PEDAGOGICAL GUIDELINES

Written by Jens Hofmann on behalf of the FASTER 3D-Partnership.

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Contents

1. Introduction

The impact of new technology might be overestimated in the short run but underestimated in the long run. Therefore, it is necessary to evaluate realistic fields of application today and future use cases.

The focus on **no-code and low threshold applications** will open the door to a faster technological adoption. For the use in vocational education and training (VET) of apprentices teaching personnel must be capable to defined educational goals of using modern technologies like 3D scanning, WebVR and 3D printing. Questions are: How does a pedagogical sound use is possible in training? What kind of skills are needed to use 3D scanning, WebVR and 3D printing? How to assess the impact among learners?

FASTER 3D focusses on:

Making educators to content creators by qualifying teachers and trainers to use modern technologies without programming skills, to create tailor-made teaching and learning scenarios for practical industry training.

These guidelines are for VET trainers to know about and to implement modern, digital media in training. In addition, they are also aimed for school administration to realize the support of trainers' needs.

2. Hard- and Software

Three technologies are applied at FASTER 3D:

3D scanning is the process of capturing the shape, size, and geometry of a physical object using specialized equipment such as a 3D scanner to create a digital 3D model.

3D printing (or additive manufacturing) is the computer-controlled layer by layer printing of material (e. g. plastic) with the aim of creating a physical representation of a 3D model.

Decisive factors for buying 3D scanners and 3D printers are presented below (table 1 and 2)

WebVR allows to experience Virtual Reality (VR) in a common web browser, e. g. Mozilla, without the use of a special VR headset.

@3D printing: some definitions

Extrusion: process by which a 3D printer melts and extrudes filament through a nozzle to create a three-dimensional object layer by layer.

Filament: material used in 3D printing that is melted and extruded through a nozzle to create a three-dimensional object layer by layer. The most common filament material used in 3D printing is thermoplastic, which softens and melts when heated and hardens when cooled.

Materials:

- **PLA** (polylactic acid): A biodegradable and eco-friendly material that is easy to print and comes in a wide range of colours.
- **ABS** (acrylonitrile-butadiene-styrene): A durable and impact-resistant material commonly used for making toys, automotive parts, and electronic housings.
- **PETG** (glycol-modified PET): A strong and flexible material that is resistant to impact, heat, and chemicals.
- **Nylon**: A strong and flexible material that is commonly used for making mechanical parts, gears, and bearings.
- **TPU** (thermoplastic polyurethane): A flexible and rubber-like material that is ideal for making phone cases, footwear, and other flexible parts.
- **PC/PTFE** (polycarbonate/ polytetrafluoroethylene – Teflon): High mechanical and heat resistance as well as hydrophobic material used for seals in industrial plants.

There are also many other types of filaments available for 3D printing, including composites that contain carbon fiber, wood, or metal particles, as well as specialized materials like conductive, magnetic, or glow-in-the-dark filaments.

Table 1: 3D scanner (selection)

	Revopoint Range	Revopoint Pop 2	Peel 3D	Artec Leo	iPad Pro 11 (LiDAR)
					
Accuracy	0.3mm	0.05 mm	0.25 mm	0.1 mm	0.5 mm
Scanning area	800 x400 mm	210 x 130 mm	340 x 475 mm	843 x 488 mm	5m (range)
Colour	Yes	Yes	Yes	Yes	Yes
Software	Revo Scan App	Revo Scan App	peel.OS, peel.CAD	Artec Studio 15	3D scanner App
Output format	PLY, OBJ, STL	PLY, OBJ, STL	dae, .fbx, .ma, .obj, .ply, .stl, .txt, .wrl, .x3d, .x3dz, .zpr, .dxf, .iges*, .step*	OBJ, PLY, WRL, STL, AOP, ASCII, Disney PTEX, E57, XYZRGB	OBJ, STL, HEIF, JPEG, DNG
Direct export to 3D printing	Yes	Yes	Yes	Yes	Yes
Weight	210 g	195 g	950 g	1800 g	466 g
Operating system (compatibility)				Not required	
Price	500 €	700 €	8.500 €	35.000 €	930 €

Table 2: 3D printers (selection)

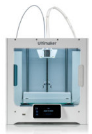
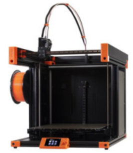
	Ultimaker 2+	Ultimaker s3 Dual Extrusion	Raise 3D Pro2 Plus Dual Extrusion	Prusa XL
				
Size	342 x 357 x 488 mm	394 x 489 x 637 mm	620 × 590 × 1105 mm	800×800×900 mm
Built volume	223 x 223 x 305 mm	230 x 190 x 200 mm	280 × 300 × 605 mm	360×360×360 mm
Extruder temp.	180-260°C	180-280°C	300°C	300°C
Print bed temp.	110°C	Max. 140°C	130°C	100°C
Print speed	< 300 mm/s	< 24 mm3/s	< 150 mm/s	tba
Dual extrusion	No	Yes	Yes	tba
Filament	PLA, ABS, CPE	PLA, ABS, CPE, CPE+, Nylon, TPU 95A, PC, PP, PVA, Breakaway, and more	PLA/ ABS/ HIPS/ PC/ TPU/ TPE/ PETG/ ASA/ PP/ PVA/ Nylon/ Glass Fiber Infused/ Carbon Fiber Infused/ Metal Fill/ Wood Fill, PC/PTFE	PLA, PETG, ASA, ABS, more
Software	Ultimaker Cura software (free slicing software)	Ultimaker Cura software (free slicing software)	ideaMaker	tba
Weight	11,2 kg	14,1 kg	59,3 kg	tba
Operating system (compatibility)				tba
Price	2700 €	4599 €	4760 €	2599 €

Table 3: 3D printing materials

Material	Printing with enclosure	Dry box recommended	Hardened nozzle required	Nozzle temperature	Bed temperature	Printable on powder coated sheet	Printable on smooth PEI sheet	Printable on satin sheet	Soluble with common solvents	Heat deflection temperature	Impact resistance Charpy	Tensile strength	Price
PLA	No	No	No	185-235 °C	50-60 °C	✓	✓	✓	✗				
PETG	No	No	No	215-270 °C	70-90 °C	✓	! with glue stick	✓	✗				
PETG HT	No	No	No	270 °C	110 °C	✓	! with glue stick	✓	✗				
ASA	Yes recommended	No	No	220-275 °C	90-110 °C	! with glue stick	! with glue stick	✓	✓				
ABS	Yes recommended	No	No	230-255 °C	95-110 °C	! with glue stick	! with glue stick	✓	✓				
PC (Polycarbonate)	Yes recommended	No	No	270-275 °C	100-115 °C	! with glue stick	! with glue stick	✓	✗				
CPE	No	Yes	No	275 °C	90-110 °C	✓	! with glue stick	✓	✗				
PVA / BVOH	No	Yes	No	195-215 °C	60 °C	✓	✓	✓	✓				
HIPS	No	No	No	225-255 °C	100-110 °C	✓	✓	✓	✓				
PP (Polypropylene)	-	No	No	220-245 °C	0-100 °C	✗ not recommended	! with PP tape	✓	✗				
Flex	No	Yes	No	220-260 °C	40-85 °C	✓	! with glue stick	! with glue stick	✗				
nGen	No	No	No	240 °C	90 °C	✓	! with glue stick	✓	✗				
PA (Nylon)	Yes recommended	Yes	No	240-285 °C	70-115 °C	! with glue stick	✗ not recommended	! with glue stick	✗				
Composite materials	-	-	Yes	225-285 °C	40-115 °C	-	-	-	✗				
Wood / metal filled	No	No	-	190-220 °C	60-65 °C	✓	✓	✓	✗				
PVB	No	No	No	215 °C	75 °C	✗ not recommended	✓	✓	✓				

3. Survey based training needs of teachers and trainers

To assess existing and future qualification needs an online survey was carried out in 03/23 among 11 IT and natural science trainers1 from German and Cyprus. All of them use as computers for their training courses. 4/11 use whiteboards/smartboards. Common software is MS office (8/11), E-learning (6/11), learning video (6/11) and simulations (6/11).

The majority does not have experience with 3D scanning (10/11), 3D printing (9/11) and using interactive simulations (8/11).

Preferred qualification formats are ready-made teaching learning materials as well as learning videos.

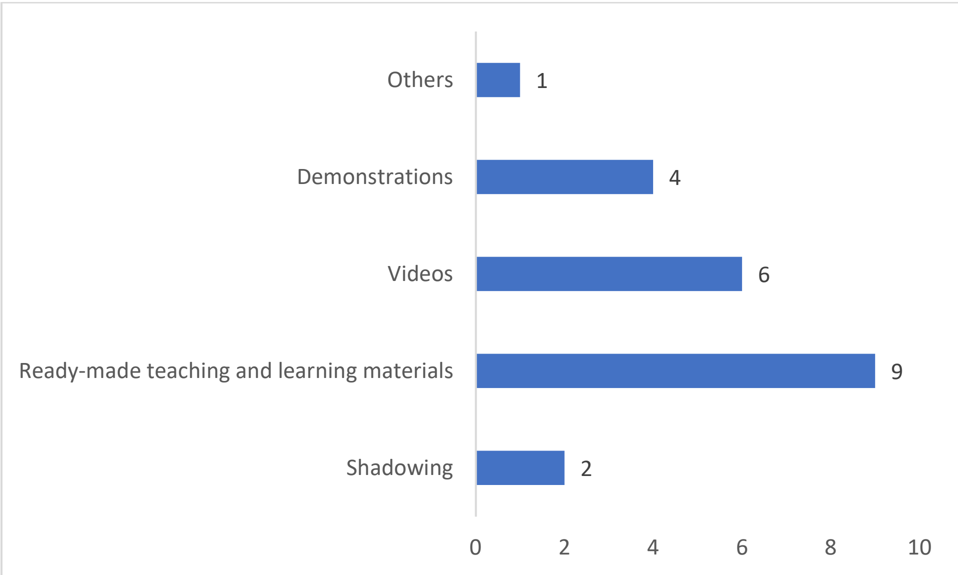


Figure 1. Qualification formats concerning 3D scanning, 3D printing and WebVR use

Indicated use cases are for 3D scanning and 3D printing are:

IT: Computer, router parts, network equipment (routers, switches, patch panels etc.), videos, visualisations

Industry (chemistry, biology, physics): Seals, wearing parts, robot arms and others for using micro controllers, models of molecules.

The subsequent in-depth interviews (DE: 1, CY: 1) showed similar results.

Faster 3D focusses on the pedagogically sound application of 3D scanning, 3D printing and WebVR in practical training. The pedagogical-sound application of these technologies requires the use of existing learning theories.

[1] IT-Instructor / teacher for CCNA, Microsoft Power BI, Programming languages and data analytics, Trainers for measurement and control (automatization), chemical engineering, chemistry/biology/physics

4. Qualification model for using 3D scanning, 3D printing and WebVR

The application of the Faster 3D (F3D) technologies must be easy and integrative to be used. In combination with the leading questions:

How can the the single or combined use of 3D scanning, 3D printing and WebVR ensure the reaching of the defined learning goals in practical training?

Existing learning theories provide frameworks and models to develop suitable approaches for technology enriched practical training.

To successfully implement a new technology within practical training a four-step approach is recommended.

Step 1: What effect the technology is expected to have.

The use of the SAMR model helps to classify the potential impact. SAMR stands for:

- Substitution (technology substitution, task the same),
- Augmentation (technology substitution, task enhancement),
- Modification (task redesign), and
- Redefinition (creation of new tasks).

The use of 3D scanning, 3D printing and WebVR is expected to rather **augment** existing working tasks by using these technologies to enrich the provision of professional and media skills further.

Step 2: Decision on sound combination of work knowledge, appropriate learning approaches technology and content.

The trainer and the apprentice require knowledge of following areas:

• Working Knowledge– What practical competences are necessary to master a task and how 3D scanning, 3D printing and WebVR support learning?
• Content Knowledge - What lesson content does he or she want to offer with 3D scanning, 3D printing and WebVR?
• Andragogy Knowledge or Adult learning approaches – What are appropriate ways to support and facilitate teaching and learning when using 3D scanning, 3D printing and WebVR?
• Technology Knowledge- How should 3D scanning, 3D printing and WebVR used to achieve the learning goals?

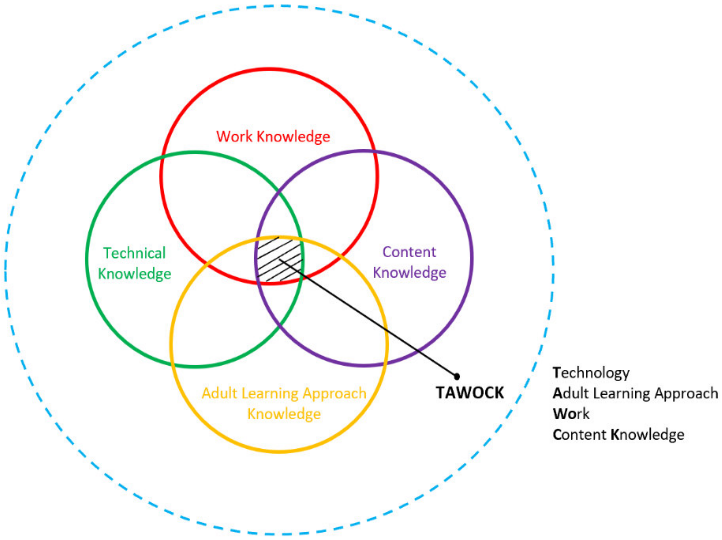


Figure 2. TAWOCK model elements

"TAWOCK" provides a framework for planning (lesson plan) and subsequent execution of practical trainings. It results in a technology-enriched and pedagogical effective provision of learning contents.

STEP 3: Decision on what are the learning objectives.

The integration of 3D scanning, 3D printing and WebVR in a specific lesson demands a careful description of the desired outcomes. This can reach from the provision of e. g. technical knowledge to the enrichment of communication and collaboration as a teaching method. The focus in practical training is according to Bloom (Appendix 1) for[2]:

a) 3D scanning: rather on activities such as "**clarify**", "**carry out**", "**integrate**" or "**judge**".
b) 3D printing: rather on activities such as "**clarify**", "**carry out**", "**integrate**" or "**judge**".
c) WebVR: rather on activities such as "**recognize**", "**recall**", "**summarize**" or "**classify**".

After the definition of the expected impact (augmentation), the integration of the relevant knowledge (TAWOCK) and the clarification of the learning objectives the lesson plan can be created. To assess the impact an evaluation must take place.

STEP 4: Evaluation of the scenario

The scenario-based integration of technologies is evaluated by formative assessments (questionnaires: trainer and self-assessment by learners). The forms are accessible in Appendix 2.

The four-step approach determines the F3D qualification model.

[2] See appendix 1 – clarification of learning objectives according to Blooms taxonomy.

5. Teaching and learning scenarios planning

The single or combined use of 3D scanning, 3D printing and WebVR is expected to support the provision of professional and media-skills as well as to increase the communication and collaboration among apprentices, by using learning stations (small-group) and presentation of results to bigger group (2+ apprentices). This will result in more self-directed and peer learning. This supports the transformation of the trainer role from an instructor to a moderator of the educational process. Modern technology, when applied in pedagogical sound way initiates and accelerates this development.

The focus on a practical training with single and complex working tasks are environment for creating specific 3D scanning, 3D printing and WebVR enriched teaching and learning scenarios. Learners are assigned to specific roles and face different problem situations. Herewith they obtain the demanded set of knowledge, skills, and competences. This way of training specifies roles, activities, resources, and relevant tools.

The 4-step approach (chapter 4) is the guideline to plan and assess the technology use.

As an example, the use of 3D scanning and 3D printing in practical training of chemical operators is planned. The focus is on the maintenance and repair of wearing parts in a chemical training plant.

STEP 1: What effect the technology is expected to have?

Augmentation, as new technology enhances the existing maintenance repairing task.

STEP 2: What work, technical and content knowledge shall be provided?

Work knowledge – Applying 3D printer and 3D scanner (hard- and software) during group work

Technical knowledge – Operate 3D scanner and 3D printer

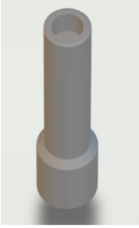
Content knowledge – Maintenance and repairing task in chemical training plant

STEP 3: What are the learning objectives? (Combining Steps 1+2)

The technology choices are intended to **augment** practical training. It is important to define for what working steps on which scenario and which way of provision (**TAWOCK[3] model**) 3D scanning and 3D printing is used. Both are focus rather on carry out or judge something.

Below a lesson plan on integrating 3D scanning and 3D printing of wearing parts in maintenance and repair tasks.

[3] See page 9.



Chemical plant: Participations in maintenance and repair with 3D scanning and 3D printing of a blind plug

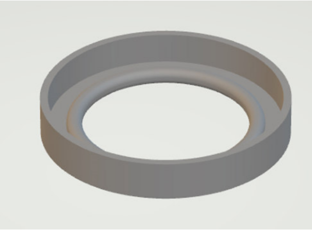
Dura -tion	**Learning phase**	**Learning content** **(What should the apprentice learn?)**	**Learning activities** **(Apprentice actions to meet the objectives?)**	**Teacher/trainer activities** **(What is the role of the teacher/trainer and what is he/she going to do?)**	**Communication and collaboration forms**	**Resources, tools and media** **(Which tools or media are used and how are they used?)**
60 min.	**Intro-duction and Orien-tation**	• Providing working task: Production of spare part (blind plug) • **3D scanner (Revopoint Range) or iPad 11**: How to do it? Advantages and disadvantages: safety rules, using technical equipment	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D scanning • Learn to use the 3D scanner by verbal and written instruction	• Providing safety rules • Providing introduction to 3D scanner • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D scanner (hardware and software) • Manual 3D scanner • Written instructions
120 min.	**Execution of the task**	• **Scanning blind plug** • Load scan in scanning software and change size if needed	• Learn functioning of the equipment • Learn to prepare scanning setting • Learn to scan	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• 3D scanner and 3D scanning software or iPad (with Polycam app)
30 min.	**Assess-ment /Check**	• **Operate the scanner or iPad according to the safety rules** • Check the quality of the scan data	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Computer

Dura -tion	Learning phase	Learning content **(What should the apprentice learn?)**	Learning activities **(Apprentice actions to meet the objectives?)**	Teacher/trainer activities **(What is the role of the teacher/trainer and what is he/she going to do?)**	Communication and collaboration forms	Resources, tools and media **(Which tools or media are used and how are they used?)**
30 min.	**Intro-duction and Orien-tation**	• Providing working task: Printing of blind plug • 3D printer: How to do it? Advantages and disadvantages: safety rules, using technical equipment, filament (PC/PTFE)	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D printing • Learn to use the 3D printer by verbal and written instruction	• Providing safety rules • Providing introduction to 3D printing • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D printer (hardware and software) • Filaments for 3D printing • Manual 3D printer • Writing instruction
90 min.	**Execution of the task**	• Select filament for printing (PC/PTFE) • Load blind plug scan in 3D slicer software • Printing blind plug	• Learn functioning of the 3D slicer program • Learn to prepare 3D scanning setting • Learn to 3D print	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• Slicer software and 3D printing software
30 min.	**Assess-ment /Check**	• Operate the 3D printer according to the safety rules • Check the quality of the 3D print • Installation of the 3D printed blind plug in the chemical plant	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Printed blind plug

Chemical plant: Participations in maintenance and repair with 3D scanning and 3D printing of a hose connection

Dura-tion	Learning phase	Learning content **(What should the apprentice learn?)**	Learning activities **(Apprentice actions to meet the objectives?)**	Teacher/trainer activities **(What is the role of the teacher/trainer and what is he/she going to do?)**	Communication and collaboration forms	Resources, tools and media **(Which tools or media are used and how are they used?)**
60 min.	**Intro-duction and Orien-tation**	• Providing working task: Production of spare part (hose connection) • **3D scanner (Revopoint Range) or iPad 11**: How to do it? Advantages and disadvantages: safety rules, using technical equipment	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D scanning • Learn to use the 3D scanner by verbal and written instruction	• Providing safety rules • Providing introduction to 3D scanner • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D scanner (hardware and software) • Manual 3D scanner • Written instructions
120 min.	**Execution of the task**	• **Scanning hose connection** • Load scan in scanning software and change size if needed	• Learn functioning of the equipment • Learn to prepare scanning setting • Learn to scan	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• 3D scanner and 3D scanning software or iPad (with Polycam app)
30 min.	**Assess-ment /Check**	• **Operate the scanner or iPad according to the safety rules** • Check the quality of the scan data	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Computer

Dura-tion	Learning phase	Learning content (What should the apprentice learn?)	Learning activities (Apprentice actions to meet the objectives?)	Teacher/trainer activities (What is the role of the teacher/trainer and what is he/she going to do?)	Communication and collaboration forms	Resources, tools and media (Which tools or media are used and how are they used?)
30 min.	**Intro-duction and Orien-tation**	• Providing working task: Printing of hose connection • 3D printer: How to do it? Advantages and disadvantages: safety rules, using technical equipment, filament (PC/PTFE)	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D printing • Learn to use the 3D printer by verbal and written instruction	• Providing safety rules • Providing introduction to 3D printing • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D printer (hardware and software) • Filaments for 3D printing • Manual 3D printer • Writing instruction
90 min.	**Execution of the task**	• Select filament for printing (PC/PTFE) • Load hose connection scan in 3D slicer software • Printing hose connection	• Learn functioning of the 3D slicer program • Learn to prepare 3D scanning setting • Learn to 3D print	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• Slicer software and 3D printing software
30 min.	**Assess-ment /Check**	• Operate the 3D printer according to the safety rules • Check the quality of the 3D print • Installation of the 3D printed hose connection in the chemical plant	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Printed hose connection



Chemical plant: Participations in maintenance and repair with 3D scanning and 3D printing of a ball socket

Dura-tion	Learning phase	Learning content (What should the apprentice learn?)	Learning activities (Apprentice actions to meet the objectives?)	Teacher/trainer activities (What is the role of the teacher/trainer and what is he/she going to do?)	Communication and collaboration forms	Resources, tools and media (Which tools or media are used and how are they used?)
60 min.	**Intro-duction and Orien-tation**	• Providing working task: Production of spare part (seal) • **3D scanner (Revopoint Range) or iPad 11**: How to do it? Advantages and disadvantages: safety rules, using technical equipment	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D scanning • Learn to use the 3D scanner by verbal and written instruction	• Providing safety rules • Providing introduction to 3D scanner • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D scanner (hardware and software) • Manual 3D scanner • Written instructions
120 min.	**Execu-tion of the task**	• **Scanning seal** • Load scan in scanning software and change size if needed	• Learn functioning of the equipment • Learn to prepare scanning setting • Learn to scan	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• 3D scanner and 3D scanning software or iPad (with Polycam app)
30 min.	**Assess-ment /Check**	• **Operate the scanner or iPad according to the safety rules** • Check the quality of the scan data	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Computer

Dura -tion	Learnin g phase	**Learning content** (What should the apprentice learn?)	**Learning activities** (Apprentice actions to meet the objectives?)	**Teacher/trainer activities** (What is the role of the teacher/trainer and what is he/she going to do?)	**Communication and collaboration forms**	**Resources, tools and media** (Which tools or media are used and how are they used?)
30 min.	**Intro-duction and Orien-tation**	• Providing working task: Printing of seal • 3D printer: How to do it? Advantages and disadvantages: safety rules, using technical equipment, filament (PC/PTFE)	• Work in small groups (2 person) on a learning station • Apprentices familiarize with the task of 3D printing • Learn to use the 3D printer by verbal and written instruction	• Providing safety rules • Providing introduction to 3D printing • Evaluating short report	• Trainer-apprentices (verbal instruction, report) • Collaboration in apprentice group at the learning station	• 3D printer (hardware and software) • Filaments for 3D printing • Manual 3D printer • Writing instruction
90 min.	**Execu-tion of the task**	• Select filament for printing (PC/PTFE) • Load seal scan in 3D slicer software • Printing seal	• Learn functioning of the 3D slicer program • Learn to prepare 3D scanning setting • Learn to 3D print	• Observe implementation and provide support if needed	• Apprentices – apprentice (group discussion) • Trainer - apprentice	• Slicer software and 3D printing software
30 min.	**Assess-ment /Check**	• Operate the 3D printer according to the safety rules • Check the quality of the 3D print • Installation of the 3D printed seal in the chemical plant	• Active participation in the group discussion moderate by the trainer	• Moderating discussion and evaluating the results	• Trainer-apprentices	• Printed seal

IT: 3D Scanning and WebVR Router/Firewall

Duration	Learning Phase	Learning Content	Learning Activities	Teacher/Trainer Activities	Communication and Collaboration Forms	Resources, Tools, and Media
30 min.	Introduction and Orientation	- Inform on working task to 3D scan the router/firewall - Usage of Advantages and disadvantages of 3D scanning	- Work in small groups on a learning station - Apprentices familiarize with the task of 3D scanning - Learn to use the 3D scanner by video and written instructions	- Provide introduction to 3D scanning with phone - Provide information and best practices when 3D scanning	- Trainer/apprentices (verbal instruction, report)	- Phone for 3D scanning - 3D scanner (software) - Video - Written instruction
90 min.	Execution of the Task	- Scanning process - Using 3D scanner and software - Use the webvr platform - Adjusting settings	- Learn functioning of the phone app - Learn to prepare scanning settings - Learn to scan - Learn to upload to webvr platform	- Observe implementation and provide support if needed	- Apprentices – apprentice (group discussion) - Trainer / apprentice	- Phone for 3D scanning - 3D scanner software and hardware -Webvr platform
30 min.	Assessment/Check	- Operating scanner on phone - Check quality of scan object	- Operate scanner following best practices – Evaluate scan quality	- Moderating discussion and evaluating the results	- Trainer/apprentices (verbal instruction, report)	- Computer - Phone

IT: 3D Scanning and WebVR Desktop PC Parts

Duration	Learning Phase	Learning Content	Learning Activities	Teacher/Trainer Activities	Communication and Collaboration Forms	Resources, Tools, and Media
30 min.	Introduction and Orientation	- Inform on the task of 3D scanning a PC computer. - Discuss advantages and disadvantages of 3D scanning.	- Work in small groups on a learning station - Apprentices familiarize with the task of 3D scanning - Learn to use the 3D scanner by video and written instructions	- Provide introduction to 3D scanning with phone - Provide information and best practices when 3D scanning	Trainer-apprentices (verbal instruction, report)	Phone for 3D scanning - 3D scanner (hardware and software) - Video - Manual 3D scanner - Written instruction
90 min.	Execution of the Task	- Scanning process for PC components. - Using the 3D scanner software - Use the webvr platfrom - Adjusting settings.	- Learn how to use the 3D scanning software for scanning PC parts. - Practice preparing scanning settings. - Perform scans of PC components. - Learn to upload to webvr platform	- Observe the implementation and provide assistance if needed.	Apprentices – apprentice (group discussion)	- Phone for 3D scanning - 3D scanner software and hardware - Webvr platform
30 min.	Assessment/Check	- Operating scanner on phone - Check quality of scan object	- Operate scanner following best practices – Evaluate scan quality	- Moderating discussion and evaluating the results	Trainer-apprentices (verbal instruction, report)	Phone for 3D scanning - 3D scanner software and hardware

IT: 3D Scanning and WebVR 3D Data Center Parts
patch Panel

Duration	Learning Phase	Learning Content	Learning Activities	Teacher/Trainer Activities	Communication and Collaboration Forms	Resources, Tools, and Media
30 min.	Introduction and Orientation	- Inform on the task of 3D scanning a Patch Panel. - Discuss advantages and disadvantages of 3D scanning.	- Work in small groups on a learning station - Apprentices familiarize with the task of 3D scanning - Learn to use the 3D scanner by video and written instructions	- Provide introduction to 3D scanning with phone - Provide information and best practices when 3D scanning	Trainer-apprentices (verbal instruction, report)	Phone for 3D scanning - 3D scanner (hardware and software) - Video - Manual 3D scanner - Written instruction
90 min.	Execution of the Task	- Scanning process for Patch Panel components. - Using the 3D scanner software - Use the webvr platfrom - Adjusting settings.	- Learn how to use the 3D scanning software for scanning patch panel parts. - Practice preparing scanning settings. - Perform scans of patch panel components. - Learn to upload to webvr platform	- Observe the implementation and provide assistance if needed.	Apprentices – apprentice (group discussion)	- Phone for 3D scanning - 3D scanner software and hardware -Webvr Platform
30 min.	Assessment/Check	- Operating scanner on phone - Check quality of scan object	- Operate scanner following best practices – Evaluate scan quality	- Moderating discussion and evaluating the results	Trainer-apprentices (verbal instruction, report)	Phone for 3D scanning - 3D scanner software and hardware

More information on using 3D scanning, 3D printing and WebVR will be available in the learning management system (LMS) of the project webpage: https://www.sbg-dresden.de/aktuelles/projekte/faster-3d.

6. Recommendations

The creation of fast 3D scans is possible with existing hard- and software. We recommend the following:

1. Ask the **pedagogical questions** first: What problem is solved? (provision of professional skills by modern technology, more self-directed and exploratory learning, increase of motivation among learners etc.)

2. Select scanning hardware according to your needs: Smartphone or Tablet (e. g. iPhone or iPad) for smaller objects, hand scanner (like Revopoint Range) for bigger objects. Plan some time for post-processing to add a ground, colour etc.)

3. When scanning, use a turntable and sufficient lighting.

4. For: a) smaller and simpler objects under 50cm in size– design it, b) for objects of >50cm use smartphone or tablet app or a hand-scanner

5. The selection of the 3D printer should be tailored to your needs. For the chemistry scenario, we needed higher printing temperature (up to 300°C) to apply special filament PC/PTFE, which is more thermic stable, when used in the chemical plant.

6. A good 3D design software is FreeCad or Blender. We made good experiences with the slicer software ideaMaker from Raise. Common are also PrusaSlicer (for Prusa 3D printers) and Ultimaker Cura.

7. Select the printing material (filament) according to your needs. Common are PLA (polylactic acid), a biodegradable and eco-friendly material that is easy to print and comes in a wide range of colours, as well as ABS (acrylonitrile-butadiene-styrene), which is a durable and impact-resistant material commonly used for making toys, automotive parts, and electronic housings.

8. Optimize the printing condition like temperature, printing speed, ventilation speed etc.

9. Higher quality scans ensures easier use as WebVR.

10. For the continuous professional development of training personal to inspire them be discussions on their specific needs (e. g. media-pedagogy) followed by exploring the possibilities during e. g. hands-on sessions, which are tailored to their specific (in-class or in-training) needs.

11. To support the digital transformation process of educational organisations by providing the freedom to explore and experiment at first among selected training personal, who transfers the learnings to decision-makers and further teachers/trainers. This will start a vivid cycle of technology screening and testing to support the reflection of current and future needs. It will anticipate qualification needs as well as contributes to the future preparedness of organisations.

APPENDICES

APPENDIX 1: Formulation of learning objectives (Bloom)


Create an innovative learning portfolio.
Reflect on one's progress.
Design an efficient project workflow.
Deconstruct one's biases.
Judge efficiency of sampling techniques.
Assemble a team of experts.
Use techniques that match one's strengths.
Integrate compliance with regulations.
Determine relevance of results.
Generate a log of daily activities.
Predict one's response to culture shock.
Carry out pH tests of water samples.
Differentiate high and low culture.
Check for consistency among sources.
Identify strategies for retaining information.
Clarify assembly instructions.
Provide advice to novices.
Select the most complete list of activities.
Recall how to perform CPR.
Classify adhesives by toxicity.
Respond to frequently asked questions.
Recognize symptoms of exhaustion.
Summarize features of a new product.
List primary and secondary colors.
metacognitive
Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.
procedural
How to do something, methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
conceptual
The interrelationships among the basic elements within a larger structure that enable them to function together.
factual
The basic elements students must know to be acquainted with a discipline or solve problems in it.
The Knowledge Dimension
create
Put elements together to form a coherent whole; reorganize into a new pattern or structure.
evaluate
Make judgements based on criteria and standards.
analyze
Break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose.
apply
Carry out or use a procedure in a given situation.
understand
Construct meaning from instructional messages, including oral, written, and graphic communication.
remember
Retrieve relevant knowledge from long-term memory.
The Cognitive Process Dimension

APPENDIX 2: Evaluation

LEARNER FEEDBACK / SELF-ASSESSMENT (CLASSROOM TRAINING) on tools tested and learning methods applied

Scaled questions (suggest 5-point scale).

Question	Yes/Very much/ A lot				No/ Not at all
Did you find the session/course well organised and structured?					
Did you find the process straightforward to follow?					
Do you feel that your understanding of the topic has increased?					
How satisfied are you with your performance of the tasks?					
How confident are you that you can use what you have learned at work/in an independent project?					
Did you find it easy to recover from mistakes or misunderstandings?					
Did you find it easy to get answers to any questions you had?					
Was the technology (3D scanning, 3D printing, WebVR) comfortable to use?					
Was it easy to find your way around the technology?					
Was it easy to move from one step to the next using the technology?					
Did you feel that the technology helped you learn?					
…					

OBSERVATION (CLASSROOM TRAINING AND LIVE TRAINING)

This template is for multiple learners for one major activity or task.

Activity													
Observer													
Name	**Qs**	**Help**	**Step 1**		**Step 2**		**Step 3**		**Step 4**		**Total**		**Level**
			Time	Err	Time	Err	Time	Err	Time	Err	Time	Err	

Note on columns:

- Questions – these are questions seeking to clarify process, get feedback etc. Ignore 'interest' questions e. g. asking for more advanced knowledge.
- Help – where the learner is stuck and needs the trainer's help to move on.
- Time – to complete the step.
- Errors – number of obvious errors at end of step.
- (If there are no clear breaks in the process, ignore the intermediate steps).
- Level – decide on a scale e.g. 1-5 each with clear criteria (e.g. novice-to-expert definitions, see end of document).

Comments:

Add your comments e. g. about learners' engagement and 'flow', and for technology-mediated groups their ease of use of the technology.

ASSESSMENT (CLASSROOM TRAINING AND LIVE TRAINING)

This is a rough outline as there may be other requirements e. g. if it is contributing to certification.

Learner:

Assessor:

Date of assessment (and how long after training):

Description of task or activity:

EQF/national level if relevant:

Success criteria (these will normally be, or be an expansion of, the learning objectives):

Criterion	Achieved	Comments

For the task overall, what level of proficiency did the learner reach? (Use a scale with clear description – see the example at the end).