

SAM

SECTOR SKILLS STRATEGY
IN ADDITIVE MANUFACTURING

2nd Follow up and impact of AM Training Report

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1. Introduction

This report provides an overview of the results obtained with the follow-up to the participants involved in the 2nd stage of SAM piloting activities, six months after the training occurred. These activities cover the implementation of revised training guidelines for the IAMQS (International Additive Manufacturing Qualification System), including its Quality Assurance System integrated in the piloting of the methodology for creating professional profiles and skills.

The SAM piloting courses, conducted under WP5 (5.4 Piloting events of the 2nd Stage Real Case Scenarios), addressed the implementation of the following Competence Units (CUs)/Units of Learning Outcomes (ULOs): Certification, Qualification and Standardisation (CU63), Business for Additive Manufacturing (CU64), Overview on polymer materials and properties (CU65), Designing Polymers AM Parts (CU66), Post Processing for Polymers (CU67), Design for Material Extrusion (MEX) (CU68), Design for Powder Bed Fusion (PBF) Polymer (CU69), and Design for VAT Photopolymerization (CU70). In total, eight CUs were implemented from June to July 2021. The implementation of the 2nd Stage Real Case Scenarios counted with 292 participants, from which 271 students were assessed, with a 77% of the participants successfully approved.

This report compiles the information obtained through the implementation of D2.6 *Kit for tracking students, future employees and job seekers in AM* (developed in Work package 2) as well as some recommendations to improve future training sessions, collected among the participants of the 2nd Stage Real Case Scenarios Piloting Events. Despite having 292 participants in the AM pilot courses, only 79 responses were collected with the 6-month follow-up questionnaire.

2. Tracking and follow up survey results

After 6 months of the 2nd stage piloting course taking place, participants were invited to provide their feedback regarding the impact and usefulness of the AM Training courses received. A total of 79 answers were collected, and the findings are described below.

2.1 Participants background

In terms of profile and current job position, as demonstrated below in Fig. 1, the survey participants were Designers (14%), Managers (8%), Process Engineers (6%), Operator/Technicians (6%), Managers (6%), Supervisors (3%), Inspector & Quality Assurance (2%). However, the majority of the participants selected "Other" (61%) to describe their profile, such as: Student, Researcher, Product Engineer, Manufacturing Engineer, Materials Engineer, Project Manager, Teacher, Staff Associate, Manufacturing Engineer, CNC Programmer/Setter, Sole Trading Consultant, Senior Technical Officer, Strategy and Business Development, Entrepreneur, Sales Engineer and Senior Engineer, as represented below on Fig. 2.

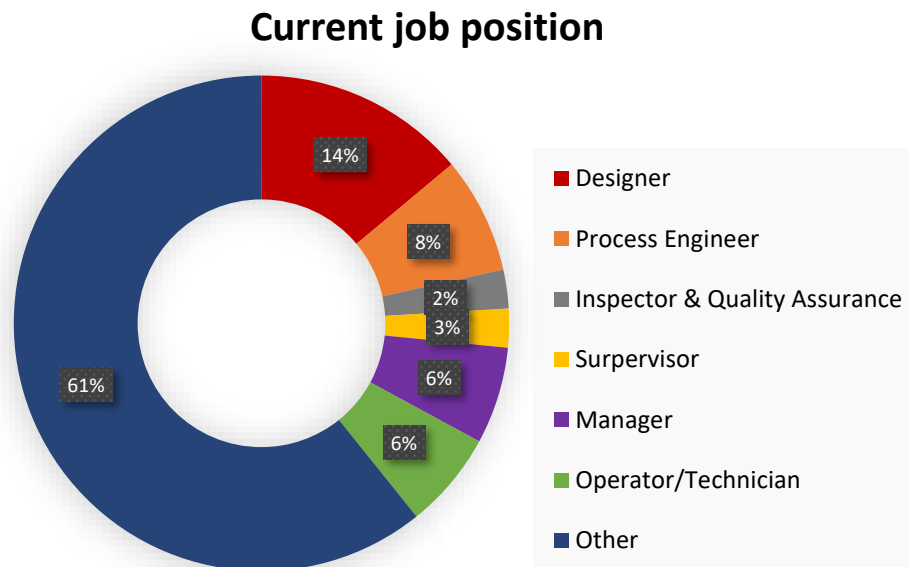


Figure 1 Current job position within your organisation

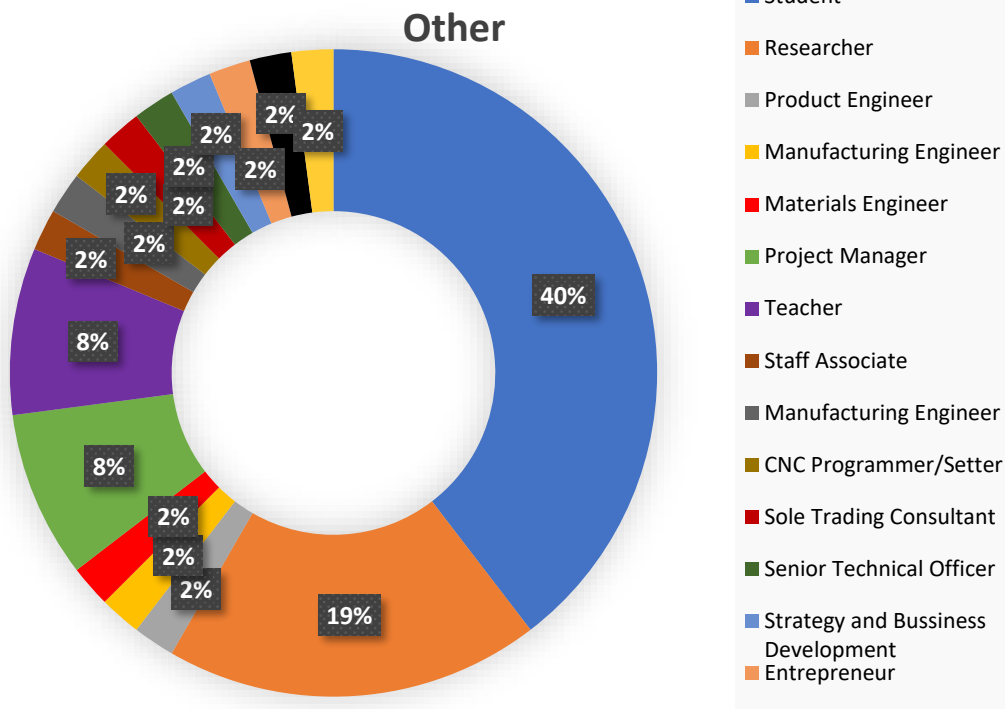


Figure 2 Current job position within your organisation/Other

In terms of employability data, most of the participants replying to the survey were employed before starting the training (80%), compared to 20%, who were unemployed, as represented in Fig. 3. These findings are quite positive, as they show participants' **commitment to lifelong learning and re-skilling towards a specialization and/or acquisition of knowledge in the AM field**. As for the unemployed participants, their enrolment in training, can be translated as an investment in learning about AM as a mean to improve their future career/ employability and to increase their opportunities to integrate into the labour market.

Employability before the training

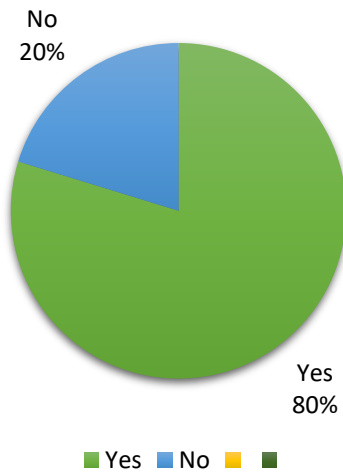


Figure 3 Employment before the training

2.2 Competence unit course (SAM Pilots) feedback

Participants replied to the follow-up questionnaires, after attending the training courses, which are distributed among eight different CU/ULOs as shown in Fig. 4, by decreasing order of number of participants:

- 37% from CU65: Overview on polymer materials and properties
- 33% from CU63: Certification, Qualification and Standardisation (CQS) in Additive Manufacturing
- 12% from CU66: Designing Polymers AM Parts
- 9% from CU64: Business for Additive Manufacturing
- 4% from CU68: Design for Material Extrusion (MEX)
- 4% from CU70: Design for VAT Photopolymerization
- 1% from CU67: Post Processing for Polymers.

Replies by Competence Unit

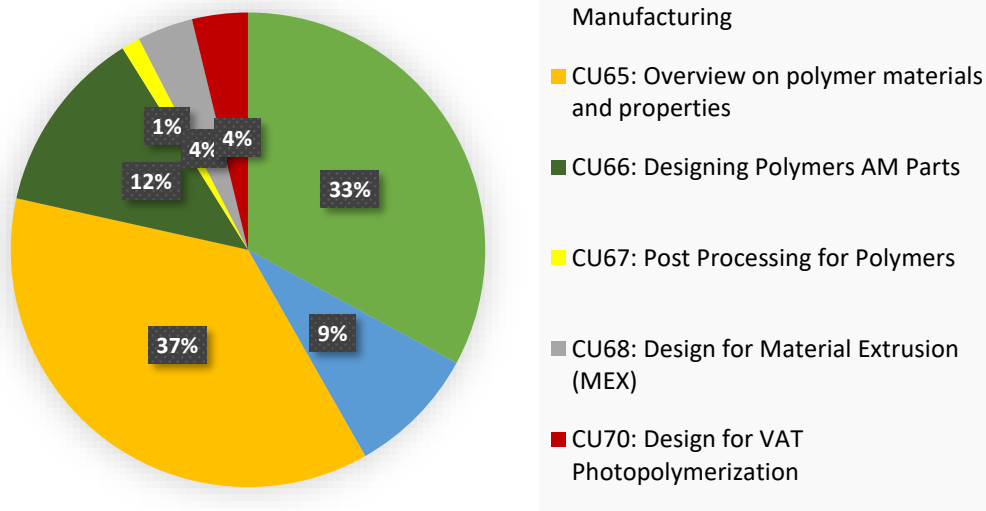


Figure 4 Replies by CU

2.3 Applicability and future training

In terms of **applicability of the knowledge and skills** before and after the training for **Certification, Qualification and Standardisation (CQS) in Additive Manufacturing (AM)**, most participants considered their knowledge has significantly increased in all topics after the training, as showed below in Fig. 5.

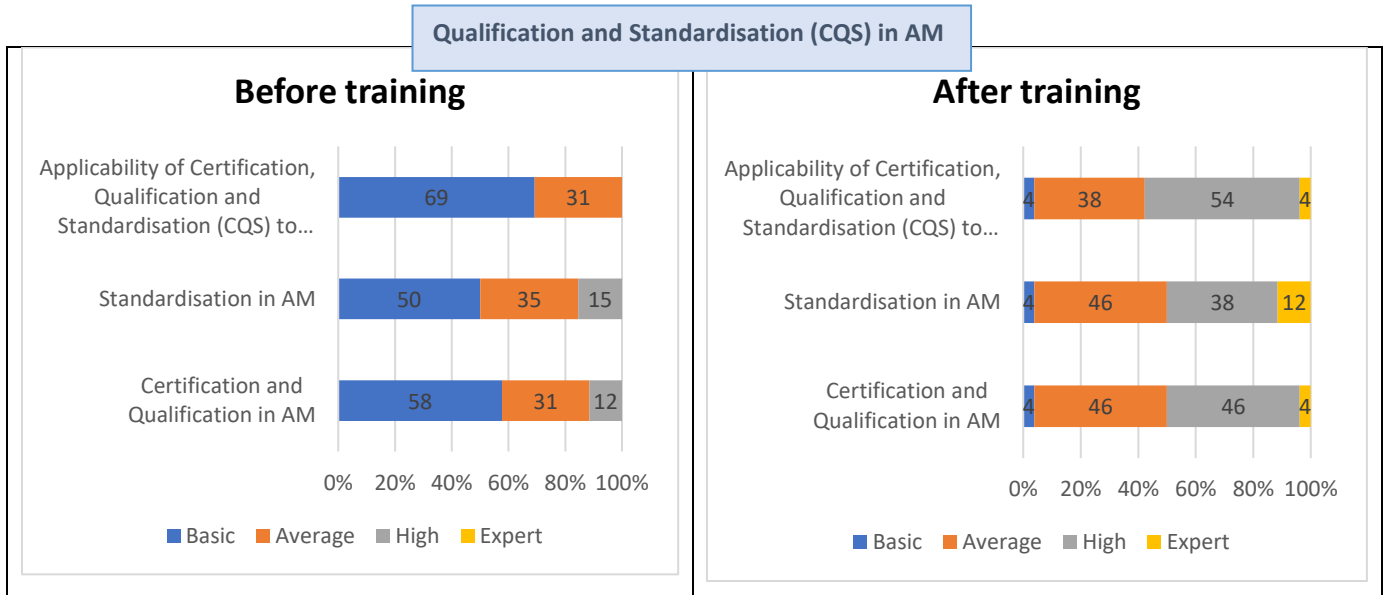


Figure 5 Applicability of the knowledge and skills on CQS before and after training

In terms of **applicability of the knowledge and skills** before and after the training on **Business for Additive Manufacturing (AM)**, all participants also considered a significantly increase in their knowledge and skills in all topics, from Basic, Average and High prior to the training and to Average and High after the training, as showed below in Fig. 6.

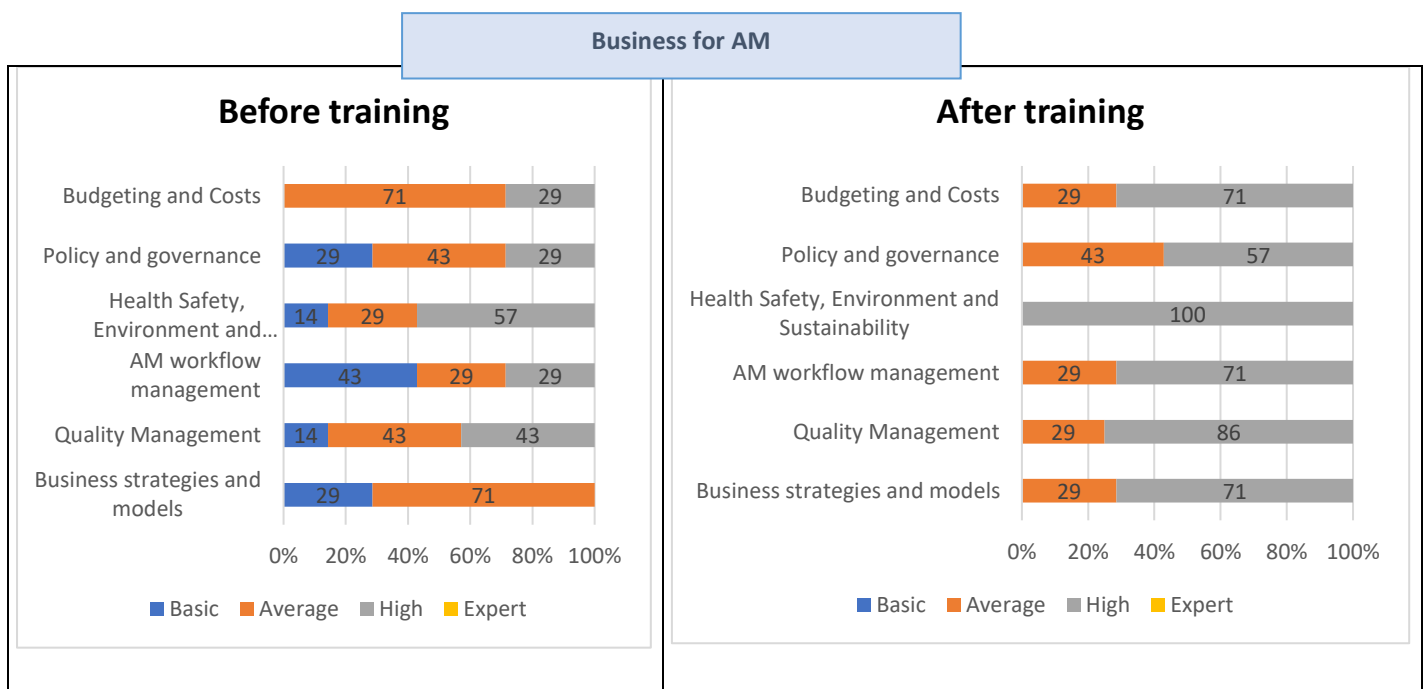


Figure 6 Applicability of the knowledge and skills on Business for AM before and after training

In terms of **applicability of the knowledge and skills** before and after the training on **Polymers Materials and Properties**, most participants considered they're between Basic, Average, High and Expert prior to the training and with an improvement to Average, High and Expert knowledge and skills after the training, as showed below in Fig. 7.

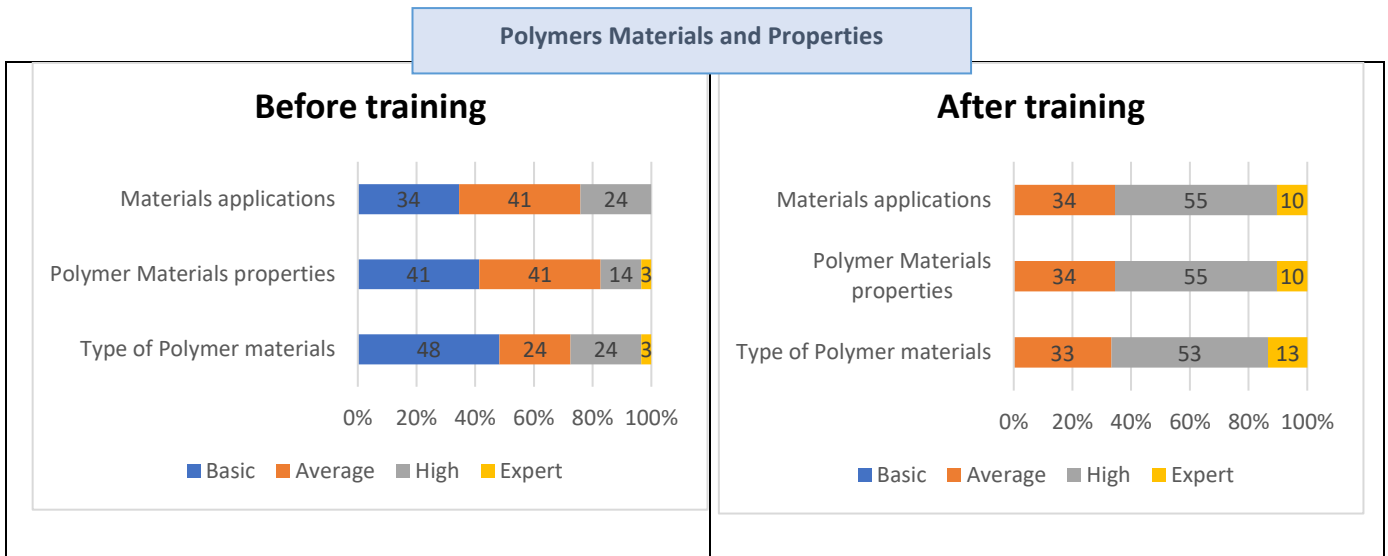


Figure 7 Applicability of the knowledge and skills on Polymers Materials and Properties before and after training

In terms of **applicability of the knowledge and skills** before and after the training on **Designing Polymers AM Parts**, participants replied a comprehensible progression from Basic and Average levels towards High and Expert levels in all topics, as showed below in Fig. 8.

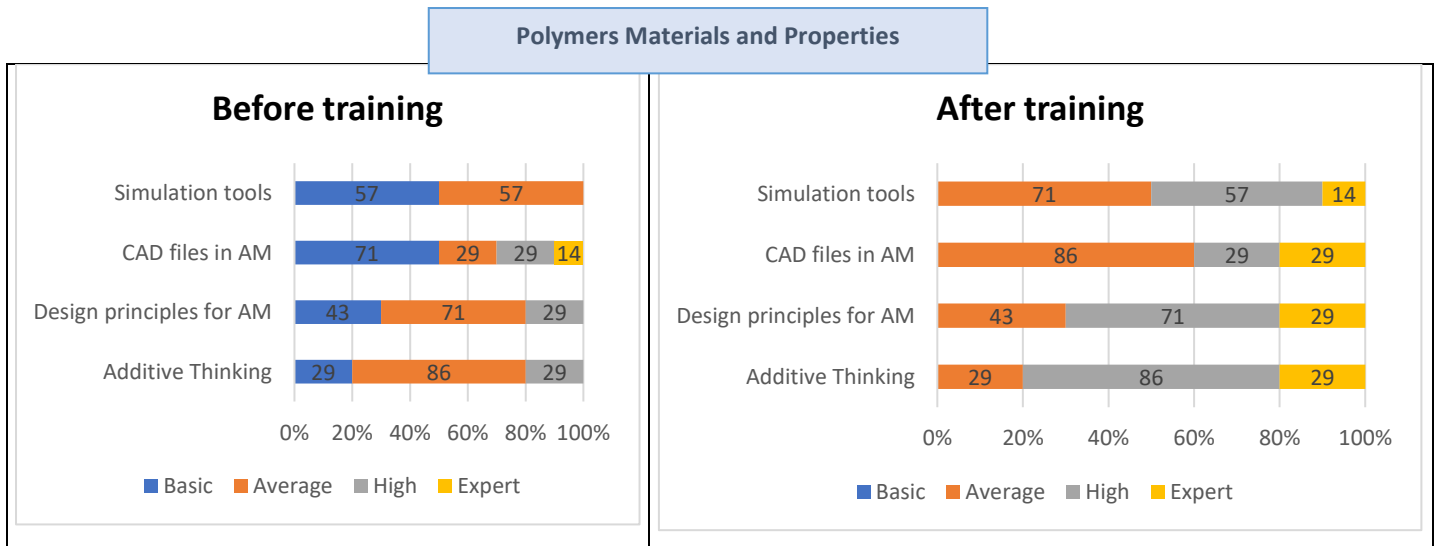


Figure 8 Applicability of the knowledge and skills on Designing Polymers Parts before and after training

In terms of **applicability of the knowledge and skills** before and after the training on **Design for specific Additive Manufacturing (AM) Processes (PBF/MEX/VAT)**, the majority of participants considered they're between Basic, Average and High prior to the training, with the majority of the participants replying that there was an increase in their knowledge and skills after the training, towards Average, High and Expert after the training, as showed below in Fig. 9.

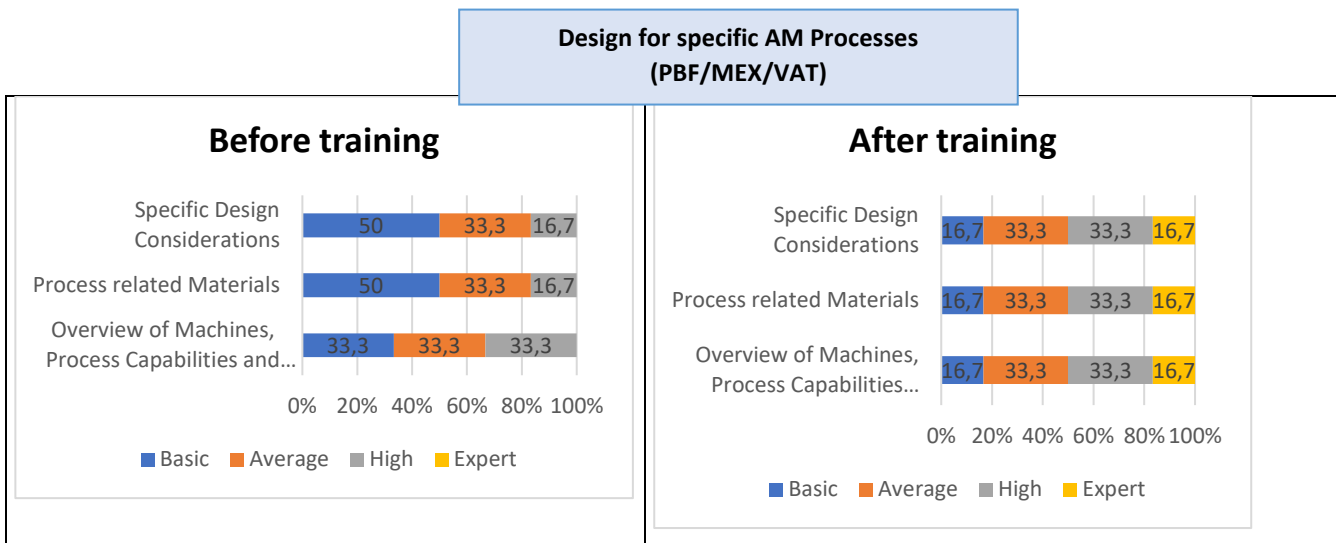


Figure 9 Applicability of the knowledge and skills on Design for specific AM Processes (PBF/MEX/VAT) before and after training

In terms of further participation in training, as seen in Fig. 10, 80% of the participants mentioned not having attended any other course/training after SAM piloting courses, in opposition to 20% of participants that have enrolled in other courses. From this percentage, 9% mentioned they have enrolled in Master's Degree, Post Graduate Certificate/Diploma (EQF Level 7); 8% in Other courses such as online courses, another training course, MEng in Mechanical & Materials Engineering, Operation of 3D Printer, PhD Materials Engineering and PhD ; followed by 2% in Bachelor's Degree, Graduate Certificate/Diploma (EQF Level 6); and 1% in Higher Education Certificate/Diploma (EQF Level 5).

Enrollment in further courses and training

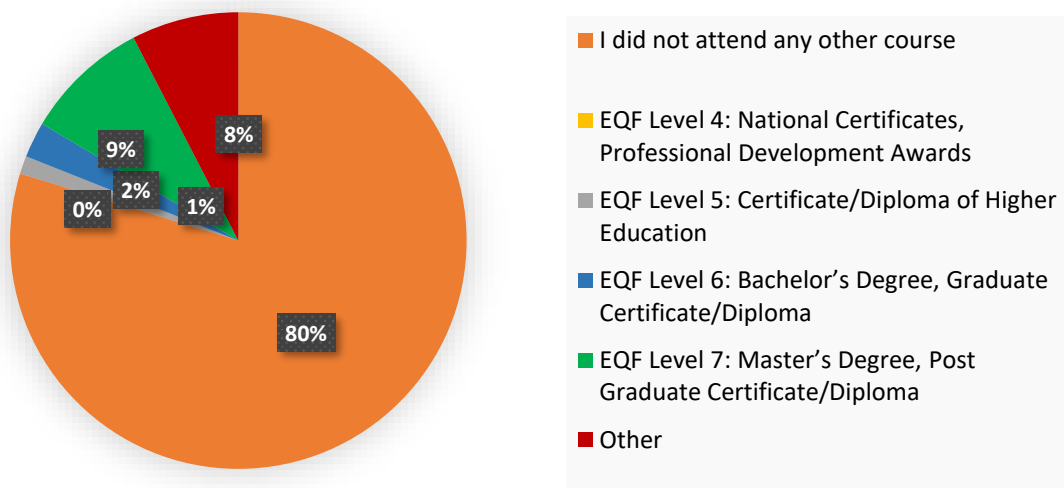


Figure 10 Enrollment in further courses/training after the training course

Regarding the transferability of training for professional activities, more than 80% of the participants rated it positively, as seen in Fig. 11, where most of the participants considered it as Good when applied to their working reality, either to their company's real needs; to their career; and to their job.

Furthermore, some comments were left, by the participants, to justify the less positive rating, such as: "More information on how to automate and control 3D printers: sensors needed, etc"; "AM is not core to

our business and is supplementary”; “Different industrial or desktop systems used in material extrusion can be included. Lastly, “Lecturing about other categories” can provide good insight as well.

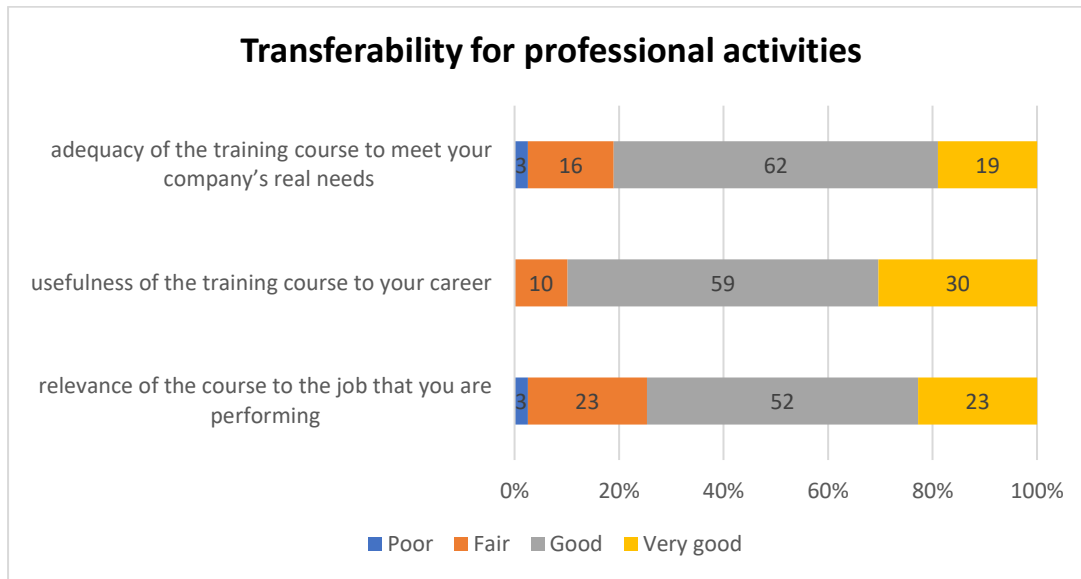


Figure 11 Rating of transferability for professional activities

Concerning the applicability of the practices presented during the training in the participants daily professional activities, as seen in Fig. 12, 86% of the participants didn't encounter any barriers, as for 8% of the participants some barriers, such as: “Lack of commitment by superiors”; “Cost/Financial Issues”; “Lack of information in your team”; “Lack of equipment”. In addition, 6% of the participants stated that they haven't been able to put into practice what they learned yet.

Barriers in applying practices in professional activities



Figure 12 Applicability of the practices presented during training in daily professional activities

2.4 Qualitative Feedback

Based on the comments left by the participants of the pilot courses (Table 2), it was possible to conduct a SWOT Analysis, see Table 1, aiming to identify the pilot courses main strengths, weaknesses, opportunities and threats.

Table 1 SWOT Analysis

SWOT Analysis		
S trengths	characteristics of the course considered as advantages over others	The presentations and the way they were delivered were enjoyable. It was convenient the lectures were recorded. Inviting people from ANSYS was extremely insightful into the capabilities of their software GRANTA. Experienced trainers in the field providing the courses Use of examples to support the theoretical presentations Transferability of the knowledge gained to research and development activities Access to useful resources for self-study and repository of recorded sessions
W eaknesses	characteristics of the course that place it in disadvantage comparing to others;	More breaks throughout the sessions (even if for only 5 minutes) since there was a lot of information presented at once Extensive online sessions that can lead to the decrease of learners' engagement
O pportunities:	external elements to the course that can be exploited in its favour;	Use of case studies of real-world application and failures.
T hreats	external elements to the course that need to be improved/controlled to avoid their impact over the course	Lack of feedback and response regarding the exams. Follow up after the examination

Table 2 Additional comments

Would you like to add any additional comments?
<i>"I have had the opportunity to participate in a couple of AM-related projects since the course and have been able to use some of the knowledge I learnt on the course, despite the fact that one was for metals rather than polymers. I've also contributed to in-house process control documentation and feel that the course gave me confidence as well as the knowledge itself."</i>
<i>"Being over Zoom it can be hard to maintain concentration for long periods of time. There were some breaks throughout the sessions, but I think I would've taken more in if there had been more frequent breaks (even if for only 5 minutes) as I felt there was a lot of information presented to me all at once."</i>
<i>"I have asked about feedback on the exams we had but unfortunately no response. It will be good if we have been supplied with the feedback so we could prepare well for the second round of the exam. Also, I have been asked if there will be a third round for exam but no response as well."</i>

"The content of the presentation was very well prepared and structured. The presenter was capable to include clear and illustrative examples."

"The focus of the course was perfect, the content highly optimized for the available time."

"I enjoyed the presentation and the way it was delivered. It was convenient the lectures were recorded since I live in the American continent and had to wake up in the middle of the night to attend these courses. Inviting people from ANSYS was extremely insightful into the capabilities of their software GRANTA."

This way, the qualitative feedback of the participants can be used for the improvement of future AM training courses.

3. Conclusions

The report compiles the information obtained through the implementation of D2.6 *Kit for tracking students, future employees and job seekers in AM* (developed in Work package 2) among all participants of the 2nd Stage Real Case Scenarios Piloting Events. Despite the low number of responses collected during the implementation of the impact and follow-up survey (e.g. 79 answers were collected with the follow-up questionnaire from the overall AM pilot courses 292 participants) it was possible to conclude about the following:

- **AM course contents were attractive for both workers** (80% of the participants were employed before starting the training) **and unemployed people** (20% of the participants had no current working position);
- Diversity of profiles attending the course and replying to the Survey, being most of the respondents involved in Engineering, Machine Operations, Design, Management and Research activities;
- The training provided had a lower impact as a trigger for enrolling in future training (only 20% mentioned having started another course).
- The training provided had a **positive impact concerning the applicability and transfer of knowledge and skills into the professional activity** (rated in its majority as Good, followed by Very Good).
- In all follow up assessed CUs, participants considered a significantly increasing of their knowledge and skills in all topics, being:
 - **CU66 "Designing Polymers AM"**, followed by **CU65 "Overview on polymer materials and properties"** the ones with a higher impact and progression for the participants.
 - Although in some CUs [Design for specific Additive Manufacturing (AM) Processes (PBF/MEX/VAT) and Certification, Qualification and Standardisation (CQS) in Additive Manufacturing (AM)], at least one of the participants had replied to maintain the same level of knowledge and skills after training, the majority had replied an increase either to an average or high level of knowledge and skills
- Based on the qualitative feedback provided by participants, there is room for improvement regarding the implementation of CUs trough online sessions, namely, to increase either the

number of small breaks or introduce more dynamic interactions with participants to ensure engagement in the sessions.

- On the other hand, the use of real case studies is considered by the participants as an added value for the training courses
- Overall, comparing the before and after training applicability of the knowledge and skills, **there was a sustained impact demonstrated by the increased results**, where 86% of the participants found **no barriers in transferring the acquired knowledge and skills to their working practices** and more than 80% considered “Good” and “Very good” the impact of the training for their company’s real needs, their professional career and for their current job.