

Address FOR FUTURE



WP5: Training Curriculum Designs

Result 4. Additive Manufacturing Workforce Transformation Program

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1. INTRODUCTION

The activities of WP5 were developed starting from the main results of WP4, which analyzed the differences and similarities between conventional manufacturing and additive manufacturing (AM). These insights provided a solid foundation for identifying the skills required for AM, helping to bridge the gap between traditional manufacturing techniques and the innovative demands of AM. WP5 focused on the creation, implementation, and evaluation of training modules aimed at addressing both technical AM skills and entrepreneurship, ensuring the workforce was well-equipped to fully exploit the potential of AM.

WP5 was structured into distinct tasks, beginning with the preparation of training modules on AM technologies and AM entrepreneurship. These modules were designed by project partners, experts from academia, and industry, based on relevant industry needs to ensure their relevance and practical application. The training content not only addressed technical skills in the field of AM technologies but also entrepreneurial knowledge with a specific focus on the AM industry, with the objective of raising awareness among young professionals about the potential of AM for business development.

More in detail, the first activities of WP5 included virtual training sessions (LTT1 and LTT2), which involved trainers, educators, and representatives from small and medium-sized enterprises (SMEs). These sessions transferred up-to-date knowledge and established standardized curricula for key roles in AM, such as AM Operator, AM Engineer, and AM Designer. Furthermore, specialized entrepreneurship training was provided to illustrate how AM technologies could be applied in various business contexts, supporting the development of entrepreneurial initiatives in the AM field.

Subsequently, the training modules were tested through face-to-face activities (LTT3 and LTT4). These sessions were critical for gathering direct feedback from participants and allowed for the observation of how the content was received and applied in real-time. The comparison between face-to-face training and the upcoming digital platform-based training was also explored, ensuring that both delivery methods were equally effective. Company visits and practical applications reinforced the theoretical knowledge, providing a more comprehensive learning experience.

2. AIM AND SCOPE

At this stage, the objective of WP5 was to ensure that the digital environment would achieve results comparable to those of face-to-face training. This included observing participant questions, addressing critical areas, and facilitating knowledge sharing. Additionally, the outcomes of the training sessions were analyzed, considering elements such as needs assessment, target groups, innovation aspects, expected impact, and potential for transferability. This process not only provided educational value but also served as an experimental phase ahead of the creation of the digital platform.

The contents were first specifically designed to be implemented in the digital platform (to be then developed in WP6) accounting for the inputs from WP3 and WP4 and then tested by integrating the AM training content delivered during the virtual sessions (LTT1 and LTT2) and the face-to-face sessions (LTT3 and LTT4). Real business examples were also designed to be then incorporated into the digital platform, and feedback from participants was gathered to assess the suitability of the content and practical case studies. This approach provided a new way to bridge the gap between education and industry, resulting in the creation of training materials in the field of AM that had not previously existed, ensuring their long-term usability and impact.

The training scheme is arranged following the subsequent main activity steps.

1. Preparation of AM training modules

Starting from the skill map developed in WP4, an initial search for existing E-learning courses on AM was conducted. This search served as a starting point for developing the necessary content for unskilled, non-technical, and technical students. These individuals will be introduced to AM technology, entrepreneurship, and business models. The course dedicated to AM technology was structured into three levels (beginner, intermediate, and advanced) to ensure comprehensive training for participants who are not yet experts in AM technology, allowing them to either follow the levels sequentially or select a specific level based on their existing knowledge.

After conducting a curriculum analysis within the scope of the project and mapping the skills of the existing human resources, the curriculum preparation group was established including experts from CEF, Gazi University, EPMA, UPM, Bologna University, and Infotron. The curriculum preparation group worked on creating a trainer training program. This group of trainers aimed to disseminate knowledge of cutting-edge AM technologies, integrate industry-relevant examples to integrate into the curricula to be prepared.

Subsequently, the training modules on AM technologies were prepared. Given that these curricula will serve as a vast resource library for SMEs, trainers, professionals, and learners, they will be translated into the languages of all project partners (English, Turkish, Bulgarian, Spanish, and Italian) without the need for external linguistic support.

2. Preparation of Entrepreneurship training modules

Similarly, the entrepreneurship training modules were created to transfer entrepreneurship knowledge, business modeling, and market entry strategies to both unskilled and skilled students.

The entrepreneurship modules were developed to benefit future entrepreneurs and SMEs. These modules aimed to support young entrepreneurs and individuals in acquiring the skills necessary to adapt to AM-driven markets.

3. Training of trainers for AM and Entrepreneurship

The primary goal was to deliver cutting-edge knowledge on AM technologies, integrating real-world industry examples. So, online lectures were organized to transfer knowledge of AM technology and entrepreneurship from field experts to future trainers. These sessions aimed to equip trainers with the skills necessary to effectively teach AM technologies.

After conducting curriculum analysis and skill mapping, initial training sessions were provided to trainers, teachers, and SME representatives.

4. Test group trainings

Trainers, who have been prepared to impart knowledge on AM and entrepreneurship, conducted face-to-face training sessions for unskilled, non-technical, and technical students, with the involvement of project partners. These sessions aim to deliver comprehensive AM training to engineers, engineering students, and potential technical workforce (both employed and unemployed) in Turkey and Bulgaria. The objective is to replicate the benefits of face-to-face training in a digital environment by closely observing participant questions and identifying critical areas of focus.

In the upcoming work package (WP6), a digital platform will be integrated for training purposes. To ensure the effectiveness of this platform, its applicability will be tested by incorporating AM training content used in face-to-face sessions. Face-to-face training serves two main purposes: first, to interact directly with participants, addressing their questions, observing their engagement, and understanding their learning experience; and second, to compare the effectiveness of face-to-face training with that of the digital platform, ensuring that the latter meets the same standards of quality and effectiveness.

3. METHODOLOGY

The methodology for this work package involved assessing the knowledge required and preparing curriculum to train experts in additive manufacturing (AM). Initial research conducted by the project partners focused on existing e-learning courses on AM, which provided valuable insights for defining the training content. This research was essential in developing comprehensive training modules designed for individuals seeking to acquire skills in AM.

Following a thorough curriculum analysis and skill mapping of existing human resources, the curriculum preparation group developed a trainer training program. The training modules were structured into three levels, beginner, intermediate, and advanced, to cater to various target groups including students with different educational backgrounds, unemployed individuals, and working professionals.

In addition to the AM training modules, entrepreneurship modules were developed to equip future AM experts with the necessary knowledge of innovative business models. These modules aim to provide a comprehensive understanding of both the technical and business aspects of the AM industry.

The developed modules underwent a testing phase. Initially, a "training of trainers" (LTT1 and LTT2) phase prepared instructors to oversee subsequent "test group activities" (LTT3 and LTT4). During this phase, a group of students tested the AM and entrepreneurship training modules in person, offering valuable feedback that informed further refinements to enhance the effectiveness and relevance of the training.

a. The methodology to prepare training modules

As seen in WP3, a modular CID is proposed which contains three levels of AM training: (1) Beginner, (2) Intermediate and (3) Advanced. This modular approach ensures a progressive learning experience for learners/students, allowing them to acquire the necessary knowledge and skills in a structured manner. In this work package, the following steps were completed to finalize the modules, where the prepared draft CID was taken as reference and improved with additions.

- 1. Identify existing E-learning Platform capabilities:** This task involves evaluating the features and functionalities of current e-learning platforms to determine their suitability for delivering AM training. The assessment helps in understanding how these platforms can support interactive and comprehensive training experiences.
- 2. Search online for existing courses:** An extensive search for existing e-learning courses on AM was conducted to gather information on current offerings. This search aimed to identify gaps and areas where additional content or improvements are needed based on what is already available.

b. Preparation of AM training modules

The implementation of the AM training modules has been articulated into the following tasks:

1. **Template definition:** The template used for existing AM courses was refined based on data gathered from the collection of current AM courses. This updated template incorporates the necessary information and organizational structure for the development of new AM courses.
2. **Definition of the learning outcomes:** Establish clear objectives for what each training module aims to achieve, ensuring that learners acquire the necessary skills and knowledge in AM technology.
3. **Identification of the key topics:** Determine the essential subjects and concepts to be covered within each module to provide comprehensive and relevant training in AM.
4. **Identification of the target audience:** Specify the groups for whom the training is intended.
5. **Organization in levels (beginner, intermediate, advanced):** Structure the training into three distinct levels to accommodate varying degrees of prior knowledge and skill, allowing for progressive learning.
6. **Definition of the training modules for each level:** Develop specific modules for each level, ensuring they are aligned with the learning outcomes and include appropriate content and complexity.
7. **Definition of the structure of AM training modules:** Outline the format and components of each module, such as final assessments, presentations, and videos, to ensure a coherent and engaging learning experience.
8. **Data collection by the partners:** Collect relevant information for each module by filling out the predefined template, ensuring consistency and completeness of data across all modules.
9. **Preparation of the contents of each AM module:** Develop the educational materials for each module, including presentations, additional resources, and videos, to support effective teaching and learning.

c. Preparation of Entrepreneurship training modules

The implementation of the Entrepreneurship training modules has been articulated into the following tasks:

1. **Definition of the learning outcomes:** Set clear objectives for the entrepreneurship modules to ensure learners gain essential business skills for the AM industry.

2. **Identification of the key topics:** Select the core subjects related to entrepreneurship and business models to be included in the modules.
3. **Identification of the target audience:** Specify the groups for whom the training is designed, such as skilled or un-skilled students.
4. **Definition of the training modules:** Develop modules covering various aspects of entrepreneurship relevant to AM professionals.
5. **Definition of the structure of Entrepreneurship training modules:** Outline the module format, including presentations and videos.
6. **Data collection by the partners:** Complete the template for each module with relevant information (such as reference books, learning outcomes, etc) gathered by the partners.
7. **Preparation of the contents of each Entrepreneurship training module:** Create and compile materials such as presentations, additional resources, and recorded videos for each module.

d. Training of trainers (LTT1 and LTT2)

LTT1 and LTT2 activities were conducted to enhance the knowledge, skills, and abilities of the team consisting of trainers, academicians, and professionals who are finalizing the AM and Entrepreneurship training modules. These activities aimed to provide international peer learning, calibrate the curricula before their release to end users, and ensure that all trainer candidates are adequately prepared to train future trainers, as outlined in the ADDRESS project.

LTT1 and LTT2 focused on testing the AM and Entrepreneurship training modules developed after a skills analysis and a survey of existing AM e-learning courses. They were designed to help partners improve their skills in areas beyond their primary expertise, enabling them to support other trainers effectively.

During these activities, virtual lectures were organized, attended by selected participants from the project's partners. Each module was presented by the main instructor, who provided an overview of the module's structure, including lesson organization, illustration of the prepared teaching materials, and the structure of intermediate and final assessments, as well as any additional educational resources. The key learning outcomes were outlined, and the main aspects of the lesson contents were summarized to equip future trainers with the essential elements of the module and effective teaching methods. Each presentation ended with a brief plenary discussion aimed at gathering feedback to refine the module content and presentation.

This structured approach was applied to all modules, including AM training modules (beginner, intermediate, and advanced) during LTT1 and Entrepreneurship training modules during LTT2.

e. Test group activities (LTT3 and LTT4)

The LTT3 and LTT4 activities were conducted in person in Ankara, Turkey, and Sofia, Bulgaria, with the goal of testing the prepared training modules and gathering feedback from participants, which included students and workers with limited experience in the AM topics presented.

The methodology for the LTT3 and LTT4 activities was designed to create an immersive and interactive learning experience. A blended approach was adopted, combining preparatory materials, in-person instruction, practical exposure through site visits, and follow-up resources. Surveys were conducted to collect participant feedback, aimed at gathering useful insights for potential adjustments to the developed modules, if necessary. A final assessment was also carried out to certify course completion. This structure ensured a comprehensive learning process that balanced theoretical understanding with practical application.

4. KEY RESULTS

a. Template for collecting existing E-learning AM courses

The template illustrated in this section was developed to collect detailed information about existing E-learning AM courses. The partners used this template to systematically gather data for each AM course, and the compiled results are included in the attached report (Appendix 9. Existing E-Learning AM Courses). The template has been designed to ensure a comprehensive overview of the courses and their key elements.

The template is organized into the following sections:

- 1. Overall structure of the E-learning platform and AM course:** This section presents information about the platform and the course, including the course title, language of instruction, target audience, overall duration, an overview of the platform's structure, the course's objectives and content, any assessment methods, required prerequisites, and the course lecturers.
- 2. Teaching material:** This section lists available teaching resources such as textbooks, publications, any available videos, and additional materials used to support learning.
- 3. E-learning platform and course detailed structure:** Here, the course structure is detailed, including the platform's capabilities. The course organization is outlined, including tools used like recorded lectures, intermediate tests, assignments, tutorials, and repositories.
- 4. Assessment methods and criteria:** This section details the presence of intermediate tests, assignments, projects, final exams, or other forms of evaluation, specifying how many of each are included in the course and providing a brief description of their structure.

5. **ECTS:** This section details the total activities required for the course (such as training hours, tutorial hours, reading tasks) to assess the equivalent ECTS.
6. **Course learning outcomes:** This section outlines the learning outcomes expected from successful completion of the course, including the skills and competencies students will acquire upon completing the program.
7. **Detailed course content:** In this section, the specific content of the course is detailed, highlighting each topic covered within the module. This includes the organization of recorded videos, self-assessment activities, final tests, resources and additional materials provided to support the learning process.

The existing E-learning AM courses are listed in Appendix 9, where the detailed module sheets are included. The information related to the courses found was entered into the sheets following the provided template. The following figure shows an illustration of the template.

TEMPLATE FOR ONLINE COURSES WITH THE EXPLANATIONS		
Section1. Overall structure of the E-learning platform and AM course		Explanations
Title of the Course/Training		
Language of Instruction		
Level of Course/Training Unit	Technical/Undergraduate/Graduate	
Platform name / web site		
Target Audience	Un-Skilled/Non-Technical/Technical Persons	
Duration	5 Weeks- 40 Hours	
Overall platform organization	Recorded videos + supplemental material + ...	
Type of Course/Training Unit	Standalone/module of course	
Objectives of the Course/Training	Introduction to Additive Manufacturing, AM Processes, AM Design Perspective	
Course/Training Content		
Prerequisites and co-requisites		to previous courses is mandatory/strongly suggested; Co-requisites: e.g. additional knowledge necessary to full understand the contents
Course/Training Coordinator		
Assessment/verification		
Final certificate		
Name of Lecturers/Trainers		
Section 2. Teaching material		
Resources		
Suggested main Text Books		Materials: e.g. articles, books, videos from lab, video tutorials, developed examples ...
Additional material		
Section 3. E-learning Platform & course detailed structure		
	Description	Describe the course structure in relation to the platform capabilities. For example: - PowerPoint presentations - lecturer explains using a whiteboard - the type of assignments - intermediate test is a quiz or open questions, ...
Recorded lectures (videos)		
Intermediate tests		
Assignment (homework)		
Tutorials		
repository		
other 1		
other 2		
other 3		

Section 4. Assessment Methods and Criteria				
In-Term Studies	Quantity	Description		
Intermediate tests				
Assignments				
Other type				
Projects				
Final test				
Total				
Section 5. ECTS Allocated Based on Student Workload				
Activities	Quantity	Duration (Hours)	Total Work Load	Subdivision of the total course activities into equivalent ECTS
Weekly Theoretical Course/Training Hours				
Weekly Tutorial Hours				
Reading Tasks				
Material Design and Implementation				
Midterm Exam and Preperation for Midterm Exam				
Workshop practices				
Final Exam and Preperation for Final Exam				
Total Work Load		Number of ECTS Credits:		
Section 6. Course/Training Learning Outcomes: Upon the successful completion of this course/training, students/attendees will be able to:				
No	Learning Outcomes			
1				
2				
3				
4				
Section 7. Detailed Course/Training Contents				
Lecture/module	Content	Structure of the lecture	Main teaching Material	Supplemental material
1: title of the module	Ref. in Section 1: Course/Training Content. Organization of the course in modules, each one with a specific structure organized in videos, self-assessment, graded assessment, resources (textbooks and additional materials), etc.	5 videos of 10 min+1 assignment+1 self assesment test+ tutorial,....	[Text 1, 2]	[Ref1]
2: title of the module			[Text 1, 2]	[Ref2]
3: title of the module			[Text 1, 2]	

b. Template for AM training modules

The present section illustrates the template developed to define the detailed information about E-learning AM courses produced. The partners used this template to systematically collect, check, evaluate data and information for each AM course, and the compiled results are included in the attached report as AM and Entrepreneurship Training Modules, in Appendix 10, 49, 50, 51 and 52 with 5 different languages. The template was designed to provide a comprehensive overview of each course and its key components.

The template is organized into the following sections:

- 1. General information:** This section includes essential details about the platform and the course, such as the course title, language of instruction, course level, target audience, overall duration, course objectives, required prerequisites, assessment methods, certification upon completion, and the course lecturers.
- 2. Teaching material:** This section lists the available teaching resources, including textbooks, publications, videos, and any supplementary materials provided to support the learning process.
- 3. Self-assessment and final tests:** This section describes the types of evaluations used in the course, such as intermediate tests, homework assignments, projects, and final tests.

It specifies how many of each are included and provides a brief explanation of their structure and purpose.

4. **Learning outcomes:** This section outlines the expected learning outcomes upon successful completion of the course, detailing the skills and competencies students will acquire throughout the program.
5. **Detailed course description:** In this section, the specific content of the course is described, highlighting each topic covered within the module. It provides details about the content organization, including the number and duration of recorded videos, presentations, and the use of supplementary materials, as well as the different assessment methods applied to each topic.
6. **Guidelines for the preparation of the contents for the modules:** The materials for each module are prepared according to specific guidelines to ensure consistency across the platform. These guidelines set the standards for content creation, ensuring uniformity in structure and quality for the E-learning platform. They include instructions for preparing PowerPoint presentations, recorded videos, suggested additional materials, self-assessments, homework, projects, final tests and forum activities. Specifically, the recommended additional materials consist of: (i) videos which may include laboratory experiments or case studies, (ii) textbooks, (iii) papers and other relevant resources.

The following figure shows an illustration of the template.

Section 1. General Information		
		Explanations
Title of the Course/Training		
Language of Instruction	English	
Level of Course/Training Unit		
Target Audience		Un-Skilled/Non-Technical/Technical Persons
Duration		
Objectives of the Course/Training		
Prerequisites and co-requisites		
Course/Training Coordinator		Prerequisites: e.g. attendance to previous courses is mandatory/strongly suggested; Co-requisites: e.g. additional knowledge necessary to full understand the contents
Assessment/verification		
Final certificate		
Name of Lecturers/Trainers		
Section 2. Teaching Material		
Resources		Explanations
Suggested main Text Books		Materials: e.g. articles, books, videos from lab, video tutorials, developed examples ...
Additional material		

Section 3. Self-Assessment Tests and Final Test

In-Term Studies	Quantity	Description
Intermediate tests		
Homework		
Projects		
Final test		
Other type		

Section 4. Learning Outcomes

(Upon the successful completion of this course/training, students/attendees will be able to:)

Learning Outcomes	
1	
2	
3	

Section 5. Detailed Description of The Content

Module title	Content	Power point presentations	Recorded Lecture	Main teaching	Other videos (from other sources)	Additional materials	Self assessment	Homework/ projects	Final test	Overall structure of the lecture
	Brief description of the content	Description of the organization and number of PPTs to be provided for each module	Description of the structure, number and expected duration of the recorded videos for each module	Books and lecture hand notes prepared by the lecturer	Additional videos from external sources (Youtube,...)	Scientific papers, readings, tutorial, other type of material,...	Describe the type of test: multiple-choices, open questions,...	Provide details on whether homework is required. If so, describe the type of homework, or project, and provide instructions on how the student should develop it	Describe the final test	Summarize the overall structure of the module. E.g. number and sequence of PPT, recorded videos, additional material, number of tests, final test
1 - TITLE										
2 - TITLE										
3 - TITLE										

Guidelines for the preparation of the contents for the modules

PRESENTATION	RECORDED VIDEOS OF THE LECTURE	MAIN VIDEO CONTENT WORK RELATED TO EACH TOPIC	Other videos (from other sources)	RELATED READING ASSIGNMENT (OPEN SOURCE LINK)	Self-assessment test	Homework/ project
The presentation should be prepared following the template provided by the coordinator	It is suggested to record brief videos of a duration between 5-30 minutes. The structure of the videos should follow the organization of the PPT and possibly be embedded within the presentation	Suggested videos could include some lab experiments, demonstrations of the process, designed parts,...	Videos from free sources	The articles section should be left optional for completing the course.	The answers and the right answers should be provided after the completion of the test	Homework should not be mandatory for completing the course
Suggested structure for each presentation: (1) Introduction with a clear explanation of the outline of the lecture, (2) body of the presentation structured with bullets and figures, (3) conclusions with key points/concepts to remember				Provide links to the articles. A brief description of the article content should be given. An information note should be included, stating that the articles are highly recommended.	Documents should be prepared following the template provided by the coordinator.	The homework should be assigned if it is strictly necessary.
Presentations should be prepared to be complemented by the recorded videos of the lecture						

c. AM training modules

The AM training modules were structured into three distinct levels: beginner, intermediate, and advanced, to address the varying needs of different target groups, including students from diverse educational backgrounds, unemployed individuals, and professionals. The training is divided into 1 comprehensive beginner module, followed by 5 intermediate modules, and 5 advanced modules.

The titles of the AM training modules are as follows:

Beginner level:

- (0) Beginner for Additive Manufacturing

Intermediate level:

- (1) Design for Additive Manufacturing
- (2) Performance-Oriented Design and Analysis of Additively Manufactured Components
- (3) Additive Manufacturing Process Development
- (4) Numerical Simulation of Additive Manufacturing Processes
- (5) Inspection and Quality Control

Advanced level:

- (6) Post-processing Methods
- (7) Additive Manufacturing Standards and Cost Analysis
- (8) Advanced Additive Manufacturing Techniques
- (9) Practical Applications – Theoretical
- (10) Practical Applications – Case studies

The module sheets also outline the assessment methods, detailing the number of self-assessments included at the end of each module, and, where applicable, a final test. In some instances, students are also expected to complete homework or projects, with clear instructions on how these should be developed.

To maintain consistency across all modules, specific guidelines were followed during their creation. The presentations were designed using a common template, beginning with an introduction that clearly outlines the lecture, followed by the main content supported by relevant figures, and concluding with key points and concepts to remember.

The AM training modules are provided in Appendix 10, 49, 50, 51 and 52 with 5 different languages, where the detailed module sheets are included. The well-structured and consistent format of these modules ensures a comprehensive, high-quality training experience for learners at all levels.

The following figures report a graphical illustration of the topics of each module.

AM Virtual Training Module			Topics	Lead Partner
Beginner	0	Beginner for AM	Overview on AM processes, Classification of AM processes, the ASTM/ISO/NADCAP classification of AM technologies, main characteristics, advantages and manufacturing constraints, polymer basic principles, polymer material knowledge, polymer constraints, metal basic principles, metal material knowledge, metal powder metallurgy, metal constraints, metal application, design for AM main concepts and objectives, design for AM 3D modeling, design for AM analyses based design, design for AM design optimization and topology, design for AM shape complexity, design for AM (DfAM) rules, biomimetic design approach, main concepts on the whole process planning chain, use of common AM software	CEF
Intermediate	1	Design for AM	Generative Design, Topology, Shape and Size Optimization, Lattice Design, Reverse Engineering	Gazi
	2	Design and Analysis	Mechanical and Thermal Analysis, Software implementation, Analysis of FEM results	UPM
	3	Process Development	Process Parameter Selection, Part Orientation, Support Generation, Scanning Strategies, Path Planning and Process Parameter Control	UNIBO
	4	Numerical Simulation	Thermal Analysis, Distortion Analysis, strain analysis, support structure analysis, orientation analysis	UPM
	5	Inspection and Quality Control	Non-destructive Testing Methods, Mechanical Testing methods, Microstructural Analysis, SEM, CT Analysis, Surface Topography Measurements Methods, Dimensional and tolerance measurements and analysis	Infotron
Advanced	6	Post Processing Methods	Surface enhancements methods, Heat Treatment, Support Removal, Finishing etc.	CESOL
	7	AM Standards & Cost Analysis	Standardization and cost estimation (material, energy, operating etc.)	EPMA
	8	Advanced AM Techniques	AI in AM, Micro-Nano Printing, Bioprinting, 4D Printing, Hybrid AM, FGM and Smart Materials, environmental and social implications	Infotron
	9	Practical Application Theoretical	Production Planning & Preparation, industrial and business case models, Process Optimization and Simulation, Machine Operation, raw material handling (loading and depowdering etc.), Workshop Production, Post Processing, testing and Inspection, Maintenance of AM machine and its units	Gazi
	10	Practical Application Practical Cases	Structural design for AM, WAAM technology and manufacturing, WAAM application and testing	UNIBO

d. Entrepreneurship training modules

The Entrepreneurship training modules were designed to address the varying needs of target groups, equipping them with the entrepreneurial skills necessary to succeed in the AM sector.

The titles of the Entrepreneurship training modules are as follows;

- (1) Testing Entrepreneurship Features and Business Idea
- (2) The concept of Business Plan and its Components
- (3) Workshops to Reinforce Business Plan Elements
- (4) Issues to be considered in Writing and Presenting the Business Plan Entrepreneurial Person Profiles and Evaluating Opportunities
- (5) Enterprise Finance and Financial Management
- (6) Business Model and Enterprise Strategies
- (7) Technology and Innovation Management
- (8) AM Themed Entrepreneurship Examples and Hands-on Learning Contents

Each module was developed with a uniform structure that serves with 5 languages.

To further enhance the learning experience, supplementary resources such as suggested reference books, readings, and relevant videos were provided alongside the core materials. These additional resources were selected to provide learners with solid support throughout their training.

The Entrepreneurship modules are presented in Appendix 10, with their own tailored format that differs from the template used for AM modules. The module sheets include key information about each module, such as topic, leading organization responsible for the module, instructor, main contents, and suggested references (e.g. additional videos on case studies, textbooks, papers, etc).

The AM training modules are provided in Appendix 10, where the detailed module sheets are included. The well-structured and consistent format of these modules ensures a comprehensive, high-quality training experience for learners in entrepreneurship.

The following figures report a graphical illustration of the topics of each module;

Entrepreneurship Training Modules	Topics	Lead Partner
1	Testing entrepreneurship features, business idea Activity Description (including profile of participants per organization, goals and results of the activity) development and creativity exercises	UNIBO
2	The concept of business plan and its components (market research, marketing plan, production plan, management plan, financial plan)	UNIBO
3	Workshops to reinforce business plan elements (market research, marketing plan, production plan, management plan, financial plan)	Cesol
4	Issues to be considered in writing and presenting the business plan, Entrepreneurial Person Profiles and Evaluating Opportunities	CEF
5	Enterprise Finance and Financial Management	LOT
6	Business Model and Enterprise Strategies	Cesol
7	Technology and Innovation Management	CEF
8	AM-themed entrepreneurship examples and hands-on learning contents	Gazi

e. Training of trainers on AM (LTT1)

The LTT1 activity was designed to provide partners with expertise about AM in fields outside their consolidated expertise. The lectures, organized by the University of Bologna, were delivered as virtual lectures for participants selected from the partners. The lectures were led from February 2nd 2024 to March 8th 2024 in 9 days with 10 different session. Upon completion, the participants were trained to be trainers in the subsequent LTT3 and LTT4 activities.

Detailed information, together with a schedule, list of participants from all the partners, and instructors of the virtual lectures are provided in the annex dedicated to the LTT1<T2 report.

f. Training of trainers on Entrepreneurship (LTT2)

As for LTT1 activity, the LTT2 activity was designed to provide partners with expertise in Entrepreneurship skills. The lectures, organized by the University of Bologna, were delivered as virtual sessions for participants selected from among the partners. The lectures were led from February 15th 2024 to March 5th 2024 over a span of 6 days.

Detailed information, together with a schedule, list of participants from all the partners, and instructors of the virtual lectures are provided in the annex dedicated to the LTT1<T2 report.

g. Test group activity in Turkey (LTT3)

LTT3 activity was held at Gazi University from May 22nd to 25th 2024. The activity was organized with pre-training materials provided to the participants, then, combining face-to-face lectures with a technical visit to TUSAŞ facility, and provided post-training resources and references. The lectures allowed participants to ask questions and engage in discussions on the covered topics. Feedback from participants and the final assessment offered invaluable insights into areas where the training content needed revisions or where participants felt additional detail was required. Additionally, it was possible to reach out to potential participants interested in trying the program and gauge their interest.

Detailed information, including the activity calendar, list of participants, lecturers, and survey results, is provided in the annex dedicated to the LTT3 report.

h. Test group activity in Bulgaria (LTT4)

LTT4 activity was organized by LOT-CONSULT in Sofia, Bulgaria, from April 15th to 17th 2024, attended by 18 participants. The activity was planned adopting the same format as LTT3, with pre-training materials provided to the participants, then, combining face-to-face lectures with a technical visit to B2N facility, and provided post-training resources and references. The lecturers encouraged discussions on the covered topics. Feedback from participants and the final assessment offered invaluable insights into areas where the training content needed revisions or where participants felt additional detail was required. Additionally, it was possible to reach out to potential participants interested in trying the program and gauge their interest.

Detailed information, including the activity calendar, list of participants, lecturers, and survey results, is provided in the annex dedicated to the LTT4 report.

7. DISSEMINATION ACTIVITIES

In this work package period, studies were carried out on the benefits of the content to be produced to the target group in terms of dissemination. For this purpose, the summary activities are as follows;

1. Additive manufacturing trainings were provided for VET students.
2. A scanning technology training was provided where use case examples were obtained from the Associated Partner in terms of scanning technology, thus increasing the use cases of the curriculum.
3. The project was introduced at the "Good Examples" Conference organized by the Turkish National Agency.

4. The project was introduced at the METEK Conference.
5. In a live broadcast of the TV channel named Ekotürk, the project was widely mentioned in a broadcast focused on CEF. AM method was emphasized in terms of future technologies. It was conveyed that a curriculum was being prepared and that it would be offered to individuals free of charge through a platform channel.
6. A protocol was signed with Uludağ University, thus achieving a sustainable benefit for some of the university's additive manufacturing curriculum to be carried out in line with the outputs obtained from the project.
7. In order to spread the benefits of this AM-focused project and increase its impact, a project focused on AM was selected and funded by CEF in the grant project activity, which is a different field of activity of the Project Coordinator CEF. (Konak Vocational and Technical Anatolian High School)
8. Insights were provided to the 3D Printing-The Future of Work and Opportunities for Developing Countries report prepared by UNDP and the project was transferred.
9. LTT studies and the results they produce were shared with target groups via social media and the website.

The above-mentioned and all other related activities can be accessed in Appendices 34 and 35.

8. CONCLUSIONS

WP5 was focused on the development and implementation of the “Additive Manufacturing Workforce Transformation Program”. This program aimed to address the rapidly evolving needs of the Additive Manufacturing industry by providing targeted training and resources to transform the workforce and enhance professional expertise in AM technologies.

Here are the key achievements and findings of WP5;

- a) **Comprehensive Analysis of Existing AM Training Resources:** The initial phase of WP5 involved a thorough review of existing E-learning platforms and training resources related to AM. This analysis highlighted the strengths and limitations of current offerings, which guided the development of a new, optimized E-learning platform offering AM courses. The goal was to create a platform that delivers high-quality, up-to-date content and meets the diverse needs of learners, from beginners to advanced practitioners.
- b) **Development of AM Training Modules:** A significant outcome of WP5 was the creation of structured AM training modules. These modules were designed to provide different levels of expertise:

- **Beginner Level:** A foundational module introducing the basics of AM, aimed at individuals with little to no prior knowledge.
- **Intermediate Level:** Five modules addressing more specialized topics such as design for AM, performance-oriented analysis, process development, and others.
- **Advanced Level:** Five modules covering advanced techniques, post-processing methods, and practical applications, tailored for individuals with prior experience in AM.

Each module was developed with a uniform structure that includes PowerPoint presentations, recorded lectures, and supplementary materials like textbooks and reference videos.

- c) **Entrepreneurship Training Modules:** In addition to AM training, WP5 also focused on developing entrepreneurship training modules. These modules are designed to equip learners with the necessary skills to succeed in the AM sector. The structure includes powerpoint presentations, recorded lectures, and supplementary resources, with detailed information available in Appendix 10.
- d) **Training of Trainers:** The virtual Training of Trainers activities (LTT1 and LTT2) played a crucial role in enhancing the capacity of trainers to deliver effective AM and entrepreneurship training.
- **LTT1:** This activity focused on AM training and involved adjustments based on participant feedback. Despite deviations from the initial plan, the training exceeded expectations in terms of participation and curriculum quality. Updates were made to curricula based on the training outcomes.
 - **LTT2:** This activity addressed entrepreneurship training, also exceeding expectations and contributing to the refinement of training materials.

Reports from these activities underscore the success of the virtual delivery methods and the positive impact on trainer effectiveness. The reports are provided in Appendix 11.

- e) **Test Group Activities:** Test group activities conducted in Turkey (LTT3) and Bulgaria (LTT4) provided valuable insights into the effectiveness of both online and face-to-face training methods. Feedback from these sessions led to improvements in training content and presentation, enhancing the overall quality of the program. These activities also helped identify areas for further development and refinement. The reports of the activities are provided in from Appendix 12 to 17.

All curricula contents were presented with 5 languages as seen in Appendices 10, 49, 50, 51 and 52.

WP5 has made significant progress in advancing knowledge within the AM sector by developing high-quality training resources as curriculum and implementing effective training strategies.



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