Skills Needs and Upskilling Addressing the European Metal AM Industry

Eurico Assunção, Adelaide Almeida and Ana Beatriz Lopez
European Federation for Welding, Joining and Cutting (EWF), Porto Salvo, Portugal

Abstract: As Europe seeks to retain its leading position in industrial competitiveness, there is an urgent need to establish a platform for Additive Manufacturing (AM) skills at European, National and Regional levels. AM processes enable economic component production through the efficient use of materials and increased design freedom as compared to conventional manufacturing. AM also raises the level of digital literacy among workers, and it contributes to the digitisation of European Industry. In face of this increasing growth of Metal AM technology, and consequent requirement of the definition of new professional profiles and skills and knowledge for personnel working in this sector, the European Federation for Welding, Joining and Cutting (EWF) recently launched the first International Additive Manufacturing Qualification System (IAMQS). For creating and managing the IAMQS, EWF relies on its experience of more than 25 years in managing a European/International Training/Educational System for qualification and certification of welding and joining personnel, covering different levels (from Operator to Engineer), assessing knowledge and skills (examination) and providing a Quality Assurance System that ensures that the same qualification is recognised in all countries that share the system, is recognised by the Industry and is accepted by Enterprises, professionals, training institutions and certification bodies. IAMQS is also based on the work currently being developed in the scope of three European Funded projects in the field of AM, in which EWF is actively involved, together with the respective partners from eight EU countries. In collaboration with SAM, CLLAIM and ADMIRE projects’ partners, EWF has conducted market searches/surveys to collect information on market needs and possible solutions for future workers and professionals already involved in AM sector, carried out validation workshops with experts from the Industry and Education, and developed European qualification pathways. This systemic approach that encourages a close collaboration with major European AM companies and organisations to collect inputs from different sources in the creation of AM Qualification System, ensures Professional Profiles’ quality and transparency. As a result of the skills gap analysis carried out by EWF during the last 2 years, 7 Qualifications for Additive Manufacturing, ranging from Operator to Engineer levels, were developed, while others are being finalised and validated.

Key words: AM, skills forecast, education, training for am, training trends.

1. Introduction

The Wohlers Report (2019) [1] indicates that Additive Manufacturing (AM) market continues to rise, with more new companies using AM, more investment made, and a higher number of new and innovative products designed for AM being released to the market, a trend that is predicted to evolve in the upcoming years. Technology in AM is evolving at a much faster pace than the development of knowledge and skills that allow using it. This increasing growth in AM technology requires the definition of new professional profiles, skills and knowledge for personnel working in this sector. However, due to a fragmented training offer, which does not cover all levels of education, there is a lack of responses to those requirements and to AM labour market’s needs for skilled professionals.

In face of this reality, European Federation for Welding, Joining and Cutting (EWF) recently launched the first International Additive Manufacturing Qualification System (IAMQS), in line with the ManuFUTURE Vision 2030 Strategy [2], making this a unique initiative of high relevance for the labour market, creating new qualification levels,
from Operators to Engineers. The AM Qualification System is based on knowledge and skills’ assessment and on a Quality Assurance System that ensures the recognition of the same qualification in all countries sharing the System, reducing the hurdle of skills recognition and assuring the reliability of the awarded diploma at International and European levels as it is recognised and accepted by industry, training institutions and certification bodies.

2. Applied Methodologies

2.1 For the Validation of Needs

The harmonised IAMQS (Fig. 1) is based on a continuous search for innovative methods to improve AM personnel training and qualification and to continuously update EWF training and qualification system, intercepting the needs, contents and paths for the new professional figures required by the international industrial world.

The main European Funded Projects supportive and involved in this activity are as follows: SAM, CLLAIM and ADMIRE (Figs. 2-4).

In collaboration with the different project partners, EWF is developing different inputs that will contribute to creating and implementing the International AM Qualification System.

Fig. 1 International Additive Manufacturing Qualification System (IAMQS).

Fig. 2 Sector Skills Strategy in Additive Manufacturing (SAM).

Source: Ref. [3].

Fig. 3 Creating Knowledge and Skills in Additive Manufacturing (CLLAIM).

Source: Ref. [4].

Fig. 4 Knowledge Alliance for Additive Manufacturing between Industry and universities (ADMIRE).

Source: Ref. [5].

Fig. 5 Systematic approach for the identification and validation of needs.

To ensure that the developed AM Qualifications are aligned with industry needs and requirements, a systemic approach with several stakeholders involved has been applied to collect inputs from different sources, as demonstrated in Fig. 5.

In collaboration with SAM, CLLAIM and ADMIRE partners, and with the support of relevant AM organisations, EWF has conducted market searches and surveys, to collect information on market needs for future workers and professionals already involved in the AM sector. Validation workshops with experts from the Industry and Education were also organised. This holistic approach that encourages a close collaboration with major AM organisations to collect
inputs for the establishment of the IAMQS, ensures Professional Profiles’ quality and transparency.

The methodology applied to the development of International Qualifications encompasses a set of steps where the different European funded projects and partners are involved towards the development of a full AM Qualification System (Fig. 6).

2.2 For the Design of International AM Qualifications and Competence Units

A Qualification is a formal outcome (certificate, diploma or title) of an assessment process which is obtained when an individual has achieved the required learning outcomes. It includes the job requirements: knowledge, skills, autonomy and responsibility required to perform specific tasks attached to a particular work position.

In terms of structure, a Qualification is composed by a definition of a certain professional profile and a respective Curricula, containing all the activities related to the design, organisation and planning of its education or training actions.

This section addresses the pedagogical approach used for the design of AM European qualifications, including the approach for the definition of professional profiles and strategy for design of upskilling qualifications, and to design the Curricula.

2.2.1 Professional Profiles

EWF’s methodology for design of Qualifications is structured into a top-down approach, where based on the professional profile, the mapping of the major job functions and related activities leads to the development of Competence Units with description of Learning Outcomes in terms of Knowledge and Skills to guarantee that the learners are fully competent in a specific job requirement (Fig. 7). This approach is based on the principles of functional analysis to define the occupational competencies and in setting boundaries between different occupations within EWF’s Qualifications.

The professional profile offers the “big picture” about a certain profession. Therefore, the definition of the professional profile must contain a general description of the main objective of the profession, its general responsibilities and tasks.

The grounding for this description is defined based on the labour market current requirements and anticipation of future needs as well on existing International, European and/or National Standards related with the regulation of professional activities.

Necessarily, the professional profile shall be directly interlinked with a reference proficiency level, providing the general descriptors in terms of knowledge, skills, autonomy and responsibility that a specific Qualification will address.
Fig. 7  Scheme of the top-down approach used in qualification development.

The mapping of the major professional functions is made based on the professional profile, subsequently from the previously defined general descriptions, specifying which are the core tasks of such professional activity.

Each main job function is then broken down into sub-functions/activities. For example for International Metal AM Operator for PBF-LB professional profile and major functions:

I MAM O PBF-LB is the professional with the specific knowledge, skills, autonomy and responsibility to operate metal AM machines using PBF-LB Process. He/she will be able to:

- Operate powder bed-based laser beam machines for AM, including fitting and setting up, maintenance and repair.
- Remove parts and prepare them for post-processing steps;
- Verify laser beam measurement and positioning in laser powder-bed machines for AM;
- Self-manage the handling of powder (approval, storage, contamination, traceability);
- Develop solutions on basic and specific problems related with laser powder-bed fusion machines.

2.2.2 Upskilling Qualifications

The AM qualifications are designed in a way that enhances and allows upskilling pathways, either within the same field of activity (such as Welding Coordinators), or among different spatialization areas (such as Welding Inspection and Welding Coordination).

Similarly to SOLO Taxonomy principles structure, EWF’s methodology for design of upskilling qualifications encompasses the assignment of levels of increasing complexity in learners’ understanding of subjects, which can be resumed as follows.

The progression of levels is made from the lowest to the highest level in building blocks. The highest levels start the training courses along with the lowest levels ensuring the development of solid fundamental knowledge and skills of concepts and principles. Upon successful completion of the lowest levels, learners start more complex levels. This modular approach, using the building blocks, allows AM professionals to progress their knowledge, and also their career, by obtaining new skills and knowledge inside the AM Qualifications System (Fig. 8).

2.2.3 Curricula Design

Competence Units are the smallest set of knowledge and skills, organized in learning outcomes that can be individually assessed and validated. Competence Units can also be part of a qualification or implemented individually.

Within EWF’s qualifications, there are two types of Competence Units (Figs. 9 and 10).

Cross-cutting competence unit is a competence unit whose learning outcomes are not directly linked with one job function since the knowledge and skills achieved will be mobilized in several job functions and activities.
Functional competence unit is a competence unit whose learning outcomes are directly linked with at least one job function and in which the knowledge and skills achieved will be mobilized in specific job functions and related activities.

To sum up, a modular and cumulative approach was used to design the International AM Qualifications and Competence units. This structure has the advantage of enabling a more flexible and tailored made training, as well as easier integration within National Qualifications Curriculum.

3. Results

Currently EWF offers several Qualifications in Metal AM, three of them at the Operator level and four at Engineering level (Fig. 11). It is important to point out that, due to the market search carried out, the created Qualifications are also split by type of AM Process. For example, the three existing Operators are divided into DED-Arc Operator, DED-LB Operator and PBF-LB Operator. This separation was done due to the industry feedback, where it is normal to see one single process being applied by a specific company.

The framework shows a comprehensive summary of AM Qualifications as well as expected Competence Units.

Moreover, with the collaboration of different partners EWF is receiving different inputs that will contribute to creating and implementing the International AM Qualification System (IAMQS):
Fig. 11  Current AM framework.

- Create a Network of European/International Training Centers and Universities using the same AM Qualifications.
- Create an AM Observatory, a centralised unit for the identification, assessment and validation for AM current and future skills at regional, national and European levels. This observatory in Additive Manufacturing will provide an updated mapping and monitoring of the AM industry technological trends, skills shortages and mismatches, policies and figures for the IAMQS.
- Assure the International implementation is supported by the EWF Quality Assurance System rules and operating procedures, critical in ensuring harmonization and quality in the delivery of the IAMQS.
- Develop an online Qualifications catalogue to continuously update and enlarge the IAMQS, integrating all the developed (and to be developed)
sectoral qualifications.

- Qualifications Framework (EQF) levels, boosting the recognition and transfer of credits by applying European Credit System for Vocational Education and Training (ECVET) methodology and tools.
- Enhance skills and competences of trainers in the field of AM by promote exchange of successful pedagogical methods and practices between teachers and trainers from VET and High Education.
- Develop a European Network for incentive of future cooperation and mobility in the field of education and work and promoting the project results as the best practice to other sectors.
- Create two Councils (Industry and Education) that will be able to identify and validate skills needs and implement AM training courses and approve training guidelines of the IAMQS.
- Develop and implement training guidelines of the IAMQS, according to the requirements of industry.

4. Future Qualifications

Based on the market needs new qualifications are being finalised. Some examples of those new qualifications include:

- Metal Operator for PBF-EB;
- Metal Operator for DED-EB;
- Metal Process Engineer PBF-EB;
- Metal Process Engineer DED-EB;
- Metal AM Designer;
- Metal AM Supervisor;
- Metal AM Inspector.

More will follow since the AM market keeps evolving and new processes and new materials start to have more industrial implementation. Fig. 12 shows some of the new processes and materials that are being used in industry and that will be supported by EWF Qualifications.

5. Conclusions

The support of three AM projects, SAM, CLLAIM and ADMIRE, is being essential to develop the first International AM Qualification System (IAMQS). These projects are interconnected to offer an easier progression within AM Qualification, avoiding relearning, and to enhance opportunities for changing trainees’ career paths. They offer advantages to Educational Systems by addressing emergent technologies easily integrated at a national level and designing individual learning pathways that are automatically recognised.

The creation and implementation by EWF, with the support of several organizations and partners, of the first International Qualification System for Additive Manufacturing personnel are of utmost relevance for the labour market as it reduces the hurdle of skills’ recognition and assures the recognition and reliability of the awarded diploma by the industry. International qualifications are also important in National, European and International perspectives as they promote common trust and cooperation at an operational level. By assuring that the international implementation will follow the EWF Quality System rules and operating procedures, the quality of these new qualifications will be guaranteed. The methodology implemented in the design of these qualifications (and future ones) within the IAMQS allows for a much needed upskilling in Metal AM Industry, preventing skills mismatches and provides the opportunity to the workforce to keep up with the advances of AM technology, while companies are able to cope with the challenges those advantages bring to their business opportunities.

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Fig. 12 AM areas for new qualifications.
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**References**

[1] Wohlers, T., et al. 2019. *Wohlers report 2019: 3D printing and additive manufacturing state of the industry*. Wohlers Associates.

[2] VISION 2030—Strategic Research Agenda from ManuFuture.

[3] SAM. 2019. “The SAM Project.” http://www.skills4am.eu/theproject.html.

[4] CLLAIM. 2017. “CLLAIM Project.” http://www.cllaimprojectam.eu/.

[5] ADMIRE. 2020. “Skilling the AM Future 2020.” https://www.admireproject.eu/.