recognize an idea of success.

In the fourth module, *"Applications in the traditional sector"*, after knowing the state of the art of rapid prototyping, the user will learn guidelines to put into practice so that the development of innovative products is successful, this will be done through the methodology for success designed and used by CETEM. This part also shows three success cases that have followed this methodology.



The objectives and skills of each of the modules of this project are shown graphically below.

MODULE 1. - DESIGN AND PRODUCTION PROCESSES.

OBJECTIVES

- Provide knowledge about the origin of 3D printing, the evolution of this technology and what can be done with it. Awaken the curiosity of the user to continue immersing himself in 3D printing.
- Differentiate the concepts "Rapid Prototyping" and "Additive Manufacturing" and know their characteristics.
- Gain an overview of the different software that are needed to get a 3D model from the design until the part is printed.
- Acquisition of knowledge about the most commonly used 3D printing thermoplastics, which include descriptions and main characteristics, as well as about other materials.
- Acquisition of knowledge about the world of additive manufacturing. Understanding of the production process in 3D printing and gaining knowledge and competencies about how to print and what is needed to print a 3D model.
- Acquisition of knowledge about the different technologies in additive manufacturing. Understanding of the different processes of these technologies and gaining knowledge and competencies about how to print and what is needed to print a 3D model.

SKILLS

- Expand knowledge to develop the creative part of the user. Differentiate the concepts of Rapid Prototyping and Additive Manufacturing.
- Identify the advantages of Rapid Prototyping and Additive Manufacturing over other methods.
- Be able to identify the different types of Software used in 3D printing.
- Identify the most commonly used 3D printing materials, as well as their characteristics.
- Appreciate the main differences between ABS and PLA materials. Understand how PVA material works as a support structure.
- Obtain and print a 3D object.
- Know the characteristics of the STL file.
- Be able to identify what is printable or not.
- Get knowledge about the main post-processing methods.
- Know when a support structure is needed.
- Identify what type of technology is used by each printer.
- Be able to identify the different types of technologies.
- Know when a support structure is needed.

MODULE 2. - THE CURRENT PROCESS, DIFFERENT FIELDS OF APPLICATION.

OBJECTIVES

- Acquisition of knowledge about 3D Printing technologies in the framework of the most used technologies processes, resolution, accuracy, sizes and existing top manufacturers.
- Know better about the materials that are used in the most usable 3D printing technologies - Stereolithography (SLA), Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS).
- Provide knowledge about current processes, different fields of application for the most usable 3D printing technologies, like Stereolithography (SLA), Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS).
- Differentiate between the extraction directives, post-processing and see the examples of the most usable 3D printing technologies - Stereolithography (SLA), Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS).

SKILLS

- To differentiate the between most usable 3D Printing technologies.
- Knowing technological/technical aspects of most usable 3DP technologies.
- Differentiation about the materials that are used in different but most usable 3D printing technologies.
- Expanded knowledge about most used materials by each of the most usable 3D printing technologies.
- Expand knowledge of the most usable 3D Printing technologies - Stereolithography (SLA), Fused
- Deposition Modelling (FDM) and Selective Laser Sintering (SLS).
- Go deeper with the current processes, different fields of application for the most usable 3D printing technologies.
- Know the extraction of pieces for most usable 3D printing technologies.
- Know the post-processes of most usable 3D printing technologies.
- Differentiate clearly between the extraction of pieces and post-processing of Stereolithography (SLA), Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS).

MODULE 3. - ENTREPRENEURSHIP AND 3D PRINTING: A COMMON VIEW OF THE WORLD.

OBJECTIVES

- Acquisition of knowledge about the concept of entrepreneurship, definitions and theoretical frameworks.
- Acquisition of knowledge about the main features that make a person a real entrepreneur.
- Understand the pathways that link a business idea to its practical outcome.
- Discovering examples of good entrepreneurship thanks to 3D printing.

SKILLS

- How to share the factors influencing entrepreneurship attitudes: Personal factors & Environmental factors.
- Be able to analyze a business idea.
- Find the best methods to make outcomes.
- Understand the needs of the environment and if the idea is addressed to them.
- To follow the feedback.

MODULE 4. - APPLICATION IN TRADITIONAL SECTOR, CASES OF STUDY.

OBJECTIVES

- Acquisition of knowledge about what is rapid prototyping and what are the most relevant technologies, techniques, processes for creating rapid prototypes, molds and models. To know the state of art of rapid prototyping.
- Knowing in what types of applications is the creation of prototypes, molds, tools... in the industry, divided. To identify how many prototypes there are.
- Knowing in what types of applications is the creation of prototypes, molds, tools... in the industry, divided. To identify how many prototypes there are.
- Knowing cases of study that have been developed successfully in traditional sectors.

SKILLS

- Know what rapid prototyping is.
- Know what different technologies there are.
- Be able to identify what is the most convenient technique each time.
- Be able to identify and make distinctions between different prototypes.
- Know how companies in traditional sectors are using prototypes and applications.
- Distinguish between indirect and direct rapid tooling.
- Apply a methodology to be successful.
- Know what is done in any stage of the methodology.
- Identify what are the key aspects of each stage.
- Know about projects in traditional sectors.
- Identify areas such as new nucleus and new mattresses.
- Identify areas such as air circulation systems for doors.
- Identify areas such as reproductions of cultural heritage.

4. Methodology for teaching and learning.

This section is divided into three parts. We start by naming what skills the instructor needs to be able to adapt the contents of this course to their lessons. Next, we talk about methodological tools to use in the classroom both virtual and physical and finally we will name pedagogical points to take into account in the training of new technologies.

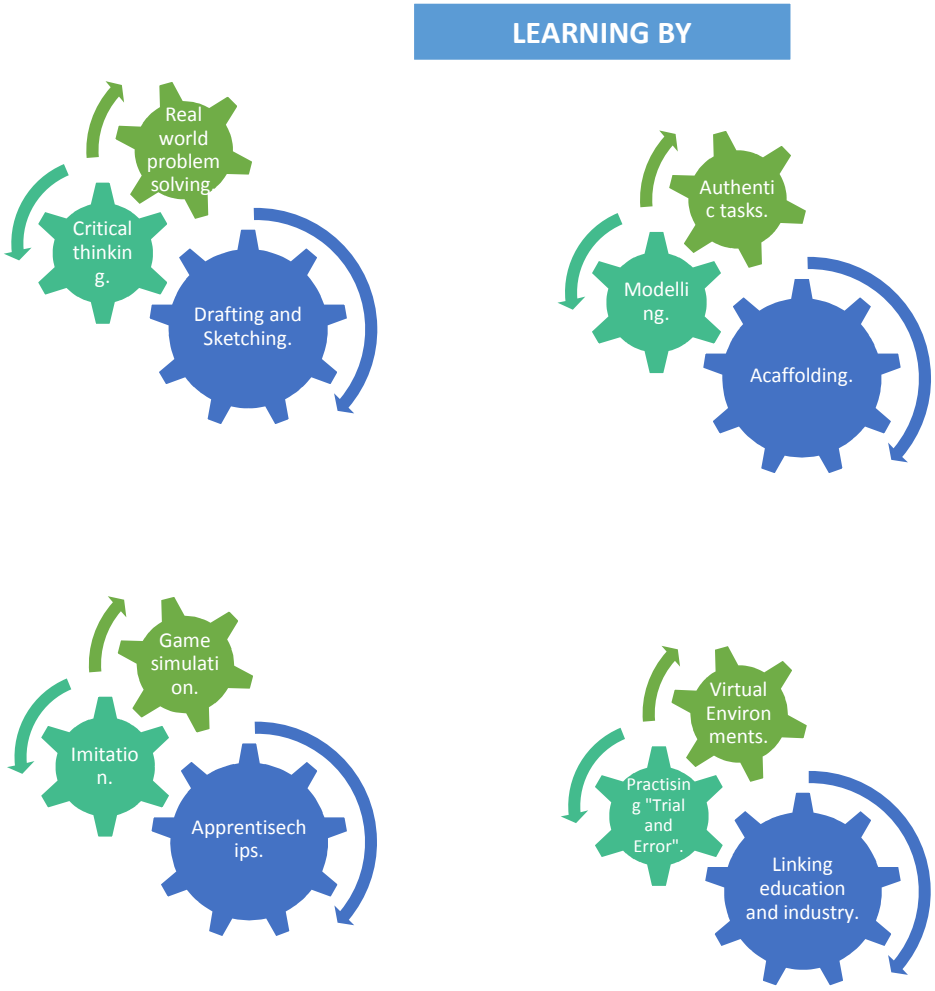
The trainer or instructor must apply their technical knowledge and pedagogical skills to ensure that the students achieve the objectives.

Skills that the trainer must have:

- Thoroughly know the subject to impart.
- Know the needs of students: Why do you want to train in additive manufacturing? Where do they come from? What do they want and for what?
- Prepare technically and didactically the subject on which the E3D + course deals.
- Think about the strategies you need for the student to participate in the lessons.
- Analyze the time necessary to put into practice the activities that students will perform.
- Know what the students know about each situation.
- Allow time for students to demonstrate to themselves what they know and what they can get to know.
- It makes the student do and get results that he can see. Motivation.
- Adapts the contents and learning activities derived from the objectives to reality, strengthening critical thinking and solving problems.

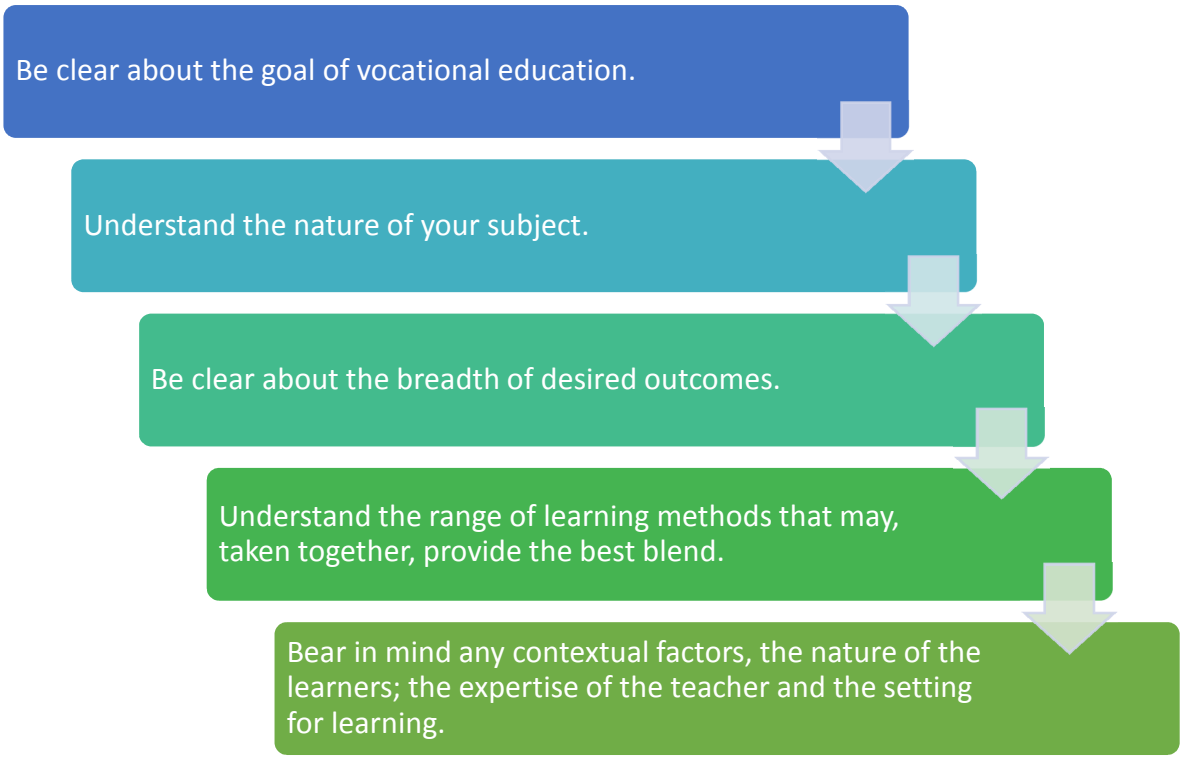
Methodological tools:

- Know the subject and the objectives well.
- Use the tools of e-learning communication: emails, forums, chats…
- Structure the classes well in content and time.
- Evaluate what has been learned and strengthen weaknesses with practical cases.



Vocational pedagogy is the sum total of the many decisions which vocational teachers take as they teach, adjusting their approaches to meet the needs of learners and to match the context in which they find themselves.

Vocational pedagogy enables us to develop models and tools which can help teachers more effectively to match teaching and learning methods to the needs of their students and their contexts. Through such means vocational pedagogy can directly impact on the quality of teaching and learning. Professor Bill Lucas, from the University of Winchester has documented "a line of thought" as he describes it. This is demonstrated in the figure below:



Learning and teaching methods that work best in VET.

Constructivist Learning Approaches:

Constructivism puts emphasis on the learning process and not on the learning outcome. The learning activities and environment should be structured in such a way that learners can create and control the development of their own learning. In this perspective, the functions of teachers and trainers are closer to guidance and coaching rather than to instruction.

Situated Learning Approaches:

Bridging apprenticeships should be designed to reduce the gap between theoretical learning in the formal instructional setting of the classroom and the real-life applications of knowledge in the work environment.

Authentic Assessment Activities.

Specifically designed assignments that apply standard driven knowledge as well as skills that refer to real world challenges. Billett (2013) has identified four key strengths in the potential for securing occupational capacities through authentic experiences:

1. Engagement in work tasks
2. Indirect guidance provided by the setting
3. Practice within that setting
4. The close guidance of other workers and experts.

Learner Centred Approaches:

One principal goal should be for the teacher to nurture and encourage self-directed learning, by empowering students to become autonomous, self-motivated, responsible for their own learning, able to make choices about how and what they will learn (King, 1999).

Problem Based Approaches.

An educational strategy and a method to organize the learning process in such a manner that the students are actively engaged in finding solutions to problems by themselves (Graaff & Kolmos, 2007).

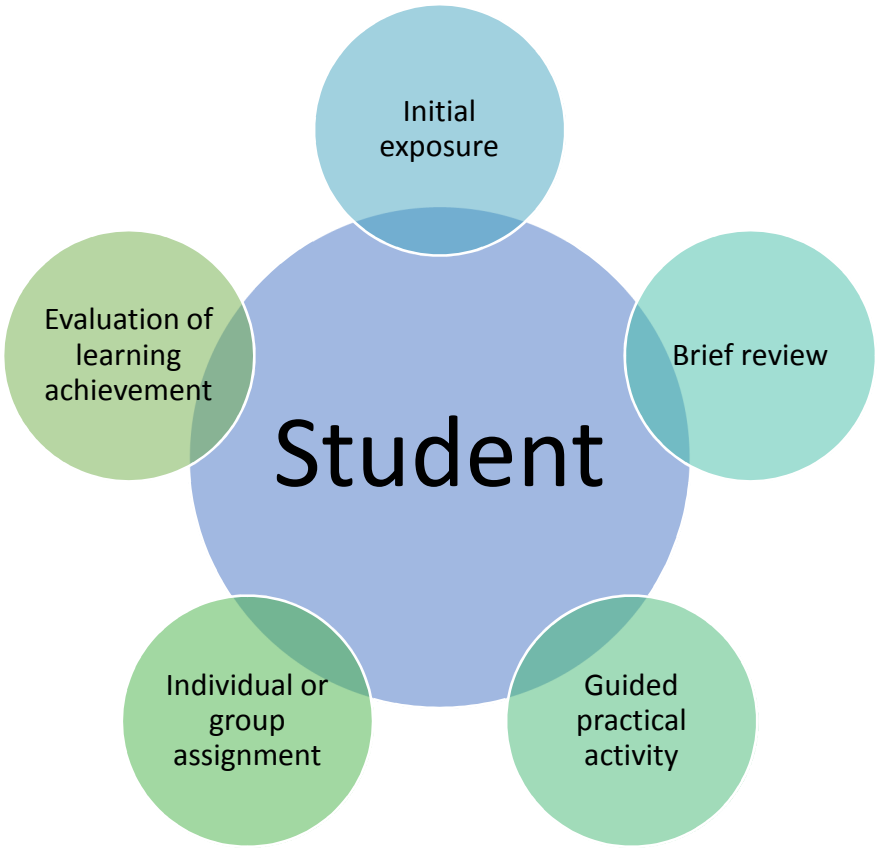
Student Mentoring.

Rather than being told what to do, learners should be asked to determine what they think and, having made an approximation, be guided by an expert mentor (Billet, 1994: 10).

Expert mentors ought to provide the modelling, coaching and scaffolding which students need to engage in authentic tasks in a gradual way, usually starting with peripheral tasks, and eventually moving into more core ones.

5. How to apply these in E3D+ Units.

E3D+ suggests that the constructivist learning phases can be adopted to accommodate the methodologies that best serve the purposes of the VET pedagogy and to teach professionals and managers. These phases promote a student-centered approach that aims to produce and instill knowledge relating to individual topics but is extensible to cover larger areas of interest. The phases are:



Initial Exposure.

Carefully selected material (readings, videos, presentations) relating to the (weekly) learning outcome(s) is available for students to interact and study. This first view happens by the students on their own to obtain a first impression and a first understanding of the material.

Brief review.

In this phase, taking place in class, students review and discuss the subject in a collaborative environment. The instructor assumes a moderator role but can also intervene and further clarify or qualify difficult or interesting point(s). This phase will lead to a practical activity to stimulate and enhance learning.

Guided practice activity.

This phase ideally takes the form of a guided lab. The instructor acts a mentor and students are called on to follow and via 'doing' achieve a clearer understanding of the activity. Either based on individuals or segregated in groups, this active learning experience will be a prelude to a homework assignment.

Individual or group assignment.

In this phase, students will have the opportunity to work on their own time and put to practice what they learned in class. This coursework could be completed individually (introductory and elementary levels) or in groups (upper intermediate levels). There are issues that need consideration with group assignments; it is possible to deal with these by setting explicit expectations and requiring everyone to 'do their bit'.

Evaluation of learning achievement.

Completion (not copying) of individual assignments can demonstrate sufficient knowledge on the learning outcomes. In the case of group work, careful planning, specific goals, in-group individual tasks and segregation of duties can ensure learning achievement for all involved.

6. Example of lesson plan.

SAMPLE OF LESSON PLANS	
LESSON	First part of the Unit: **Technologies in 3D printing.** **SLA – FDM - SLS**
WE WILL NEED	Internet access and computers. If possible, 3D printed pieces with different technologies or processes.
N° OF STUDENTS	10 – 20 (Working individually or in pairs)
DURATION	- In class 245 minutes (with two breaks of 15 min.)

	- At home (before main lesson) 20 – 30 minutes for initial exposure. - At home (after main lesson) between 1 and 3 hours for assignments.
EXAMPLE VIDEOS	SLA: https://www.youtube.com/watch?v=yYGycgnYlBM FDM. https://www.youtube.com/watch?v=u5w6pT6F5Rs SLS: https://www.youtube.com/watch?v=9E5MfBAV_tA
CLASS ORGANIZATION	Students will work on their own in guided activity. Student might pair up for assimilation activity.
SKILLS ATKEN FOR GRANTED	Good command of office suite and internet knowledge. Knowledge of the learning platform.
SCOPE	Introduce to the students some of the technologies of additive manufacturing. Recognize and differentiate them. Familiarize student's with today's 3D printing technology. Introduce criteria for choosing the right 3D printing technology.
OBJETIVES	1. - Acquisition of knowledge about the different technologies in additive manufacturing. 2. - Understanding of the different processes of these technologies and gaining knowledge and competencies about how to print and what is needed to print a 3D model. 3. - Promote the critical thinking of students. 4. - Perform a brainstorming session. 5. - Perform document analysis.
INITIAL EXPOSURE	PRE-LESSON ACTIVITY
	Learning material will be made available to the students before the class. This might happen during the previous class or via the online learning platform "Opigno". Material: - Power Point "3D Printing Technologies"

	- Instructional video to explain each technology. - Links to other instructional videos: SLA: https://www.youtube.com/watch?v=BUfh5wxj3qA FDM: https://www.youtube.com/watch?v=EnOOdBECOsg SLM: https://www.youtube.com/watch?v=kvOzqTvk7qk - Suggested reading: *"3D Printing Technologies.pdf"*. - Suggested links to online instructional websites: http://www.stratasys.com/
MAIN LESSON	
	The instructor will confirm that all students did in fact have the initial exposure experience. In the event that not all students do what is required before class, the instructor will spend between 10 and 15 minutes in an attempt to establish a basic understanding of the technologies that will be discussed in class.
BRIEF REVIEW	The instructor initiates a conversation in which students are invited to discuss their understanding of the topic. - Ask students: Why do you think 3D printing technology, which emerged nearly 30 years ago, has only recently become well-known (2011)? What happened in recent years that led to the emergence of so many new companies and technologies? - Explain: As covered in the historical review, two parallel processes of the Information Age – smarter computers, and easier to use computers – have made technology like 3D printing more accessible and more powerful. It has become more accessible in terms of knowledge, cost and material quality.

	It has become more powerful due to the complex operations machines are now able to carry out. Remember, 3D printing is not a single technology. There are may disparate technologies that are both additive and digital that we call 3D printing. After the debate, the instructor will explain the technologies in detail, dealing with the following points: - Description of the printing process. - Advantages and disadvantages. - Main applications. This part will be done with motivation exercises, visualizing explanatory videos and solving all the doubts that arise during the explanation. Printed pieces with different technologies and materials will be shown in class if possible. Students will be asked what limitations they think exist within additive manufacturing.
	The instructor will confirm that all students are clear on the subject and are ready to identify and differentiate the technologies discussed in this class.
PRACTICAL RESEARCH ACTIVITY.	Taking into account the three technologies explained in this lesson, a research activity will be carried out to internalize and better understand the acquired knowledge. Steps to follow and data to look for: - Identify two printers by type of technology. - Materials that use these printers. - Video links - How do these printers work? - Costs - Limitations of said printers / technology. Deliverable:

	- Comparative table of the analysed technologies. - Justification (previous analysis) of the most interesting technology for its use in the following real cases. 1. Real case: Prototype of a piece of furniture with good finish and accuracy. 2. Real case: Spare part for a washing machine. - Conclusion.
EVALUATION OF LEARNING ACHIEVEMENT	Students that have completed the assignment must have sufficient attainment of the learning outcomes. After the submission of the assignment and before the immediately following class you might ask the students to have an online quiz (using the online learning platform "Opigno") which might or might not relate directly to the assignment. In the immediately following lesson, you may use a brief Quiz and ascertain the level of learning. It can be: Ask some questions about how to differentiate the technologies exposed in the previous class, so that they serve as a guide in the new class, where other technologies such as Electron Bean Melting, Laminated Object Manufacturing and polyjet will be explained.

7. Conclusion.

With the modules “DESIGN AND PRODUCTION PROCESSES”, “THE CURRENT PROCESS”, “ENTREPRENEURSHIP AND 3D PRINTING” and “APPLICATION IN TRADITIONAL SECTOR” trainers in 3D-Printing are getting a basic tool box for preparing and undertaking 3D-printing teaching strategies. The teaching and preparation of courses in the field of 3D printing is characterized by 3 key features:

1. The technology of 3D printing develops and changes itself quickly and persistently.
2. The technology of 3D printing is changing fundamental and established ways of working in the industries and in the production processes.
3. With the introduction of advanced production methods such as 3D printing, traditional teacher-student roles are often changed.

These changes result in the following concepts for all teaching concepts in this area:

1. The teaching and learning concepts must be reviewed and adapted more frequently than usual in terms of content and methodology. They therefore require students and teachers to be willing and able to learn on demand and learn lifelong.
2. In addition to imparting technical and methodological knowledge on the subject of 3D printing, skills must also be imparted during the learning process in order to understand and react appropriately to the possible and caused changes in planning processes.
3. The classic teacher-student relationship can change in this process, making it necessary for both teachers and students to be able to swap roles.