IO1

Report on the situation and evolution of Additive Manufacturing in the Toolmaking & Habitat sectors and related VET training offer: high-tech T-shaped skills and competences in different occupations (mismatches and needs).

SKILLS IN ADDITIVE FOR THE TOOLMAKING MANUFACTURING AND HABITAT SECTORS

SAMANTHA

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Introduction

This document is the result of a careful analysis carried out in SAMANTHA - Skills in Additive MANufacturing for the Toolmaking and HAbitat Sectors project (project number: 2019-1-DE02-KA202-006458) funded by the European Commission through the Erasmus+ programme - KA2, Strategic Partnership for Innovation and Exchange of good practices.

SAMANTHA project aims to develop a novel training program addressing the mismatched high-tech, T-shaped skills for proper implementation of Additive Manufacturing (AM) in the value chains of such sectors through high qualified workers.

The project is carried on by a consortium of partners composed by: Karlsruher Institut für Technologie (KIT) (Germany), ILI - FRIEDRICH-ALEXANDER-UNIVERSITAET ERLANGEN NUERNBERG (Germany), AMUEBLA - AGRUPACION EMPRESARIAL INNOVADORA DE FABRICANTES DE MUEBLES Y AFINES DE LA REGION DE MURCIA (Spain), Cenfim – CENTRE DE DIFUSIO TECNOLOGICA DE LA FUSTA I DEL MOBLE DE CATALUNYA (Spain), CEIPES – Centro Internazionale per la Promozione dell'Educazione e lo Sviluppo (Italy), Centrocot – CENTRO TESSILE COTONIERO E ABBIGLIAMENTO SPA (Italy) e TECOS - Razvojni center orodjarstva Slovenije (Slovenia).

This report is composed of 5 part:

- the first one is the result of a research that partners carried out during the first phase of the implementation of the project. It focuses on the definition of the two sectors (habitat and toolmaking) and an analysis of professional categories related to them.
- The second part is related with the results of two questionnaires one for the Habitat sector and one for the toolmaking industry with whom partners found out what is the level of implementation of Additive Manufacturing, the desired and needed technological skills in workers curriculum, competences mismatches and needs for the training in these 2 sectors.

- The third part is an overview on transversal skills (T-shaped) needed or mismatched in Habitat and tool making sectors in the current panorama.
- The fourth part is related with the results of two questionnaires addressed to teachers and students and an analysis of the current VET training offer related to the Toolmaking & Habitat sectors with regards to Additive Manufacturing in each partner country.
- The fifth part concerns the results of the standardisation of national and European qualification systems among partners countries.

Thanks to this document the consortium of partners had the possibility to understand the current scenario and the needs of the target group involved in the Toolmaking and Habitat sectors and to develop the main content of the project.

To achieve the established results, the project partners used different methods and tools:

- For the analysis of professional categories related to the toolmaking and Habitat sector they used the ESCO database.
- For the questionnaires, they made simple multiple-choice questions, to involve the target group selected in a faster and easy way and without having to request too much effort to complete the them.

  Also, each partner country implemented the questionnaires using different platforms and tools in order to reach the selected targets in the best possible way. Subsequently the results were collected in a single document to facilitate the analysis.

- For the analysis of VET curricula, the consortium partner used a compilation method. The sources they have been taken into account come both from the internet, website and from face-to-face interviews that have been made to teachers and students that are attending or attended technological study courses.

In particular, partners have been analysed some internet sites that offer e-learning courses on AM technology and websites of schools that offer AM or specifically 3D printing courses.

Furthermore, the consortium of partners analysed the European, national and regional training offer of the schools in the vocational education and training field.

- For the standardisation of national and European qualification systems among partners countries, each partner analysed the current VET system in its own country, given clue document to the leader of the activity. In the end, they realised a template to better define and identify the main characteristics of the modules they are creating.

In general, all the sources that partners have been taken into account come both from the Web and from face-to-face interviews that partners have been made to teachers and students that are attending or attended technological study courses or to employee and employers of the two sectors in question.

For the analysis of the existing training offers, partners have been analysed some internet sites that offer e-learning courses on AM technology and others of schools that offer AM or in the specific 3D printing courses.

Furthermore, partners analysed the national and regional training offers of the VET institutes thanks to specific interviews with teachers involved in these fields.

Also, some results have been taken from European project websites aimed at the creation of tools for the education and vocational training system focused on 3D printing technology in the school and professional fields.

Other results have been collected thanks to some opinions given to partners by the teachers and students of their network with whom they collaborate for the different projects in the technological field.

In the end of this document it is possible to find a general conclusion about the research carried out.

1. A clear description of habitat and toolmaking sectors.

1.1 What is the Habitat sector?

Furniture industry is a labour-intensive and dynamic sector dominated by small and medium-sized enterprises (SMEs) and micro firms. EU furniture manufacturers have a good reputation worldwide thanks to their creative capacity for new designs and responsiveness to new demands. The industry is able to combine new technologies and innovation with cultural heritage and style and provides jobs for highly skilled workers.[1]

On the other hand, habitat sector is very broad and includes a wide disparity of products with very different exhibition needs, from lamps to fabrics, without forgetting large furniture.[2]

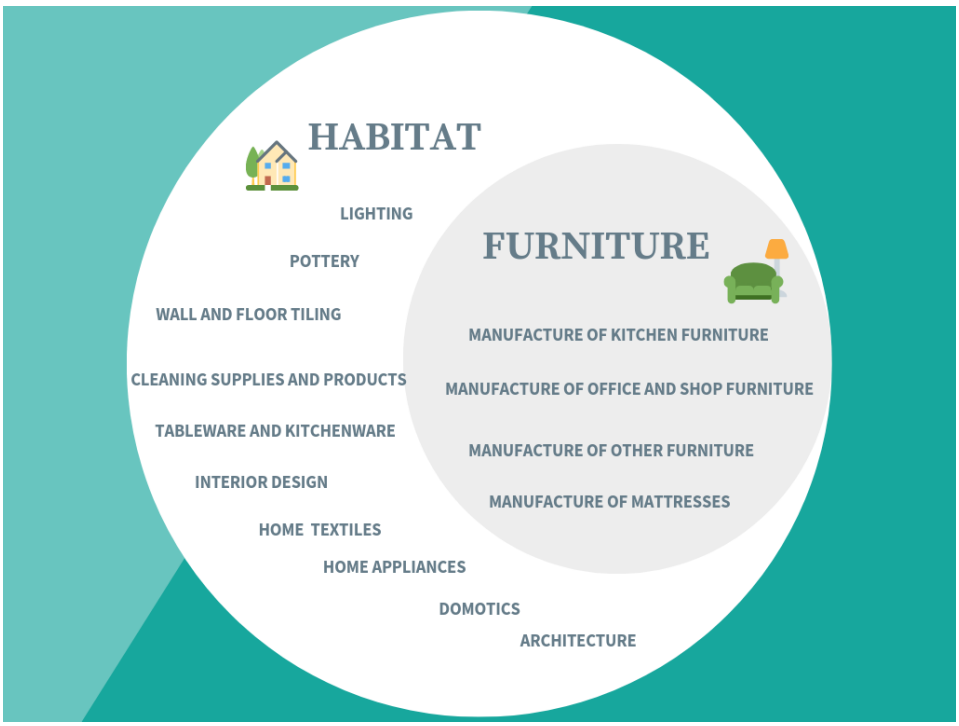

Figure 1. Differences between Furniture and Habitat sector. Source: NACE Group 36 & ICEX (Own elaboration) [3] [4]

[1] https://ec.europa.eu/growth/sectors/raw-materials/industries/forest-based/furniture_en

[2] http://en.escato.es/destacados/habitat-sector-37/

[3] https://www.cnae.com.es/obtener-cnae-4.php?nivel=310

[4] https://www.icex.es/icex/es/index.html

According to ICEX classification (Spain export and Investment) the Habitat sector is included in the consumer goods sector and is composed by:

Group 3 – Consumer goods → Habitat:

- Textile.
- Home appliances.
- Furniture.
- Lighting.
- Tableware and kitchenware.
- Decoration accessories.
- Cleaning items and products.

1.2 What is the Toolmaking sector?

A toolmaker is responsible for making precision tools (such as jigs, moulds and dies), special guides and holding devices, which are then used in the manufacturing process to make products. For example, a toolmaker might make the parts used on a car assembly line, or the part of a machine that fills a chocolate shell. They will work with a variety of materials including metals, alloys, plastics and ceramics, which are referred to as stocks or castings.

A toolmaker's job doesn't stop once they've produced the tools though; they will then monitor these tools to identify, and implement, any necessary modification or repairs. A toolmaker's job will also involve using computer numerically controlled (CNC) machines, so a solid background in a variety of technical and IT processes is very important.

Toolmaking skills are normally developed through apprenticeships. The role has evolved over time. Toolmakers frequently require a good knowledge of polymers, and may be more heavily involved in tool design, tool maintenance and optimising tool usage than in tool manufacture.

Many toolmakers develop skills in machine programming and automation after acquiring the core skills associated with the occupation. The number of toolmaking apprentices taken on by industry decreased through the 2000s and fell sharply with the economic crisis in 2008-2009. It has recovered partially since then. A number of firms consulted noted that many of their toolmakers are over the age of 50, and that retirements may contribute to future shortages.

1.3 Analysis of categories related the habitat sector

After having given a clear definition of the habitat and toolmaking sectors, the project partners analysed through the ESCO database which could be the professional categories to be considered for the specific project's target.

ESCO (European Skills, Competences, Qualifications and Occupations) is a European multilingual classification of Skills, Competences, Qualifications and Occupations. ESCO works as a dictionary, describing, identifying and classifying professional occupations, skills, and qualifications relevant for the EU labour market and education and training.

Those concepts and the relationships between them can be understood by electronic systems, which allows different online platforms to use ESCO for services like matching jobseekers to jobs on the basis of their skills, suggesting trainings to people who want to reskill or upskill etc.

ESCO provides descriptions of 2942 occupations and 13.485 skills linked to these occupations, translated into 27 languages (all official EU languages plus Icelandic, Norwegian and Arabic). Over time, it will also display the qualifications awarded in the education and training systems from Member States, as well as qualifications issued by private awarding bodies.

In total for the habitat sector the partners identified 11 categories and 38 specific professions, on the other hand for the toolmaking sector the partners identified 9 categories and 41 specific professions.

The following tables summarises the research conducted.

Analysis of categories related to the habitat sector

CATEGORIES	OCCUPATION	LINK TO ESCO DATABASE
LIGHTING	Furniture, carpets and lighting equipment distribution manager	http://data.europa.eu/esco/occupation/bd7c070b-333f-4b9d-a70a-25f135ff931e
POTTERY	Ceramist	http://data.europa.eu/esco/occupation/ec0e64c9-6d9b-4a9f-a022-a418f3b381fe
TABLEWARE AND KITCHENWARE	Production potter	http://data.europa.eu/esco/occupation/97896345-d102-4549-97a5-8851979e6938
FURNITURE	Furniture designer	http://data.europa.eu/esco/occupation/bc4d1659-6860-488e-bc13-e87eb0e36f67
	Cabinet maker	http://data.europa.eu/esco/occupation/e1416610-ad08-4f37-8b46-9f99632a5c0f
	Upholsterer	http://data.europa.eu/esco/occupation/95a89206-4dc8-4753-a5d9-bc14a0e5f7ca
	Mattress makers	http://data.europa.eu/esco/occupation/92dc335d-a116-416f-ad2b-257e5382e574
HOME TEXTILES	Textile product developer	http://data.europa.eu/esco/occupation/6833077e-e521-4605-bc1a-893f4b3d811c
BUILDING FRAME AND RELATED TRADES WORKER	Carpenters and joiners	http://data.europa.eu/esco/isco/C7115
INTERIOR DESIGN / ARTCHITECTURE	Architects, planners, surveyors and designers	http://data.europa.eu/esco/isco/C216
	Building architects	http://data.europa.eu/esco/isco/C2161
	Landscape architect	http://data.europa.eu/esco/occupation/52207284-2681-40d3-a317-ec81ca1b3e41
	Illustrator	http://data.europa.eu/esco/occupation/1b949bae-882f-40ff-9fe7-3c8ede5e38b5
	3D modeller	http://data.europa.eu/esco/occupation/bab5fa79-7f96-4e21-87b6-1eba560b8d9a
	Graphic designer	http://data.europa.eu/esco/occupation/69bcbb0a-8d80-4ecd-b0a4-9adea2a40de2

	Industrial designer	http://data.europa.eu/esco/occupation/ab7bccb2-6f81-4a3d-a0c0-fca5d47d2775
	Automotive designer	http://data.europa.eu/esco/occupation/1d8f8111-79dd-41dc-aa2a-12f3192dde3c
DOMOTICS	Mechatronics engineer	http://data.europa.eu/esco/occupation/ab360abd-32e2-4e03-967d-a10758efffa7
	Mechatronics assembler	http://data.europa.eu/esco/occupation/1a6d1acf-5956-4ba0-95bf-b15b05a02013
HOME APPLIANCES	Household appliances repair technician	http://data.europa.eu/esco/occupation/f4eaff3d-f8d0-4a6a-aa90-76827c0fbada
WALL AND FLOOR TILLING	Building finishers and related trades worker	http://data.europa.eu/esco/isco/C712
	Hand brick moulder	http://data.europa.eu/esco/occupation/149062d6-6496-4004-9c23-93c78b29b5db
	Heating, ventilation, air conditioning (and refrigeration) service engineer	http://data.europa.eu/esco/occupation/79f435d0-9bc6-4d25-a26a-acbe16569ebb
	Plasterer	http://data.europa.eu/esco/occupation/f4a22809-c00c-4dd0-8b09-c7251f8dcd1c
	Plumbers and pipe fitters	http://data.europa.eu/esco/isco/C7126
	Insulation workers	http://data.europa.eu/esco/isco/C7124
	Glaziers	http://data.europa.eu/esco/isco/C7125
	Floor layers and tile setters	http://data.europa.eu/esco/isco/C7122
	Roofers	http://data.europa.eu/esco/isco/C7121
	Resilient floor layer	http://data.europa.eu/esco/occupation/0663d464-f139-4554-ae87-97aa6c4dad77
	Carpet fitter	http://data.europa.eu/esco/occupation/e43d0f86-7abf-4c6e-b2b3-10970ddf6518
	Tile fitter	http://data.europa.eu/esco/occupation/02447817-ea01-4d8b-b09c-8bc128e447e6
	Hardwood floor layer	http://data.europa.eu/esco/occupation/4f1bb8b4-3fff-4e68-b427-8c892534a181
	Ceiling installer	http://data.europa.eu/esco/occupation/41a8e7c8-e1d8-4984-9b3c-dbbad1699f83
TEXTILE	Textile designer	http://data.europa.eu/esco/occupation/0f7c84c5-1c0d-4fc1-8949-07dbe8bd34ef
	Textile technologist	http://data.europa.eu/esco/occupation/85acc7e9-1fac-4e91-962b-8b8031f39487
	Fashion designer	http://data.europa.eu/esco/occupation/77bfd6e7-5598-4818-84cb-31e2651eb046

Analysis of categories related to the toolmaking sector

CATEGORIES	OCCUPATION	LINK TO ESCO DATABASE
MECHANICAL ENGINEERING	Tooling engineer	http://data.europa.eu/esco/occupation/79fed799-ab3a-43d9-bd91-414c2c3b2f57
	Mechanical engineer	http://data.europa.eu/esco/occupation/579254cf-6d69-4889-9000-9c79dc568644
	Equipment engineers	http://data.europa.eu/esco/occupation/1c36dd08-f6a7-43f2-a889-beebedb71c25
	Industrial tool design engineer	http://data.europa.eu/esco/occupation/53d2052f-edc0-4f44-8be1-164526412bfe
PRODUCT AND GARMENTDESIGNERS	Industrial designer	http://data.europa.eu/esco/occupation/ab7bccb2-6f81-4a3d-a0c0-fca5d47d2775
	Furniture designer	http://data.europa.eu/esco/occupation/bc4d1659-6860-488e-bc13-e87eb0e36f67
TOOLMAKERS AND RELATED WORKERS	Toolmakers	http://data.europa.eu/esco/isco/C7222
	Precision mechanic	http://data.europa.eu/esco/occupation/d1974e0c-8f92-473b-a32d-f0616c08b1ff
	Tool and die maker	http://data.europa.eu/esco/occupation/ecac98ea-9fc3-4475-9b23-8af94f41603d
	Casting mould maker	http://data.europa.eu/esco/occupation/2a8d6b4c-661d-4620-8f68-2c99e78f512e
METAL MOULDERS AND COREMAKERS	Foundry operative	http://data.europa.eu/esco/occupation/dc14bed4-87ca-4e6c-9f69-458e2689d2d6
WOOD TREATERS, CABINET-MAKERS AND RE-LATES TRADES WORKERS	Woodworking-machine tool setters and operators	http://data.europa.eu/esco/isco/C7523
METAL POLOSHER, WHEEL GRINDERS AND TOOL SHARPENERS	Tool grinder	http://data.europa.eu/esco/occupation/835d118e-11db-4b11-b055-d78bfe426cac
DRAUGTSPERSON	3D printing technician	http://data.europa.eu/esco/occupation/4cf7be91-fed9-47a7-9ca9-e74c7eb6becb
METAL WORKING MACHINE TOOL SETTERS AND OP-ERATORS	Metal working machine tool setters and operators	http://data.europa.eu/esco/isco/C7223
	Heat treatment furnace operator	http://data.europa.eu/esco/occupation/a51ab2e2-aaa9-4d7d-a747-bff2e276636a
	Router operator	http://data.europa.eu/esco/occupation/98164d70-93a8-409c-aa9f-7d56314f4d7f
	Ornamental metal worker	http://data.europa.eu/esco/occupation/c44f9f8c-46a6-40da-9630-cc568a18cc51
	Fitter and turner	http://data.europa.eu/esco/occupation/898f99f7-8c0a-4212-9e58-9ab00379e5ae
	Stamping press operator	http://data.europa.eu/esco/occupation/60b9b847-d964-4a8a-a756-904080b0f35f

	Briquetting machine operator	http://data.europa.eu/esco/occupation/0f905036-055f-41d9-b292-e3c02617a193
	Drilling machine operator	http://data.europa.eu/esco/occupation/ebe42b55-4801-493f-af18-04a35ebfbb9c
	Metal planer operator	http://data.europa.eu/esco/occupation/a5245c01-4ca8-406e-a152-620c28530ea8
	Scrap metal operative	http://data.europa.eu/esco/occupation/cb3432f8-bad7-4703-ba66-dc980a4ce4f7
	Laser marking machine operator	http://data.europa.eu/esco/occupation/733d65ac-250b-45d7-ba3c-cc5f48e9e11d
	Plasma cutting machine operator	http://data.europa.eu/esco/occupation/16811760-fb2d-42cf-912d-2215f085898f
	Moulding machine operator	http://data.europa.eu/esco/occupation/23043d05-42c4-4811-b478-f8a17d22480b
	Metal nibbling operator	http://data.europa.eu/esco/occupation/669353c2-3f5a-4bc4-939b-6afb6a0c7d13
	Computer numerical control machine operator	http://data.europa.eu/esco/occupation/5c082067-ea18-4ccb-8c43-e70b18ad8120
	Gear machinist	http://data.europa.eu/esco/occupation/02d4f153-8e43-444d-8bd4-8171d49eab12
	Oxy fuel burning machine operator	http://data.europa.eu/esco/occupation/5d46e448-b6bb-48e5-b245-5aad68e06085
	Boring machine operator	http://data.europa.eu/esco/occupation/0e09c42d-bff2-4c35-8e1f-639a6dddaa5d
	Straightening machine operator	http://data.europa.eu/esco/occupation/a67721a6-a95d-4c3b-a48c-f9920941ecd1
	Spark erosion machine operator	http://data.europa.eu/esco/occupation/18a98579-f0b1-4dde-944f-1758dc113099
	Screw machine operator	http://data.europa.eu/esco/occupation/2fc8dace-d828-4af3-b0cb-e1cb73726f4b
	Swaging machine operator	http://data.europa.eu/esco/occupation/d792974a-077b-44a7-9421-b3ab7fdc7c40
	Drill press operator	http://data.europa.eu/esco/occupation/aa3780b7-3b06-40ae-8764-293fec6819d2
	Upsetting machine operator	http://data.europa.eu/esco/occupation/8d3cc890-5902-4fac-9438-6098a3ee437c
	Chain making machine operator	http://data.europa.eu/esco/occupation/afe9eaa4-433f-4ae6-90ff-afa098ccf1bb
	Thread rolling machine operator	http://data.europa.eu/esco/occupation/77a25ee0-94ad-443e-91ea-3e6d3506181b

SHEET AND STRUCTURAL METAL WORKERS, MOD-ULERS AND WELDERS, AND RELATED WORKERS	Sheet-metal workers	http://data.europa.eu/esco/isco/C7213

2. Questionnaires addressed to the Toolmaking Industry experts and Habitat sector experts related with AM technology

2.1 Toolmaking sector

This chapter presents the result of a specially prepared questionnaire for the toolmaking industry with whom the partners found out what is the level of implementation of Additive Manufacturing, what are the desired and needed technological skills in workers curriculum and the competences mismatches and what is needed in updating the training in this sector.

With specially prepared questionnaire for toolmaking industry the consortium partners wanted to address toolmaking industry experts (employers and employees) which are familiar with Additive Manufacturing field in order to see their expertise level (skills) and current knowledge of AM technology, sector needs, materials used in AM, AM services, part design for AM, usage of any CAD templates, CAD programs and part design for AM, materials and machines for the toolmaking sector, more in-depth understanding of material characteristics, process parameters, and machine designs.

The consortium of partners delivered the questionnaire to 99 Toolmaking Industry Experts from the engineering world in the following countries: Italy, Spain, Slovenia and Germany.

In total 37 different professions were involved from which some are very similar so we can say around 29 different professions (more or less) in this phase were involved.

In particular these professions are: Artisan 2.0, Furniture designer, Lab. technician - 3DP technician, Electrical engineer, Architect, Interior designer, CAD machinery operator, Process Control Engineer, Metallurgy technician, Production operator, 3D printing technician, Production manager, Researcher, Product Design Engineer, Heating technician, Technical engineer, Environmental engineer, IT engineer, Mechanical engineer, Industrial engineering, Economics, Inventor, Industrial Designer, Designer, Precision mechanic, Head of additive manufacturing / digital manufacturing, Engineer, Mould maker and Master Toolmaker.

In total the consortium of partners collected 99 responses (9 – Germany, 29- Italy, 31 – Slovenia and 30 – Spain) from which around 70% men and 30% female gender. Furthermore, from 99 responses there were 47,5% employers and 52,5% employees. The respondents were in the age group between 23-64 years. In general, partners received the most responses from 29 years old (9x), followed by 35 years old (6x), then 27, 30, 32 and 43 years old (each 5x). Less than 5 responses were received from all other respondents who participated inside the mentioned age group.

The collected and analysed results of the questionnaire in O1/A1 showed that although experts are familiar with the technology itself and some materials. There is a lack of knowledge in AM technology for Toolmaking industry which is a specific industry where both plastic and metal materials can be used for part production along with different process parameters and AM equipment which is dependent on the used material.

Another mismatch is the part design and construction where some of the experts are not interested to do it in-house so they rather go to search for an online solution which is normally free but can be also payable (certain CAD model templates).

The consortium of partners supposed this is due to the fact that experts and their companies wants to save development costs and get faster to the market. From the results also partners saw that experts don’t use materials with implications for recyclability and they had no prior AM knowledge/skills they could use in the toolmaking industry.

To have the complete report of the IO1A1 in English language please, click the following link: https://drive.google.com/open?id=11SYbEFAQXNSk_wIisCmeBQXt9I_LhnrM

2.2 Habitat sector

This analysis report presents the valuable collected results of a specially prepared questionnaire for the habitat industry with whom we found out what is the level of implementation of Additive Manufacturing, the desired and needed technological skills in workers curriculum, competences mismatches and in updating the training in this sector.

As the toolmaking sector partners prepared a questionnaire for the habitat industry to address to habitat industry employers and employees which are familiar with Additive Manufacturing field in order to see their skills and current knowledge of AM technology and sector needs.

Thanks to this document the consortium of partners had the possibility to understand the current scenario and the needs of the target group involved in the habitat sector.

The consortium of partners delivered the questionnaire to 95 habitat industry experts from the engineering world in the following countries: Italy, Spain, Slovenia and Germany.

Below partners are presenting the final obtained results of the questionnaires that were delivered to various industry experts familiar with the habitat industry sector.

In total the consortium partners collected 95 responses (5 – Germany, 30 – Italy, 30 – Slovenia and 30 – Spain).

The main conclusions of this survey are:

- The level of knowledge of the AM technology is quite high (3.08/4) among respondents. More than the 75% (3.24%) believe that AM technology is important for the habitat sector.

- Respondents consider that the most important applications of AM technology for the habitat sector are:

  i) for prototype manufacturing (72.6%)

  ii) for parts/elements manufacturing (67.4%),

  iii) finished products manufacturing (27.4%)

  iv) tools manufacturing (27.4%).

- Almost all respondents (81%) believe that the skill most related with AM technology is Design & Modelling.

- Respondents consider that AM's most important service for the user is manufacturing and training. Almost half of the interviewed companies (37.9%) are not yet using AM technology. Of those who already use it, do it for:

  i) prototype manufacturing (36.8%)

  ii) part/elements manufacturing (18.9%).

- Respondents have a high level of knowledge about how to design an element for AM, the average level is above 70% (2.93/4). More than 70% of the respondents that use AM technology, uses CAD templates. Most of the companies that use AM technology (71%), use design & modelling software (In descending order of use: Solid works, NX, AutoCAD, Inventor, 3ds MAX and Fusion360).

- There is a high level of knowledge, more than the 75% (3.31/4) about how machines for AM technology work. The knowledge about what materials to choose for a specific application of AM technology is also high (2.97/4). There is also a high level of knowledge (3.05/4) about which AM equipment can be used in the Habitat sector.

To have the complete report of the IO1A2 in English language please, click the following link:

https://drive.google.com/open?id=1UFXItpJlxI1rhBz0EpI8QMstd_55wAbt

3. European overview on transversal skills (T-shaped) needed or mismatched in the habitat and toolmaking sectors.

In the early 90s, the concept of vertical and horizontal classification of skills came out. T-shaped refers to someone who possesses deep skills along with a broad base of shallow ones. The concept splits the T letter into two bars – horizontal one and vertical one.

Essentially, the T-shaped concept is a metaphor for the depth and breadth that an individual has in their skills. The vertical bar on the 'T' represents the depth of related skills and expertise in a single field, whereas the horizontal bar represents a breadth of skills and the ability to collaborate across disciplines with experts in other areas and to apply knowledge in areas of expertise other than one's own.

Nowadays, in a general context, on one hand there are the industries that are moving towards a T-shaped model, on the other hands there are universities who are slow to do the same with their curricula.

Currently many college and university graduates are trained to be productive in one field, but employers are placing increasing importance on skills that reach beyond a single discipline or focus. Upon graduation, students should be able to handle information from multiple sources, advance professional relationships across different organizations, contribute innovatively to organizational practices, and communicate with understanding across social, cultural, economic and scientific disciplines. Tomorrow's workers will build their careers in a globally interconnected and constantly changing world with smarter technologies in an effort to effect positive global change.

Today's T-shaped professionals are in contrast to I-shaped professionals of the past. During the 20th century, universities produced I-shaped graduates, deep in one area, and jobs changed relatively slowly. For I-shapes, just one area of depth could easily last a decade, if not an entire career.

In contrast to I-shaped professionals, T-shaped professionals are characterised by breadth as well as depth. T-shaped breadth requires a type of boundary spanning ability, boundary spanning being the ability to communicate across disciplines, systems, and cultures, as well as self-knowledge, or the "me" in the T.

In the 21st century, T-shaped professionals are sought for complexity and the pace of change.

Complexity means the number of areas of knowledge that must be combined to solve problems that are growing.

The pace of change is driven largely by rapid technological changes, but demographic, social, economic, environmental, and regulatory changes also contribute.

T-shape is a way to navigate and present individual career experience with breadth of experience (top of the T) with depth in a recognised discipline (the "I" of the "T"). The core idea is to enable professionals to work with others in complementary disciplines and to be able to pivot with uncertainty and changing workplace requirements.

In general, skills that are good to have no matter what you are doing as a specialist are:

- A broad knowledge about something (law, economy, software development, linguistics…).
- A broader context for your specialised skill set (SEO expert – e.g. internet marketing).
- A basic knowledge of how humans and the society work (biology, psychology, sociology…).
- Understanding the industry, you work in, its trends and paradigms.
- Basic knowledge of how the business world Works.

Some Soft skills it's good to have:

- Teamwork.
- Communication skills and networking, with good enough English skills.
- Time management.
- Information technology.
- Tolerance and open-mindedness.

Soft skills that provide additional value are:

- Leadership and organization.
- Negotiations.
- Presentations and giving lectures.
- Creativity and innovation.
- The basics of marketing and sales.

A problem that is often debated nowadays is that of the competitiveness of the European industry is highly dependent on the knowledge, skills, competencies and creativity of the workforce. Potential gaps on skills development combined with mismatches directly influence the job creation negatively. The World Economic Forum expects that the Fourth Industrial revolution will bring major disruption to the scale in which upskilling and reskilling efforts currently take place.

The skills requested by industry, as we said before, are not merely technical. Future professionals are likely to be creative, innovative and entrepreneurial, and capable of building relationships, advancing research and strengthening their organisations.

It would appear that employers recognise they need workers with soft skills to complement their technical prowess. While professionals with high-tech and transversal, crosscutting skills are crucial for employers, the majority of them say it is difficult to find employees with the right skillset, and to find and retaining high-tech and digital talent.

This bring up to the question whether what soft skills are due to it is difficult to define. First of all, soft skills are not simply people skills; soft skills consist of writing, knowledge of certain software packages, organisational skills and customer service; among others. Although different jobs appear to require different soft skills, communication and organisational skills seem to be scarce everywhere. These gaps often represent skills that are not taught in the traditional training programs; as it is currently happening in VET training offer associated with the toolmaking industry and habitat sector.

As such, SAMANTHA considers high-tech T-shaped skills an imperative for the EU's competitiveness on Additive Manufacturing. The notion of high-tech T-shaped skills pertains to the versatile combination of generalist skills across multiple domains and specialised skills within one domain, present within one individual worker.

The KETs Skills Vision report suggests six categories of competences for Key Enabling Technologies (PwC, 2018) These six categories were defined based on common patterns in KETs competences, and represent both the need for specialist (technical) skills and crosscutting skills:

- Technical skills in an adjacent technology domain.
- Skills related to quality, risk and safety skills.
- Management, leadership and entrepreneurial skills.
- Communication skills.
- Innovations skills.
- Emotional intelligence skills.

A specific point of attention can be raised regarding ethics so as to the importance of ethical considerations for effective, responsible and sustainable implementation of technological solutions.

The gist of the matter is that further actions need to be implemented in order to offer VET training offer with these sough-after skills. The training of T-SHAPED professionals will require

the engagement and commitment of actors from industry, academia, governments, foundations, professional bodies and other stakeholders than can help shape and implement the educational models needed to generate T-shaped professionals through formal education.

SAMANTHA aims to develop a novel training program addressing the mismatched high-tech T-shaped skills for a proper implementation of AM in the value chain of such sectors through high qualified workers.

It stands to reason that the EU competitiveness in the Fourth Industrial Revolution will be reinforced.

T-shaped skills will support and help European industry to embrace new technological breakthroughs to upscale its initiatives, and thus leverage the opportunities that AM bring. The key to capitalising on these new technical opportunities is a workforce that is capable and motivated to work intensively with them (PwC, 2019).

4. Analysis on the current VET training offer related to the toolmaking & habitat sectors with regards to Additive Manufacturing.

4.1 Questionnaire to teachers and students

In the first part of this phase the consortium of partners realised 2 different questionnaires addressed to teachers and students with a twofold objective:

1. to get to know the type of training programs that exist;
2. to examine if they meet with the needs of the industry in terms of technology and skills.

Teachers' results

The consortium of partners delivered the questionnaire to 116 teachers from the academic world in the following countries: Italy, Spain, Slovenia and Germany and in total were involved 22 European different schools.

The results of the questionnaires addressed to teachers revealed that, regarding the habitat sector, more than 70% of teachers answered that it is related with all elements around them, only 21% think that it is related only with architectural elements and 40% of them with furniture.

Regarding the toolmaking sector, 50% of teachers think that it is related with the production of tools for manufactured plastic and metal materials, 30% of teachers think that this sector serves to make tools for common use while almost 50% of them think that it is related with the industry sector.

If we focus on AM technology, 47% of the teachers stated to know the Additive Manufacturing technology, only 9% don't know it. Also, 74% of them said that AM technology is applied in the prototype manufacturing or parts and elements in manufacturing sectors (65%).

Concerning the training course on AM, more than 60% of teachers stated they know a course on Additive manufacturing technology. 49% of them stated that they know at least 1-2 courses they also said that it is possible to teach AM technology in their institutions, 46% of them are fully convinced of it while 37% more or less convinced, only 9% think that it is impossible.

Teachers involved in the questionnaire do not teach AM subjects and only the 23% teach them and in particular skills related to design & modelling software (75%) and materials, process & machine (71%). They also said that they have adequate resources for teaching skills concerning AM, only 4% stated that they don't have adequate tools or resources.
Some of the problems that teachers already identified in teaching AM technology, is the lack of specialised staff, the rigidity of curricula and the lack of learning facilities even if 48% of them stated they have different possibilities to learn new AM skills while 52% stated they have no possibilities. Also, half of the group who answer to the questionnaire would like to acquire the AM skills the other half is not interested.

Regarding the job market, teachers who answered to the questionnaire whether or not they teach AM technology skills, stated that this technology can help in finding a job position.

Students' results

Concerning the students' questionnaire, the consortium of partners delivered the it to 121 students from different school in the countries partner involved. In total, 20 European different schools were involved in this phase.

The results of the questionnaires addressed to students revealed that, regarding the Habitat sector, more than 70% of students answered that it is related with all elements around them, only 36% think that it is related only with architectural elements and 17% of them with furniture.

Regarding the toolmaking sector, 50% of students think that it is related with the production of tools for manufactured plastic and metal materials, 30% of students think that this sector serves to make tools for common use while almost 40% of them think that it is related with the industry sector.

Regarding the AM technology more than 50% of students stated that they already know AM technology and 81% of them stated that prototype manufacturing is one of the most important application related with it both in the toolmaking industry and in the habitat sector.

Contrary to teachers, more than 60% of students stated that they don't know any course on AM technology, indeed they didn't attend or are not attending any course on AM technology and more than 60% of them stated that in their institutions there aren't taught skills related with AM technology.

Concerning the fields of application, 81% of students stated that AM technology is relate with Design and modelling software, 72% with materials, processes & machine and almost 55% with creativity and innovation.

As concerning the job market more than 70% of students stated that they will use for sure AM technology skills in their working life and more than 70% stated that it is important to acquire skills on AM technology for finding a job.

4.2 Analysis on the current VET training offers: general consideration.

The field of Additive manufacturing is seeing an explosive growth in recent years due to renewed interest in manufacturing in all over the world.

The experience in drawing something in a computer and then see that part being printed in a 3D printer, which can be touched or felt is still fascinating to many of us.

In recent years, 3D printing has had considerable success, gaining a slice of the market but above all creating a great economic impact thanks to the various possibilities that it offers.

Additive manufacturing process could be used in different sectors, such as: industrial sector, educational sector, medical sector and so on…and it can be applied in very different fields, such as architecture, engineering, medicine, clothing, etc.

Many people have described this technology as revolutionising product development and manufacturing. Some have even gone on to say that manufacturing, as we know it today, may not exist if we follow AM to its ultimate conclusion and that we are experiencing a new industrial revolution. AM is now frequently referred to as one of a series of disruptive technologies that are changing the way we design products and set up new businesses.

It is important to understand that AM was not developed in isolation from other technologies. For example, it would not be possible for AM to exist were it not for innovations in areas like 3D graphics and Computer-Aided Design software.

AM technology is also now being incorporated into curricula in many schools, polytechnics, and universities around the world. More and more students are becoming aware of these technologies and yet.

In general, what is happening in the last 10 years is the use of 3D printing into the school sector, with a considerable increase in interest in the subjects in STEAM area. 3D printing has taken on greater interest in schools with the growing of the importance of science, technology, engineering, and mathematics (STEM) subjects.

In the educational sector, 3D printing needs careful consideration but the benefits it offers to both teachers and students makes the effort worthwhile. 3D printing technology in schools provides the space for ideas to develop and makes education more fun.

It is also true that in the educational system the AM technology has a slow impact due to the lack of knowledge of this technology by the experts: the teachers.

Regarding the job market it is very difficult to find, attract and retain skilled workers especially in high- tech fields. In addition, both SMEs and workers cannot afford significant training costs requiring long periods of absence at work. However, upskilling and reskilling is of key importance for them, as new technological developments quickly make existing knowledge and skills obsolete.

New online training developments offer promising opportunities in this respect as they can provide a more flexible, cost-effective and efficient way to train staff. Online training has already become an invaluable resource for most established, large-scale businesses.

In this regard, SAMANTHA project aims to create and provide useful tools and methodologies to increase knowledge and use of the AM in school to prepare future worker in the value chains of 2 sectors: Habitat and Toolmaking.

The objective is to promote new successful approaches to deliver skills related to new digital and key enabling technologies, based on new flexible and adaptable online education and training tools, and to foster the uptake of best practices. The results will be useful to reskill and upskill the workforce.

From this main objective there are several specific objectives in the project:

- Create flexible learning pathways and didactic tools based on the learning outcomes approach, able to provide, assess and recognize the key competences identified in target groups.
- To ensure good alignment of VET programmes with the requirements of the Toolmaking industry and Habitat sector regarding AM.
- To boost the Digital Transformation and the Smart Industrial Specialisation of these manufacturing sectors with a competent implementation of AM in their value chains.
- To increase competitiveness and productivity of these sectors with a continuous up/re-skilling of the workforce with the required skills needed in the Fourth Industrial Revolution.
- To raise awareness and to improve the image of KETs and STEM graduates in society as a field to work in.

Through this first analysis the consortium of partners will be able to have a general overview both at national (Italy, Germany, Spain and Slovenia) and European level of the various 3D printing courses that already exist, and the partners will be able to understand what are the needs of the target group chosen and to create ad hoc tools for them.

For the analysis of VET curricula regarding the AM technology in the two sectors taking into account the project partners initially analysed the use of AM in their countries, and in particular in Italy, Spain, Slovenia and Germany.

From this analysis it emerged that:

- **In Italy Additive Manufacturing** the growth of Industry 4.0 slows in 2019. Based on the results of the first quarter, growth stood at + 10-15% compared to 2018 when it was + 35%. This is what emerges from the research of the Industry 4.0 Observatory of the School of Management of the Milan Polytechnic.

The most popular 4.0 technologies are IT, in particular the industrial IoT, followed by industrial analytics and cloud manufacturing. Among the operational technologies, advanced automation conquers the largest market share, followed by Additive Manufacturing.

Many investments and industrial digitisation projects were billed in 2018 accelerating market expansion, which has more than doubled in the past four years. The awareness and knowledge of 4.0 technologies are now widespread in all the productive realities of the country, but to seize all the opportunities offered by this revolution it is necessary to clearly define a role that guides digital change and to support new models with a model efficient organisation to involve workers, end users of technologies, in all phases of 4.0 projects.

More than 192 companies believe that Industry 4.0 is a revolution that undergoes radical changes with great potential yet to be expressed, only few of them considering it only an evolution of what has already been done in previous years.

In the next two years 2019- 2020 the companies intend to concentrate their investments in Industrial IoT, Industrial Analytics and Advanced Automation, while if it is considered a 3-5 years horizon, the priorities become Advanced Automation, Cloud and Additive Manufacturing.

In Spain, judging by the available data, only 3.2% of Spanish companies use **AM technology**, so these tools are not yet established in the business field by far.

In general terms, the regions with the highest percentage of companies that use 3D printing are located in the northern part of the country, while the communities in which the lowest percentage of companies are located in the south.

Although AM is increasingly present in work environments, the percentage of companies that employ specialists has decreased to 19.2% in 2018. The data related to the hiring of women specialists by companies that use this profile show that 50% of companies of this type have only male specialists in their workforce.

On the other hand, there were 11.6% of companies that hired or tried to hire ICT specialists, although 3% recognized that they had difficulty finding this type of professional profile (ONTSI, 2019). In this sense, there is a big room for improvement and a large window of opportunities.

Specifically, there is a need to reconsider the current approach towards the education and training of AM professionals and to develop new/advanced models that would be better aligned with the needs of both employers and (future) employees reskilling and upskilling the workforce as the partners of SAMANTHA are committed to achieving in the toolmaking and habitat sectors to close the current skill gap.

In Germany, Additive Manufacturing has achieved significant growth in recent years. The industry is increasingly using additive manufacturing methods for prototypes, manufacturing resources and end products. So, it is clear that it has recognized the huge potential of 3D printing.

As a result, companies are not only more flexible in their production, they can also save costs, reduce the use of materials and conserve resources. Above all, the reduced material loss was a clear advantage, so that the process is already being used in series production. In order to fully recognize and use the chances of additive manufacturing, it is of central importance to research the consequences of the change by AM.

In Slovenia, Additive Manufacturing (recognised as 3D printing) offers many advantages in the production of parts, presenting unrivalled design freedom with the ability to manufacture single or multiple components from a wide range of materials. Slovenian companies started to use 3D printing in the last 5 years for real part production and practically the people who come to work in a Slovenian company has no technical knowledge about the AM but they often heard about the technology itself from professional seminars or in their native faculty.

So basically, they are then trained for a normal – regular usage of a certain 3D printer inside the company premises. The knowledge of material selection, part construction for 3D printing etc. can therefore still be improved.

For Slovenia we can state that the demand for AM skills/training is rising on a daily basis and that companies really have strong needs to employ new workers for AM field. In Slovenia there is a strong need to reconsider the current approach towards the education and training of AM professionals and to develop new/advanced models that would be better aligned with the needs of both employers and (future) employees reskilling and upskilling the workforce.

The 3D printing for educational purposes in Slovenia is a wide variety of subjects has also brought this technology to the classrooms of schools and universities around the world. In doing so, companies making 3D printers are increasingly connecting with educational institutions, enabling them to use their technology and educating teachers and students about them while promoting their business.

Students use 3D technology to create different models, such as 3D models of cities, displays of molecules and atoms, organs, etc. At the same time, they can turn many of their ideas into tangible objects, thus fostering their own creativity. In the meantime, teachers are watching their progress, sharing experiences with their peers, and gathering ideas for using 3D printers in lessons.

4.2.1 Existing national (Italy, Spain, Germany and Slovenia) and international training programmes related with the AM in the toolmaking industry and habitat sectors table

This section should provide all collected information about the existing training programmes at national level related with AM in the toolmaking industry and Habitat sector.
Entering 3D printing is not an easy task, you must acquire some technical skills to make the most of all the opportunities offered by 3D technologies. That is why many companies now offer 3D printing training and help young people and professionals get all the keys they need to succeed in their project.
It is important to distinguish between 3D printing training organizations and the various resellers of 3D printers in the market that will provide training on how to use your new machine. Organizations will allow you to acquire all the technical skills to get started in additive manufacturing and, the most advanced ones, will offer sessions on specific or even

customised topics. Now we can train in 3D modelling, in particular software, but also in trainings on machines as such, usually in the form of workshops, or also participate in introductory technology courses.

For the detailed report IO1A3 click on the following link:
https://drive.google.com/file/d/1j4HJw_vNFG7fvwXBKGouvTpxyhP2shA-/view?usp=sharing

EXISTING NATIONAL (ITALY, SPAIN, GERMANY AND SLOVENIA) AND INTERNATIONAL TRAINING PROGRAMMES RELATED WITH THE AM IN THE TOOLMAKING INDUSTRY AND HABITAT SECTORS.

N.	Title	Sector	Countries involved	Duration of the course	Target Group	Mode of Delivery	Period of availability	Certificate issued	Qualification framework
1	**3DP-Training in 3D printing to Foster EU**	General on 3D printing	RO, ES, PO, LT, IT, MT	To be defined	Schools and educational centres	At distance	2 years	Online certificate	-
2	**3D4VET**	General on 3D printing	TR, PT, RS, UK	To be defined	Schools and educational centres	At distance	Ongoing	-	-
3	**3D-HELP**	General on 3D printing	CZ, RO, MT, LT, HR	To be defined	educational centres and stakeholders	At distance	Ongoing	Online certificate	-
4	**3D Printing -Fostering Creativity Your Students**	General on 3D printing	EL	7 days	Schools and educational centres	In presence	Ongoing	-	-
5	**LeapFrog**	General on 3D printing	NL	To be defined	Schools and educational centres	At distance	Ongoing	-	-
6	**PrintLab**	General on 3D printing	NL	To be defined	Schools and educational centres	At distance	Ongoing	Online certificate	-
7	**E3D Plus**	General on 3D printing	IT, ES, SI, DE	To be defined	Schools and educational centres, Stakeholders	At distance	Ongoing	Online certificate	-

8	**Advanced 3D FDM printing**	General on 3D printing	IT	2 days	3D printer operators, 3D CAD designers, designers	In presence	Ongoing	Printed certificate	-
9	**3D ITALY**	General on 3D printing	IT	196 hours	young people unemployed resident in the Veneto region.	In presence	2017	Printed certificate	-
10	**OPPI**	General on 3D printing	IT	-	Schools	In presence	Ongoing	Printed certificate	-
11	**STEAM ACCADEMY**	General on 3D printing	IT	1 year	Schools	At distance	Ongoing	Printed certificate	-
12	**Specialized training in Additive Manufac-turing**	Tool-making	IT	32 hours	Entrepreneurs, managers, technicians, medium-sized enterprises of the regional system of mechanics, mechatronics and engines.	In presence	December 2018 – March 2019	Printed certificate	-
13	**Course in Metal Additive Manufac-turing**	Tool-making	IT	40 hours	Technical and purchasing department employees; quality workers; R&D manager; plant managers, designers of mechanical components or systems and	In presence	11 June 2020	Printed certificate	-

					functional groups.				
14	**Additive design and production techniques (3d printing and additive Additive Manufacturing course)**	Tool-making	IT	5 days	Professionals and users from the world of industry	In presence	May 2020	Printed certificate	-
15	**Additive Manufacturing course in production processes: introduction to new technology at the service of production processes – Industry 4.0**	Tool-making	IT	8 hours	-	In presence		Printed certificate	-
16	**New Production Technologies AM**	Tool-making	IT	16 hours	Industrial automation process managers and operators	In presence		Printed certificate	-
17	**Learn by Layers**	General on 3D printing	From UK but international reach	4 hours (Startup), 1 day (Standard) or 1.5 days (Advanced	Schools and educational centres (but NOT online training providers)	Face-to-Face / Online	Ongoing	Printed certificate	-
18	**MakerBot**	General on 3D printing	International	2 days	Teachers, trainers and educators	Face-to-face with online component	Ongoing	Printed certificate	-
19	**Print Lab**	General on 3D printing	UK, PL, NL	4 to 6 hours	Educators	Online	1 year	Printed certificate	-

20	**Ultimaker**	General on 3D printing	Internatio nal	Not specified	Educators	Online, non-formal	1 year	Printed certificate	-
21	**Integral 3D Printing with MakerBot**	General on 3D printing	SP	2 days	Schools and education centres	Face-to-face	Ongoing	Printed certificate	-
22	**AirBot**	General on 3D printing	SP	6 to 9 months (100 to 180 hours)	Anyone at any level (no previous knowledge necessary)	Online	Ongoing	Printed certificate	-
23	**IAM 3D Hub**	General on 3D printing	SP	1 to 3 days	Anyone	Face-to-face	Upon request	Printed certificate	-
24	**Academia 3D de oLido**	General on 3D printing	SP	15 hours + 10 online modules of 2.5 hours each	Trainers at VET centres	Blended	Upon request	Printed certificate	-
25	**VET occupation "Toolmaker"**	Toolmaking	Germany	3.5 years	Pupils/Apprentices/Trainees	Dual education in vocational school and in-incompany training	Yearly	Final designation Toolmaker / Toolmaker Examination by the Chamber of Industry and Commerce	RAHMENLEHRPLAN für den Ausbildungsberuf Werkzeugmechaniker/Werkzeugmechanikerin (Beschluss der Kultusministerkonferenz vom 25.03.2004 i.d.F. vom 23.02.2018) (FRAMEWORK CURRICULUM for the profession of

									apprenticeship Toolmaker / Toolmaker (Resolution of the Conference of Ministers of Education and Cultural Affairs of 25.03.2004 as amended on 23.02.2018))
26	**Operator 2D/3D CAD - AutoCAD, 3D printing with HWK degree CAD specialist)**	Engineering, Design	Germany	61 days	Graduate engineer, design engineer, technical draftsman or product designer	Life-Online-Course	Regular courses announced	Certificate by the Chamber of Crafts: WBS-Zertifikat, CAD-Fachkraft (HWK)	-
27	**Specialist in additive manufacturing)**	Professionals and undergraduates with diverse personal, business and academic backgrounds inclusing scientiests, engineers, technicians, managers, consultunts, product design managers, business owener, undergraduates with technical background, military, government, academia	Germany	3 months	Specialists and managers of all industries from companies in the Swabian economy as well as private 3D printing users	Face-to-face training	Regular courses announced	yes	at least bachelor's degree required or 2 years of technical experience in the industry

28	**Chamber of Industry and Commerce: Expert for additive manufacturing (3D printing)**	All industries and private 3D-printing users	Germany	2 years	Specialists and managers from all industries from companies in the Swabian economy as well as private 3D printing users	Face-to-face training	Regular courses announced	IHK certification for additive manufacturing (3D printing)	-
29	**Seminar Additive Manufacturing (3D Printing) in Karlsruhe Module 1 - 3**	Metal and electrical professions	Germany	6 weeks	Industrial and machining mechanics, tool, plant and construction mechanics and mechatronics engineers	Face-to-face training, extra-occupational and full time possible	Regular courses announced	bfw-/maxQ.-Zertifikat	-
30	**Further training: 3D prototyping & 3D printing with Fusion 360)**	A variaty of sectors: trade, medical technology, food technology, meachtronics product design, construction, mechanical engineering	Germany	4 weeks	Graduates of a degree or apprenticeship in the sectors of handicraft, medical technology, food technology, mechatronics, product design, construction, mechanical engineering, engineering	Face-to-face training offered in several cities	Regular courses announced	Certificate of the training provider: cimdata-Zertifikat	-

					or with several years of adequate professional activity				
31	**Further training: CAD design & 3D printing**		Germany	12 weeks	Graduates of a degree or apprenticeship in the sectors of handicraft, medical technology, food technology, mechatronics, product design, construction, mechanical engineering, engineering or with several years of adequate professional activity	Face-to-face training offered in several cities	Regular courses announced	Certificate of the training provider: cimdata-Zertifikat	-
32	**Fab Academy**	Envision, prototype & document ideas with digital fabrication tools	International, distributed educational model	5 months	Students with technical and non-technical background	At distance & in presence	Application time Sept.-Jan.;	Fab Academy Diploma	
33	**TÜV SÜD Academy**	Design, Manufacturing, Quality control, management	D	4-7 days	Entrepreneurs & employees	In presence	Annual, in different locations	Participation certificate for each seminar, TÜV SÜD certificate	Modular concept of courses

34	3D PRINTING AND ADDITIVE MANUFACTURING. INDUSTRY 4.0 APPLIED TO THE FURNITURE SECTOR	Furniture	Spain	30 hours	Title 2º ESO or equivalent	In presence	April 17 – May 21, 2020	-	-
35	EXPERT COURSE IN PRODUCT DESIGN FOR 3D PRINTING	General on 3D printing	Spain	100 hours/ 2 months	To complete an expert course, it is essential to have completed the PROFESSIONAL COURSE IN 3D PRINTING first	In presence	Februar y 2020	Printed certificate	-
36	3D printing course	General on 3D printing	Spain	150 hours	Bachelor's degree, Superior Technical Vocational Training, Superior Technician in Plastic Arts and Design or Superior Sports Technician	Online	March 2020	Technical Course title	6 ECTS
37	Introduction to 3D Printing	General on 3D printing	Spain	50 hours	Open to anyone interested in 3D Printing. No degree required	Online	Ongoing	Diploma issued by Business Project Managem ent Solutions and Technolo gies.	-

38	Superior Technician in 3D Printing	General on 3D printing	Spain	200 hours/ 6 months	Open to anyone interested in 3D Printing. No degree required	Online	Ongoing	Diploma issued by Business Project Management Solutions and Technologies.	-
39	Course Construction of a 3D Printer	General on 3D printing	Spain	75 hours/3 months	Open to anyone interested in 3D Printing. No degree required	Online	Ongoing	Diploma issued by Business Project Management Solutions and Technologies.	-
40	**Advanced Course in 3D Printing**	General on 3D printing	Spain	75 hours/3 months	Open to anyone interested in 3D Printing. No degree required	Online	Ongoing	Diploma issued by Business Project Management Solutions and Technologies.	-
41	**PROFESSIONAL COURSE IN 3D PRINTING**	General on 3D printing	Spain	100 hours/ 2 months	Technological entrepreneurs,	In presence	October 2020	-	-
42	**FFF technology 3D printing Expert**	General on 3D printing	Spain	21 hours / 3 days	Business, professionals, freelancers and individuals, students and unemployed	In presence	March 10-12, 2020	-	-
43	**Training Additive Manufacturing with**	General on 3D printing	Spain	100 hours	Priority for the	In presence	October 07 – Novemb	-	-

	metals, from concept to manufacturing				unemployed		er 07, 2019		
44	**NX ADDITIVE MANUFACTURING: Convergent Design, Topological Optimization and Machine Printing**	General on 3D printing	Spain	15 hours / 3 days	Business, professionals, freelancers and individuals, students and unemployed	In presence	June 12 - 14, 2019		
45	**3D Printing Technician**	General on 3D printing	Spain	200 hours/10 months	Anyone wanting to learn and who knows how to manage programs at the user level	Online	Ongoing	3D Printing Technician Diploma	-
46	**3D PRINT COURSE**	General on 3D printing	Spain	-	Age required to take the course: From 18 to 60 years old	Semipresencial,	Ongoing	-	-
47	3D printing course for beginners: get to work	General on 3D printing	Spain	29 minutes	Schools and educational centres	At distance	Ongoing	Online certificate	-
48	3D printing	General on 3D printing	Spain	8 weeks —35h	Schools and educational centres	At distance	Ongoing	Online certificate	-
49	Advanced 3D Printing Course	Advanced on 3D printing	Spain	12 weeks — 200h	Schools and educational centres	In presence	Starting in March 2020	-	-
50	3D Design and Printing Course	General on 3D printing	Spain	110h	Design professionals	At distance	Ongoing	Own degree	4 ECTS

51	Design, modelling and 3D printing	General on 3D printing	Spain	45h	Schools and educational centres	In presence	-	-	-
52	**3D Printing and Addition Technology System Operator 8583614011**	General on 3D printing	Slovenia	Cca. 100 hours	completed elementary school, Secondary vocational education	In presence	According to agreement	Yes (Validity of certificates issued: There is no time limit.)	SOK 5, EQF 4
53	**Technologies of additive manufacturing**	Mechanical engineering	Slovenia	First (winter) and second (summer) semester	PhD students	In presence	Study year	-	10 ECTS

5. Standardisation of national and European qualification systems among partners countries

The European Qualifications Framework (EQF) is related with lifelong learning, i.e. a community reference framework that serves to relate the national qualifications systems and frameworks of the participating countries.

Technically, it is an eight-level description grid, in which countries position, in an increasing order ranging from minimum to maximum complexity, the qualifications issued at the end of the educational and training courses based on learning outcomes (i.e. learning outcomes, LOs). The Framework applies to all qualifications, from those obtained at the end of a school path, up to the highest levels of academic and professional education and training.

EQF is defined as a meta-framework because it represents a reference for the national qualifications frameworks and systems, with respect to which the various States are called, on a voluntary basis, to classify their education and training systems, in order to connect them to the EQF.

EQF was established with the Recommendation of the European Parliament and of the Council of 23 April 2008 and updated with the Recommendation of 22th May 2017.

EQF makes the content of the qualifications transparent because it refers to the learning outcomes: in fact, it makes explicit what the person knows, understands and is able to do, at the end of a learning path, regardless of the specific characteristics of the course (duration, content, context, etc.). This facilitates the understanding and comparison of qualifications by users from different educational and training fields and from the world of work, at national and European level.

EQF has the dual objective of:
- to facilitate the transnational mobility of students and workers because it promotes the transparency and usability of qualifications in several countries and in different education and training systems;
- promote lifelong learning, because it makes people more aware of the value of a qualification or a title and facilitates the validation of learning achieved in non-formal and informal courses.

- EQF is useful to the world of work: it facilitates the correspondence between the needs of the labor market and education / training opportunities and allows the candidates' skills from other countries to be more easily recognized;
- EQF is useful to people: it allows to compare national and European offers more easily and to have a wider range of training and work opportunities; to educational and training bodies: it is a common reference for the development of the educational and training offer increasingly centered on the person and oriented towards a concrete increase in skills;
- EQF is useful to institutions of European countries stimulate reforms and the development of national education and training systems, promoting their integration as well as the coordination and personalization of the offer of services.

EQF is consistent with the European Credit System for Vocational Education and Training - ECVET (European Credit system for Vocational Education and Training) and with the European Credit Accumulation and Transfer System - ECTS

The partners consortium analysed the EQF system in its own country. Below the results:

In Italy, the qualifications of general and higher education, are governed by the State, meanwhile the VET qualifications are governed by the regions.
The challenge of Italian VET system is to compare and align the regional qualifications in order to develop a national qualification framework.
Italy is classified as being part of the countries being at an initial stage of EQF implementation, in fact, Italy does not have "comprehensive qualifications frameworks and qualifications are

not yet described in terms of learning outcomes", but Italy adopts national criteria and methodology to interact between the national qualifications and the EQF levels.
The implementation of the EQF is leaded by the Ministry of Education, University and Research and the Ministry of Labour and Social Policies in cooperation with the regions, autonomous provinces and the social partners.
An important role plays ISFOL- the national institute for development of vocational training that is in charge to set up the national methodologies and coordinates expert groups involving also social partners.
This institute manages the EQF implementation process and prepares the technical report, communicates with stakeholders, and planes and implements the national qualifications database.
In total in Italy there are 8 EQF levels and have been used in Italy, level descriptors to link all national qualifications from formal education and training to the EQF.

In Germany, the Qualifications Framework (DQR) is an instrument for classifying qualifications in the German education system. It aims to increase transparency, comparability and mobility both within Germany and within the EU (in connection with the European Qualifications Framework (EQF)). Classification is based on learning outcomes, i.e. on acquired competences. The transparent description of learning outcomes should make it easier to compare educational pathways and qualifications between European countries. The orientation towards learning outcomes also makes it possible to classify non-formally and informally acquired competences.

The DQF is not subject to mandatory application but has a recommendatory character.
The DQR aims to increase transparency in the education system. In particular, education and training institutions should benefit from this. Among the advantages outlined are the following:

- Education providers could use the competence-based categories of the DQR for the (further) development of curricula. This supports transparent specifications. The benefits of study or training programmes can be clearly and comprehensibly described for the target groups.
- Communication between the education sector and the world of work can be facilitated.
- The DQR intends to make a significant contribution to quality assurance in education.
- The EQF and the DQF aim to offer education providers new opportunities for international provision and cooperation in education and training.
- The equivalence between vocational education and training and higher education, for example, is to be made clearer

The allocation of qualifications to the eight levels of the DQR is designed to include all formal qualifications of the German education system, i.e. qualifications in general education, higher education and vocational education and training - in each case including continuing education and training. In addition, it is also a declared aim to include results of non-formal and informal learning.

In Spain in 2009, the Spanish Government entrusted the Ministry of Education with the drawing up of the Spanish Qualifications Framework. In 2011, the Sustainable Economy Act demanded the creation of this framework in order to encourage and increase the mobility of students and workers.

The Spanish Qualifications Framework is a national qualifications framework (degrees, diplomas and certificates) that includes lifelong learning. It is a structure that organises qualifications according to levels and comprises from the most basic to the most complex learning. It therefore covers general and adult education, vocational education and training, and higher education.

It includes:

- qualifications obtained outside the education system through in-service training, work activity, collaboration with NGOs, etc.
- qualifications obtained in the education system.

The proposed framework has eight levels and the level descriptors, defined in terms of knowledge, skills and competences, and are inspired by the level descriptors of the European Qualifications Framework for Lifelong Learning, but adapted to the national context. A Royal Decree that will establish the foundations for the implementation of the new Spanish Qualifications System, adapted to the European framework, is currently under preparation.

The eight levels of the framework cover all types of qualifications in Spain. Level descriptors are defined in terms of knowledge, skills and competences.
The four upper levels are compatible with the levels of the Spanish Qualifications Framework for Higher Education, based on the Dublin descriptors.

The Spanish Qualifications Framework aims to correlate and coordinate the different subsystems of education and training and include the qualifications obtained in compulsory, post-secondary and higher education, as well as integrate the validation of non-formal and informal learning.

The main objectives of the Spanish Qualifications Framework are:

- make qualifications more understandable by describing them in terms of learning outcomes
- improve citizens' information on national qualifications, as well as facilitate and promote mobility
- support lifelong learning and correlate initial vocational training and vocational training for employment, as well as improve access and participation in this type of training, especially of people with some kind of disability
- facilitate the identification, validation and recognition of all types of learning outcomes, including those related to non-formal and informal learning
- facilitate transition and progression between the different training subsystems
- develop procedures for the recognition of non-formal learning
- reduce early school leaving.

In Slovenia, the Qualifications Framework Act, adopted in 2015, stipulates that the Slovenian Qualifications Framework is a tool for the development and classification of qualifications into a unified system.

Qualifications are classified into levels with regard to statutory criteria, learning outcomes and descriptors.
Relationships between qualifications are shown and possibilities of horizontal and vertical transitions between qualifications are indicated.

A qualifications framework contributes to improving quality, accessibility and the recognition of qualifications in the labour market both nationally and internationally.
The unit of the SQF is the qualification.

The Act determines:

- the referencing of qualifications from the SQF to the European Qualifications Framework for Lifelong Learning (EQF) and the Qualifications Framework of the European Higher Education Area (QF-EHEA).
- Procedures and competences regarding the placement/referencing of qualifications.
- The establishment of a National Coordination Point for the SQF and EQF.
- Record keeping (SQF qualifications register).

The SQF three categories of qualifications:

- **EDUCATION,** demonstrated by a public document certifying completion of education;

- **VOCATIONAL QUALIFICATION,** demonstrated by an NVQ certificate, issued in accordance with the regulations governing NVQs, or another document certifying completion of a further training programme, issued in accordance with the regulations governing vocational and higher education;
- **SUPPLEMENTARY QUALIFICATION,** demonstrated by a certificate of acquired supplementary qualification.

In the SQF, qualifications are classified into 10 levels with regard to learning outcomes and the ten SQF levels are linked to the 8 EQF levels through the level descriptors of both frameworks.

Information about the SQF and EQF level must be visible on all public documents (diplomas, certifi cates,…) and for shortcycle higher vocational education and higher education qualifi cations the QF-EHEA level must be visible as well

In the placement of qualifications into SQF descriptors of SQF levels are used, representing a starting point for the assessment of suitability, difficulty and complexity of individual qualifications.

Descriptors of each level contain three categories of learning outcomes: knowledge, skills and competences. Each higher level also includes the knowledge, skills and competences of lower levels. Each qualification placed into the framework contains all three categories, but not every category necessarily carries the same weight within the qualification.

The register of SQF qualifications represents a publicly accessible information system of the Slovenian Qualifications Framework and provides insight into all individual qualifications that can be obtained in Slovenia. The register of SQF qualifications is available at the website www.nok.si/en/ Qualifications in the register of SQF qualifications are described in accordance with the SQF methodology and statutory provisions. The register of SQF qualifications is linked to the European Commission portal Learning Opportunities and Qualifications in Europe.

5. 1 Harmonised Learning Outcome Template

The template of the learning outcomes is composed of 4 sections.

A brief description of the learning outcomes. The learning outcomes are intended as "description of what a learner knows, understands and is able to accomplish at the end of a learning process. The results are defined in terms of knowledge, skills and competences ".

KNOWLEDGE is defined as "the result of the assimilation of information through learning. Knowledge is a set of facts, principles, theories and practices related to a sector of work or study ". In the context of the EQF "knowledge is described as theoretical and / or practical".

SKILLS: are defined as "the ability to apply knowledge and use know-how to complete tasks and solve problems".

COMPETENCES is defined as the “proven ability to use personal, social and / or methodological knowledge, skills and abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competences are described in terms of responsibility and autonomy ".

Below the table that will be used to identify the learning outcomes of the SAMANTHA project. It is possible to copy the table as much as learning outcomes the partner consortium have identified.

This template will be useful in the IO2 of the project: SAMANTHA Joint Curriculum and Training Content

Example:

Learning Outcome 1

Brief description

Knowledge	Skills	Competences

5. 2 Harmonised Unit Description Template

The template of the unit is composed of 2 sections:

The first part concerns a description of the reference professional profile.
In this part it is necessary to indicate:

- The name (Title of the Qualification)
- The EQF level
- The procedures and criteria for the assessment of the achievement of the Learning Outcomes (e.g. examination, production of a paper ...)
- ECVET Points associated
- A textual description of the professional figure

The second part is related with the description of the modules identified divided in units.
In each unit it is necessary to indicate:

- Learning Outcomes identified in the template before with knowledge, skills and competences.
- Procedures and criteria for the assessment of the Unit (e.g. multiple-choice tests).

Below the table that will be used to identify the units of the SAMANTHA project.
It is possible to add units to the table as much as units the partner consortium have identified.

This template will be useful in the IO2 of the project: SAMANTHA Joint Curriculum and Training Content

Example:

Title of the Qualification

EQF Level		Procedures and Criteria for Learning outcomes assessment		ECVET Point associated	
Insert a brief description of the qualification					

Module 1: title

No. Unit	Title	Learning outcomes	Knowledge	Skills	Competences	Procedures and Criteria for Unit assessment
1						

Conclusion

In general, AM technology is having a significant expansion both in the industrial and in the educational sector. There are numerous training courses at European level concerning the use of 3D printing technologies.

In Italy there is a high offer of online training courses specifically dedicated to experts in the toolmaking sector but few for the habitat sector.

On the other hand, vocational education and training institutions at national level have a very varied didactic offer and do not always offer courses on additive manufacturing. Usually these are projects that are part of the Erasmus+ programme lasting a few hours or days.

What from Italian research is highlighted is that in general there are numerous courses concerning the teaching of 3D printing skills: modelling software, materials, how 3D printing technology works, strengths and weaknesses of the technology, and so on ...

The most specialised courses are mostly paid (around € 1000 per course) the free ones are part of European projects.

Certainly, there is a lack of provision of professional courses concerning 3D printing in the toolmaking and habitat sectors. We should understand the needs of the target group to which these courses are intended to improve the training offer in itself and increase the teaching of technological skills that can be spent in today's job market which is increasingly moving towards a real digitalization.

Regarding the T-Shapes skills in Italy the industry is moving towards a T-shaped model, but universities are slow to do the same with their curricula. In this regard there are a lot of students that already have a deep knowledge in technical filed but they have difficult to acquire soft skills or better called T-shaped skills.

In Spain, the offer of AM courses is quite new and in continuous growth. Some importance evidences are:

- The VET offer of AM courses targets all sectors (generic courses). The offer of AM courses in High Education is more specialised and addressed to specific sectors (generic courses are also available in HE).

- The duration of the courses is quite variable (between 1 and 200 h). AM courses are in presence and at distance (both options available) Most of the courses offer a certificate once completed and passed.

- Potential gaps on skills development combined with mismatches directly influence the job creation negatively. These gaps often represent skills that are not taught in the traditional training programs; as it is currently happening in VET training offer associated with the toolmaking industry and habitat sector.

- Over the last decade, the notion of "T-shaped" skills have emerged, referring to an individual worker having a combination of both general skills across multiple domains and specialist skills within one domain.

- The breadth of the future professional reflects the individual's willingness and ability to collaborate across industries, sectors and disciplines (horizontal bar of the T). The depth of the future professional refers to the depth of the industry-related and sectoral skills and knowledge that the individual possesses (vertical bar of the T).

- The KETs Skills Vision report suggests six categories of competences for Key Enabling Technologies (PwC, 2018) These six categories were defined based on common patterns in KETs competences, and represent both the need for specialist (technical) skills and crosscutting skills:
  - ✓ Technical skills in an adjacent technology domain;
  - ✓ Skills related to quality, risk and safety skills;
  - ✓ Management, leadership and entrepreneurial skills;
  - ✓ Communication skills;
  - ✓ Innovations skills;
  - ✓ Emotional intelligence skills.

In Germany, AM technology is still a very young and innovative field and various further training courses are offered for this purpose, some of which are aimed at specific sectors - e.g. engineering - but also at specialists from all industries.

The duration of training courses ranges from four weeks to two years, although five of the six training courses are limited to a maximum of three months. The training content is usually communicated face-to-face.

At the end of the training programs, participants receive a certificate for all training courses. Also, elements of AM technology are also included in the training to become a tool manufacturer.

However, it could be criticized here that compared to the great upswing in AM technology in recent years, the contents of the training can still be expanded considerably.

In Slovenia, too, the rise of 3D printers has contributed to the emergence of many innovative companies that are pushing the boundaries of the possible and breaking the field in the field of additive manufacturing solutions. AM is today the extended hand of all innovators who want to turn their bold ideas into reality.

In Slovenia, companies are specialized in custom 3D printing, but after more than 25 years of operation, they do not know the impossible challenges, despite the fact that it takes a lot of time and effort to personally educate new employees in the AM field. Each of the projects outsourced to clients is thus upgraded with a wealth of knowledge and the latest technology, recognizing that after the effort of development, running on the target plane requires a top partner and experienced, qualified and trained staff. Companies for Toolmaking and Habitat sector make both simpler and more demanding products, always adhering to the agreed deadlines and striving for ultimate customer satisfaction.

They specialize largely in:
- Development of functional prototypes
- Production of molds for casting
- Casting
- 3D Printer Sales

As can be seen in this report in Slovenia has only 2 existing national training programmes from which the 1st one is intended for general 3D printing. The 2nd one is intended for PhD students who want to get special in-depth knowledge about AM technology. Objectives and competences here for the PhD students are following:
- Provide detailed knowledge of the principles of additive manufacturing (AM) technologies;
- Provide required techniques and skills for application of specialized software's in the AM-specific domain;
- Develop ability in students to apply theoretical knowledge to solving practical engine ering problems in the domain of additive manufacturing;

SAMANTHA aims to develop a novel training program addressing the mismatched high-tech T-shaped skills for a proper implementation of AM in the value chain of such sectors through high qualified workers.

References

- https://3d-p.eu/
- http://3d4vet.eu/?page_id=391&lang=en
- http://3dhelp.euda.eu/
- https://enabling.gr/en/3dprintingcourse/
- https://leapfrog-3d-printers.thinkific.com/
- https://classroom.weareprintlab.com/p/printlab-certification-course-v2
- https://www.e3dplus.ceipes.org/
- https://www.energygroup.it/3dp-academy/stratasys-corsi-stampa3d
- https://www.3ditaly.it/corsi-di-formazione-sulla-stampa-3d/
- http://oppi.it/corsi/stampa-3d-a-scuola/
- https://www.paleos.it/steam-academy
- https://www.wtraining.it/corsi/formazione-specialistica-in-additive-manufacturing
- ttps://www.aqm.it/it/prodotto/corsi/processi-produttivi-e-progettazione/additive-manufacturing/corso-additive-manufacturing-base-leghe-metalliche/?print-products=pdf
- https://3d4growth.com/corsi-stampa-3d
- https://www.ifoa.it/corsi/ca_produzione_impresa-4punto0-additive-manufacturing-tecnologia-servizio-processi-produzione/#start-dettagli
- https://www.ifoa.it/corsi/ca_produzione_impresa-4punto0-additive-manufacturing-tecnologia-servizio-processi-produzione/#start-dettagli
- https://www.learnbylayers.com/lessons/
- https://www.makerbot.com/education/3d-printing-certification/
- https://ultimaker.com/en/resources/education
- https://ultimaker.com/en/resources/52563-ultimaker-core-lessons-steam-set
- https://classroom.weareprintlab.com/p/printlab-certification-course-v2
  ttps://integral3dprinting.com/impresoras-3d/makerbot/makerbot-para-educacion/
- http://www.surgeformacion.com/asesores/intro3d.pdf
- https://iam3dhub.org/our-services/
- https://colido.es/wp-content/uploads/download-files/dossier/dossier-academia-3d.pdf
- e-Skills Manifesto - European Commission - Europa EU
- https://www.infinance.it/assets/Uploads/InFinance-HBR-Rapporto-Formazione-Manageriale-luglio2019.pdf
- https://stemfoundation.org.uk/asset/resource/%7B3EA5228A-B620-4783-AE91-190F2C182DAA%7D/resource.pdf
- http://www.sefcarm.es/web/pagina?IDCONTENIDO=7643&IDTIPO=100&RASTRO=c$m29962,30040
- https://eddm.es/curso-impresion-3d-profesional/curso-experto-diseno-producto-impresion-3d/

- https://www.seas.es/diseno-mecanico/curso-impresion-3d
- https://www.bpmsat.com/introduccion-a-la-impresion-3d/
- https://www.bpmsat.com/tecnico-superior-impresion-3d/
- https://www.bpmsat.com/construccion-de-una-impresora-3d/
- https://www.bpmsat.com/curso-avanzado-en-impresion-3d/
- https://eddm.es/curso-impresion-3d-profesional/
- https://www.aysformacion.com/cursos-formacion/fff-technology-3d-printing-expert/
- https://www.aysformacion.com/cursos-formacion/formacion-fabricacion-aditiva-con-metales-desde-el-concepto-a-la-fabricacion/
- https://www.aysformacion.com/cursos-formacion/curso-nx-additive-manufacturing-diseno-convergente-optimizacion-topologica-e-impresion-en-maquina/
- https://www.cursosccc.com/a-distancia/curso-tecnico-impresion-3d#zona_form2
- https://www.masterd.es/curso-impresion-3d
- https://www.3dnatives.com/es/formacion-impresion-3d-curso-espana-050920182/
- https://www.mastoner.com/blog/post/mejores-cursos-impresion-3d/
- https://www.3dnatives.com/es/directorio-impresion-3d/listado/trimaker
- https://miriadax.net/home
- https://cursosindustriales.es/curso-impresion-3d-avanzada/
- https://www.inesem.es/Curso-Impresion-3d
- https://fedetoformacion.es/curso/diseno-modelado-e-impresion-3d/
- https://am.vdma.org/documents/3586442/3754129/EU-Foerderung%20fuer%203D-Druck.pdf/6ca67ae9-4f14-4449-bf21-3470aea45e23
- https://www.cadplace.de/Hardware/3D-Drucker/Additive-Fertigung-Industrie-erkennt-Potenzial-der-neuen-Verfahren
- https://netzkonstrukteur.de/fertigungstechnik/3d-druck/#frueher-und-heute-entwicklung-des-3d-drucks
- https://www.bitkom.org/sites/default/files/file/import/180403-Bitkom-Positionen-3D-Druck-2.pdf
- https://www.kmk.org/themen/berufliche-schulen/duale-berufsausbildung/downloadbereich-rahmenlehrplaene.html?type=150&tx_fedownloads_pi1%5Bdownload%5D=41173&tx_fedownloads_pi1%5Baction%5D=forceDownload&tx_fedownloads_pi1%5Bcontroller%5D=Downloads&cHash=a0c3231aadf9d8f1af840fdc8456f006
- https://www.wbstraining.de/weiterbildung-cad
- https://www.addit3dprinting.com/de/seminar-and-weiterbildung/
- https://www.ihk-akademie-schwaben.de/weiterbildung/lehrgang/229206/augsburg/ihk-fachkraft-fuer-additive-fertigungsverfahren-3d-druck-neu-ulm-augsburg-kaufbeuren-3d-druck-additive-fertigung-cad-fachkraft-druck-rapid-prototyping
- https://www.bfw.de/angebot/weiterbildung/karlsruhe/zusatzmodul-additive-fertigung-3d-druck/
- https://www.cimdata.de/weiterbildung/fusion-360/

- https://www.cimdata.de/weiterbildung/cad-konstruktion-3d-druck/
- https://www.print.de/news-de/t-shaped-skills-qualifikationen-in-die-breite-und-in-die-tiefe-foerdern/
- https://www.denkmodell.de/hintergrund/der-mythos-vom-t-foermigen-mitarbeiter/
- http://www.perspektive-mittelstand.de/IT-Kompetenz-Generalisten-Spezialisten-und-T-Shaped-Professionals/management-wissen/3182.html
- https://www.pro3d.si/index.php?route=storitve/izobrazevanja
- https://www.3d-tisk.si/kategorija/izobrazevanja/
- https://www.3d-tisk.si/prakticno-izobrazevanje-uporaba-3d-tiska-v-arhitekturi/
- https://www.solidworld.si/izobrazevanje/individualno-izobrazevanje
- http://www.3dprint.si/tecaji/
- https://www.3way.si/storitve-vzvratni-inzeniring/#3d-printanje
- https://www.napovednik.com/dogodek329079_delavnica_3d-tiska
- https://ferroecoblast.com/sl/industries/additive-manufacturing-3d-printing
- https://www.chemets.si/3d-tiskanje-osvaja-panogo-za-panogo/
- http://www.npk.si/katalog.php?katalogid=85836141
- National Observatory for Telecommunications and the Information Society (ONTSI). Report on the Information Society and Telecommunications and the ICT and Content Sector in Spain by Autonomous Communities (Edition 2019). Retrieved from: https://www.ontsi.red.es/sites/ontsi/files/2019-10/Informe%20Espa%C3%B1a.pdf
- PwC (2019). Curriculum Guidelines for Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT). Interim report. Doi: 10.2826/356798
- PwC (2018). Vision and Sectoral Pilot on Skills for Key Enabling Technologies: Key outcomes and recommendations. FINAL REPORT v2.0. retrieved from: https://skills4industry.eu/sites/default/files/2019-04/SIS-DT-Interim%20Report%20-%20Full%20version.pdf