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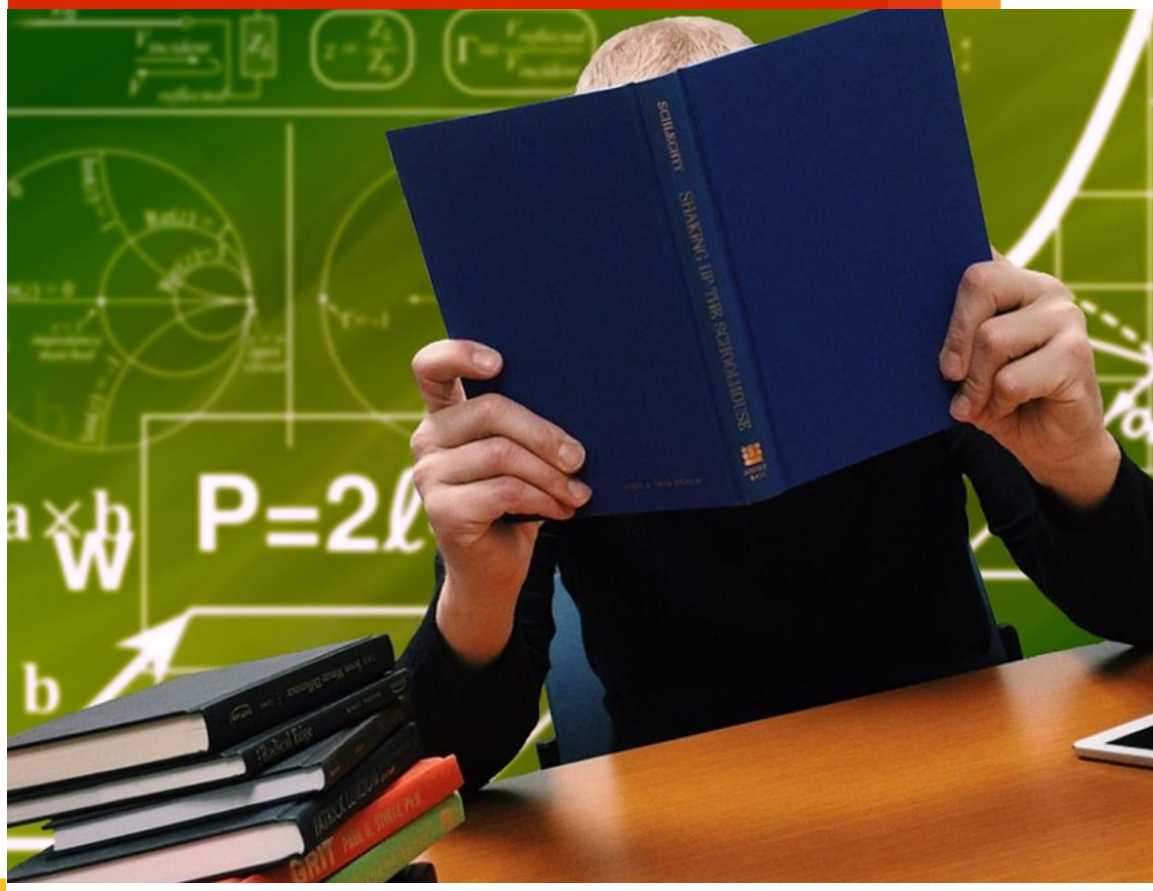
Expert workshop on "Aligning Advanced Manufacturing education & training with the 21st Century needs: Non-tertiary vocational education"

Curriculum Guidelines for Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT)
Third expert workshop

Contract nr EASME/COSME/2017/004

WORKSHOP REPORT



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For further information on this report, please contact:

Dr. Kristina Dervojeda
Project Manager and Senior Expert
Tel.: +31 88 792-3228
Email: kristina.dervojeda@nl.pwc.com

Engagement Partner:
Anton Koonstra
Public Sector Leader PwC NL
Tel.: +31 88 792-3303
Email: anton.koonstra@nl.pwc.com

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Executive summary

This document summarises the key points discussed at the third expert workshop focussing on "Aligning Advanced Manufacturing education & training with the 21st Century needs: Non-tertiary vocational education", organised in the context of the "Curriculum Guidelines for KETs and AMT" initiative of the European Commission.

The workshop focused on the approaches aiming to improve curricula/learning strategies for non-tertiary vocational education1 in the field of AMT. The workshop featured good practice examples and practical illustrations of the proposed solutions from VET providers. The workshop particularly aimed to offer a discussion platform to address key challenges and actions that would need to be introduced at the EU level. It brought together key practitioners, researchers and policy makers active in the field of AMT education & training in Europe, with a particular focus on VET.

The outcome of the workshop will be used for shaping the curriculum guidelines for the EU education & training providers active in the AMT domain for years to come. The curriculum guidelines will be highlighting the key points of attention when it comes to aligning the approach towards AMT education & training with the 21st Century needs. The guidelines will be developed based on the extensive state-of-play analysis and active stakeholder contribution.

The guidelines need to be applicable for both designing fundamentally new educational offers and/or advancing the existing curricula, depending on the level of required change. The objective is to offer educational and training institutions a source of inspiration, conceptual guidance and good practice examples.

The key outcomes of the discussion are as follows:

- The term 'competencies' which is broader than skills, needs to be used. It includes a combination of knowledge, skills, attitudes and values.
- Special attention needs to be paid to the development of 'soft' skills. These skills can be developed when students work on hands-on challenges. A particular role needs to be assigned to ethical issues.
- The role of schools, teachers and trainers needs to be reconsidered, with the learning ecosystem built around learners. Learner and teacher roles become increasingly interchangeable.
- Schools still play a crucial role. There is a need for a solid initial knowledge base, before one can start applying a "nugget approach". The role of the schools is thus to teach the basics, that can be further built on.
- There is a high risk of developing unrealistic expectations regarding what students should know when they finish their studies. It is not possible to address every need. Finding a good balance is key.
- Students need to learn how to be self-critical, but at the same time stay self-confident.
- It is crucial to find ways to assess the development of specific skills. Reflection often does not have a priority for education & training institutions; hardly any attention is paid to it.

[1] https://eacea.ec.europa.eu/national-policies/eurydice/general/6-secondary-and-post-secondary-non-tertiary-education_en

1. Introduction

This document represents a workshop report for the expert workshop on "Aligning Advanced Manufacturing education & training with the 21st Century needs: Non-tertiary vocational education". The workshop was organised in the context of the "Curriculum Guidelines for Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT)" initiative (contract nr. EASME/COSME/2017/004), that is coordinated by PwC EU Services (PwC), under the auspices of the Executive Agency for Small and Medium-sized Enterprises (EASME) and the Directorate General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW) of the European Commission (the Commission). The workshop took place at Thon Hotel EU in Brussels (Belgium) on 13 December 2018. It is the third out of the six workshops that are foreseen in the context of the abovementioned initiative.

The introduction session of the workshop included a brief presentation of the workshop context, rationale and objectives, as well as an introductory round of participants.

1.1. *Opening words*, Giovanna D'Addamio, EASME (Belgium)

Ms. Giovanna D'Addamio welcomed all the participants and emphasised that this initiative aims to help the Commission assess the current state of play and identify the key focus areas for future efforts when it comes to aligning AMT-related education and training with the 21st Century needs. The initiative involves data collection and research, design of guidelines, validation and dissemination, taking into account industry and market needs, best practices, and contributions from key stakeholder groups.

This is the third workshop (out of the six foreseen) in the context of this initiative. The first expert workshop (W1) had an explicit focus on the good practices aiming to improve curricula for Higher Education (HE) for AMT, and resulting inputs for the curriculum guidelines. This workshop brought together researchers and practitioners in AMT-related HE. The second workshop (W2) focussed on-the-job training and the resulting implications for the curricula guidelines. The current one (W3) has a focus explicitly on non-tertiary vocational education. The remaining three workshops (W4 - W6) will address specific proposals for curricula guidelines, again separately for Higher Education (W4), vocational education (W5), and on-the-job training (W6).

1.2. *Workshop context, rationale and objectives*, Kristina Dervojeda, PwC (Netherlands)

Dr. Kristina Dervojeda briefly addressed the context of the workshop, its rationale and objectives.

The manufacturing domain is undergoing a fundamental transformation (known as the fourth industrial revolution or Industry 4.0) that is driven by the following major developments[2]:

- **Technology trends**: the advancement of manufacturing is supported by a range of different emerging technologies and systems that enhance organisation, sharing and analysis of data; improved sensing and interacting with the material world; and greater connectivity, data gathering, and control of manufacturing system elements;

- **Customer demand trends**: evolving customer preferences refer to product variety; personalised products and services; faster response to needs; expectations of added-value services (social media

[2] UNIDO (2017) "Emerging Trends in Global Advanced Manufacturing: Challenges, Opportunities and Policy Responses", Report developed with support of the University of Cambridge and Policy Links, available at: https://institute.unido.org/wp-content/uploads/2017/06/emerging_trends_global_manufacturing.pdf

interaction, order status tracking); and societal and economic pressure to increase environmental and resource sustainability;

- **Industry pressures and drivers**: there is an increasing need for asset and resource efficiency; growing reliance on supply chain and need for robustness and tracking; increasing security risks; shorter product lifecycles; emerging opportunities to offer value-added services throughout product life-cycle; and increasing manufacturing complexity of products, production and data;

- **Policy and regulatory developments**: An increasing demand for high quality standards, safety and sustainability leads to a focus on creating advanced products that have a smaller environmental impact; a need for high-quality packaging and delivery; and regulatory guidance on, for example, safety and health at work.

These developments have **direct implications for the skills needs**. The AMT professionals need to possess skills related to digital technologies, analytical thinking, machine ergonomics, as well as understanding manufacturing technologies (including design for manufacturing, design for assembly and design for automation). The AMT domain also heavily relies on skills linked to merging and adaptation of technologies. Examples include merging laser technologies with printing techniques, rapid prototyping technologies with tissue scaffolding etc. Similar skills become increasingly needed also by lower levels in organisations, to be innovative about implementing process and technique changes. This also relates to management skills needed to recognise, understand and manage change[3].

The number of jobs in manufacturing as a whole requiring high-level qualifications is projected to rise by 1.6 million (21%) by 2025[4], whereas the growing automation of production processes will see the number of low- and medium-skilled jobs decrease by over 2.8 million. A similar pattern is expected in the high- and high-medium technology industries within manufacturing, although the shifts are less pronounced at the high-technology end of the scale[5]. However, these estimates should be treated with caution, as the numbers vary per source/methodology.

An extensive analysis of skill requirements for KETs professionals has been performed by PwC in the context of the "Vision and Sectoral Pilot on Skills for Key Enabling Technologies" initiative (2014 – 2016) (hereafter "KETs Skills Initiative") for DG GROW of the European Commission[6]. KETs professionals here refer to all key groups of workers active in KETs domains, that broadly speaking comprise operators, technicians, engineers and managers. When the KETs Skills Initiative was carried out, KETs included Micro-/Nanoelectronics, Nanotechnology, Photonics, Advanced Materials, Industrial Biotechnology and Advanced Manufacturing Technologies[7].

The following six categories of KETs competencies were identified[8]:

[3] UNIDO (2017) "Emerging Trends in Global Advanced Manufacturing: Challenges, Opportunities and Policy Responses", Report developed with support of the University of Cambridge and Policy Links, available at: https://institute.unido.org/wp-content/uploads/2017/06/emerging_trends_global_manufacturing.pdf
[4] European Commission (2014) "EU Skills Panorama: Focus on Advanced Manufacturing", available at: http://skillspanorama.cedefop.europa.eu/sites/default/files/EUSP_AH_AdvManufacturing_0.pdf
[5] *Ibid*.
[6] PwC (2016) "Final report on Vision and Sectoral Pilot on Skills for Key Enabling Technologies", prepared for DG GROW of the European Commission, Service contract nr. SI2.ACPROCE060233200
[7] In line with the initial definition of the Commission's Staff Working Document "Current situation of Key Enabling Technologies in Europe" SEC(2009) 1257. In the meantime, the definition of KETs by the European Commission has been adjusted. KETs currently include Materials and Nanotechnology, Photonics and Micro- and Nano-electronics, Life Sciences Technologies, Artificial Intelligence, Digital Security and Connectivity (based on the report from the High-Level Strategy Group on Industrial Technologies (2018) "Re-finding industry", Conference document, 23 February 2018).
[8] PwC (2016) "Final report on Vision and Sectoral Pilot on Skills for Key Enabling Technologies", prepared for DG GROW of the European Commission, Service contract nr. SI2.ACPROCE060233200

(1) **Technical**: competencies related to practical subjects based on scientific principles (e.g. programming, computational thinking, mathematical modelling and simulation, top-down fabrication techniques etc.);
(2) **Quality, risk & safety**: competencies related to quality, risk & safety aspects (e.g. quality management, computer-aided quality assurance, quality control analysis, emergency management and response, industrial hygiene, risk assessment etc.);
(3) **Management & entrepreneurship**: competencies related to management, administration, IP and finance (e.g. strategic analysis, marketing, project management, R&D management, IP management);
(4) **Communication**: competencies related to interpersonal communication (e.g. verbal communication, written communication, presentation skills, public communication, virtual collaboration);
(5) **Innovation**: competencies related to design and creation of new things (e.g. integration skills, complex problem solving, creativity, systems thinking); and
(6) **Emotional intelligence**: the ability to operate with own and other people's emotions, and to use emotional information to guide thinking and behaviour (e.g. leadership, cooperation, multi-cultural orientation, stress-tolerance, self-control).

KETs rely on a balance of **both technical and non-technical competencies**.

The abovementioned challenges signify **a need to reconsider the current approach towards the education and training of AMT professionals** and to develop new/advanced models that would be better aligned with the needs of both employers and (future) employees.

To this end, EASME and DG GROW of the European Commission have recently launched a new initiative for developing **"Curriculum Guidelines for Key Enabling Technologies (KETs) and Advanced Manufacturing Technologies (AMT)"**. This initiative aims to contribute to increasing the quality and relevance of existing curricula and to promote better cooperation between industry and education and training organisations in order to align AMT education and training with the 21st Century needs. It involves data collection and research, design of guidelines, testing and validation, taking into account industry and market needs and best practices, based on contributions from key stakeholder groups. The initiative focusses on **VET, higher education and on-the-job training for AMT**.

Two distinctive but closely interrelated directions for action are being explored:

Teaching new skills:

- New technical skills, emotional/social intelligence, multidisciplinary mind-set, learning-to-learn skills, systems thinking, STEAM (STEM with Arts) etc.;

Teaching skills in a new way:

- Student-centric approach;
- Problem-based learning and experience-based learning (real-life cases, apprenticeships, engaging employers in curriculum development etc.);
- Technology-enhanced learning (MOOCs, augmented/virtual reality, AI etc.);
- Learning ecosystem: connecting learners to employers and other key stakeholders through project work, industrial placements, matchmaking events etc.
- Upskilling teachers and equipping them with the right tools.

The outcome of this initiative will play a prominent role in forming the EU policy making regarding upskilling of the AMT workforce.

The tasks of this initiative are grouped into three Work Packages (WPs) corresponding to the two main phases of 12 months each.

The **first phase** was dedicated to research, collection and analysis of latest information and data, based on desk research, expert workshops and interviews with key stakeholders. An interim report, presenting the results of the analysis and the state-of-play in the EU on education & training for AMT, signifies the end of this phase. The interim report will later be integrated into the final report.

The **second phase** will concentrate on documenting best practices, engaging a broader ecosystem of stakeholders, designing European curriculum guidelines and quality labels for AMT, and formulating recommendations. A final report will be delivered at the end of this phase.

As mentioned above, in total, six expert workshops are foreseen in the context of this initiative.

The first expert workshop, held in Brussels on 12 June 2018, aimed to focus on **new/alternative approaches to Higher Education, and specifically Bachelor and Master Programmes, in the field of AMT**. It was concluded that there is a clear need to disseminate information on good practice examples among the educational institutions and companies in Europe. It is crucial to explore the replicability of good practices, as awareness raising is meant to serve only as the first step towards replicating/upscaling successful practices. There is also a need to look for financially sustainable business models for the educational offer such as, for example, sponsorship by companies that would like to have a tailor-made programme, alumni contributors, sublicensing etc. When it comes to relevant policy initiatives, they do not always have to be explicitly focussed on education & training to make an impact. Education & training elements can also be embedded into broader programmes, as a compulsory element.

The second expert workshop, held in Brussels on 18 September 2018, focussed on the initiatives aiming **to improve curricula/learning strategies for on-the-job training in the field of AMT**. The workshop suggested that there is a need for a dedicated learning platform that would comprehensively combine a wide range of relevant courses with dedicated learning modules and link them to specific learning paths. Policy makers could play a role in facilitating the process of creating and maintaining such a platform. Special attention needs to be paid to new/updated job descriptions. Motivation of the learner is one of the key factors for successful upskilling/reskilling. It is suggested to play a more important role than education.

This third expert workshop focuses on the approaches aiming **to improve curricula/learning strategies for non-tertiary vocational education[9] in the field of AMT**. The workshop featured good practice examples and practical illustrations of the proposed solutions from VET providers. The workshop particularly aimed to offer a discussion platform to address key challenges and actions that would need to be introduced at the EU level. It aims to bring together key practitioners, researchers and policy makers active in the field of AMT education & training in Europe, with a particular focus on VET.

In the context of this initiative, the project team is currently conducting an **online survey**. It aims **to validate the findings of the first phase of this initiative and to set priorities for the curriculum guidelines** that are to be further developed within its second phase (January – November 2019). The curriculum guidelines will be developed for Europe's education & training organisations, with an aim to highlight the key points of attention and good practice examples. The workshop participants were invited to take part in the survey.

[9] https://eacea.ec.europa.eu/national-policies/eurydice/general/6-secondary-and-post-secondary-non-tertiary-education_en

2. Advanced Manufacturing for the 21st Century: implications for non-tertiary vocational education

The morning session of the workshop was continued by the presentation on the actual 21st Century needs when it comes to non-tertiary vocational education. The objective of this presentation was to further set the scene for the workshop, collect initial expert feedback and frame the discussion.

2.1. *Recalling the 21st Century needs,* Kristina Dervojeda, PwC (Netherlands)

The "**Manufacturing professionals 4.0**" refer to all key groups of workers of the Advanced Manufacturing domain, that broadly speaking include technicians/operators, engineers and other highly skilled professionals (computer coders, app developers, data scientists, 3D printing specialists etc.) and managers.

According to the VDI White Paper (2015)[10], in order to derive skills and qualifications of the future manufacturing professionals, there is a need to consider three distinctive tiers:

- *Tier 3*: including factors that have a considerable influence on the workforce in a factory of the future, such as tools & technologies; organisation & structure; working environment, intraorganisational and interorganisational cooperation;
- *Tier 2*: Tasks;
- *Tier 1*: Skills and qualifications.

When it comes to **tools & technologies**, the factory of the future implies:

- a decreasing need to perform manual and routine tasks;
- access to real-time information on a certain situation to perform a task efficiently;
- worker's ability to control and monitor production processes through the analysis of data and information supported with devices;
- optimised human machine interfaces allowing the worker to make qualified decisions in a shorter time; *and*
- active use of collaborative robotics.

The observed change in the **organisational structure** refers to a decreasing need for workers to be bound to a certain production area, which leads to improved possibilities of job rotation and job enrichment. In addition, the factory of the future implies larger responsibility and more decision-making power; a mix of short- and long-term teams; and an ecosystem in which problem solving is done in collaboration with all participating parties on the shop floor and without much influence of a higher hierarchy. The latter signifies the transition towards a flat organisation structure.

[10] VDI (2015) "A Discussion of Qualifications and Skills in the Factory of the Future: A German and American Perspective", April 2015, White Paper by the Association of German Engineers, with support of ASME American Society of Mechanical Engineers, available at: http://www.vdi.eu/fileadmin/vdi_de/redakteur/karriere_bilder/VDI-ASME__2015__White_Paper_final.pdf

The future **working environment** for AMT professionals is anticipated to represent an open, clean, and creative space. It is associated with improved ergonomics (due to automation of dangerous and hazardous jobs); active use of devices and assistance systems; and larger flexibility with respect to shifts or working day. The latter would lead to more transparent work planning, improved work-life balance, emergence of entirely new shift modes (no need to stand at one specific production station for the course of the entire shift), and opportunity to work from home.

The **intraorganisational and interorganisational cooperation** implies more teamwork, more cooperation, more communication. The factory of the future is associated with accelerated learning curves within production networks due to access to all kinds of information and data, and an opportunity to organise workshops, seminars, and training sessions within the cyberspace. Communication does not only happen with humans but also with other elements of cyber-physical systems, such as robots, machines, or the actual product. Service providers become increasingly able to access robotics systems in a manufacturing plant from outside the factory to perform service updates or react to errors right away. Increased collaboration can be observed with external parties and specifically research institutes, universities, and parties that are not classical suppliers, due to the interdisciplinary character of digital production.

The abovementioned developments signify changes in the associated **tasks** (Tier 2), and specifically lead to a greater task variety and the need for more qualified work. Monotonous and ergonomically challenging tasks are expected to decrease to a minimum due to automation. Tasks heavily based on data and information processing will be dominating, signifying a shift from material flow to information flow. Tasks will be mainly performed through devices and assistance systems.

The changes in tasks lead to changes in the **required qualifications and skills**. Key *technical skills* that are expected to be gaining importance include knowledge/data management skills; multi-disciplinary understanding of organisation, its processes and used technologies; IT security and data protection; proficiency in methodologies for real-time decision making (UNIDO, 2017); as well as computer programming or coding abilities or similar deep technical knowledge (useful but not compulsory). Key non-technical skills for the factory of the future include adaptability/flexibility, communication skills, teamwork skills, self-management, and a general mind-set for continuous improvement and lifelong learning.

The evolving skill requirements require **reconsidering the current approaches towards non-tertiary vocational education** of AMT professionals. In general, there is a need for creating hands-on opportunities within education & training systems; close collaboration of business and educational institutions; offering learners real-world experience, exposing them to real challenges and advancements of industry; focusing on real-world application of skills, and developing and elevating micro-credentialing programs for employees. Education needs to follow a holistic approach with a multidisciplinary nature and prepare people for life-long learning.

The current initiative aims to produce **guidelines** for education & training organisations, highlighting the key points of attention and good practice examples, when it comes to aligning their approach with the 21st Century needs. The guidelines will be developed based on the extensive state-of-play analysis and active stakeholder contribution. The aim is to follow a holistic approach covering a broad spectrum of dimensions relevant to curriculum design and implementation. Specifically, the following eight dimensions will be considered by the **analytical framework**:

(1) Strategy;
(2) Collaboration;
(3) Content;
(4) Learning environment;
(5) Delivery mechanisms;
(6) Assessment;
(7) Recognition;
(8) Quality.

The guidelines will be developed separately for VET, HE and on-the-job training.

2.2. *Discussion and feedback of participants*

Dr. Kristina Dervojeda invited the workshop participants to express their feedback regarding the presentations given during the introductory session.

The key points of the discussion included the following:

- Special attention needs to be paid to **ethical issues**, with the latter not being just as 'part' of non-technical skills. It is important to acknowledge that ethical issues are closely related to technical skills.
- The term 'competencies' which is broader than skills, needs to be used. It includes a combination of knowledge, skills, attitudes and values.
- It could be helpful to explore to what extent all the eight dimensions of the curriculum guidelines framework are present in the existing curricula. The project team advocates for applying a **holistic approach** and considering all eight dimensions for curriculum design and implementation.

3. Teaching new skills and teaching skills in a new way (Part 1)

The morning session continued with specific presentations featuring good practice examples with regard to teaching new skills and teaching skills in a new way. The session consisted of three presentations followed by a detailed discussion and feedback of participants.

3.1. *Didactical Concepts for Future Training for Manufacturing*, Reinhard Pittschellis, Festo Didactic (Germany)

Mr. Reinhard Pittschellis presented the didactical concepts for the future training for manufacturing, based on Festo Didactic experience.

Digital transformation will never be as slow as it is today. There is a need for tools to make education efficient in embracing change, to bring practice into schools, to bring knowledge directly to the workplace. This may require the use of new media. The notion of a **Learning Factory** represents a promising approach in this respect. A "Learning Factory" is a realistic, but for didactical reasons simplified model of real working environments, which allows problem based, project based and action-oriented trainings.

At Festo Didactic, design of a lesson starts with a job profile. The latter then leads to a question of what type of competencies are needed for this job profile. The competencies, in turn, are based on related activities, procedural knowledge and declarative knowledge. **The key orientation is therefore on competencies that are relevant for the job**.

Learning Factories are located in the heart of the factory and implies:

- Learning on demand;
- Short training units (30 min);
- Managers as trainers;
- Train the trainer concept;
- Administration by apprentices;
- Covering: basics (Soldering, screwing etc.); product trainings; automation; organisation (5S, One-piece flow) etc.

At the Learning Factory, short lessons can be given, focusing on exactly what learners need, and they can apply it right away, opposed to going a seminar or an offsite course.

Adaptive multimedia learning paths are competency-oriented, curated learning paths that adapt to individual learning behaviour are based on reusable **learning nuggets** that use a variety of didactic media. Based on this, is it easier to develop specific lessons. The approach implies building lessons on many smaller parts instead on one big box. That ensures flexibility and personalisation. It also makes it easier for the student to see where the knowledge is useable. Theory is best delivered in smaller portions (nuggets), and students do work assignments, and have reflection afterwards.

Training usually implies a mix of many media. It can have different nuggets. It can include e-learning, seminar, simulation etc. In that respect, Virtual Reality (VR) will hardly become the next learning revolution, but it can help a lot. A mix might be different for each learner and each topic. With different nuggets, one can arrange

them for different learning paths. It is possible to reuse each nugget in different paths, and to adapt this also to each learner. This can also be done automatically in a long run.

3.2. *Basque System of Vocational Training and examples*, Jon Labaka, TKNIKA, Basque Centre of Research and Applied Innovation in VET/Unai Ziarsolo, IEFPS MIGUEL ALTUNA (Spain)

Mr. Jon Labaka and *Mr. Unai Ziarsolo* presented Basque System of Vocational Training and related examples.

The objective of the Hubs is to guide the Basque applied Innovation System through the development of the available to companies necessary differential capacities, in direct relation to the Smart Specialisation Strategy of Euskadi.

In total, 19 centers participate in the four Hubs in development:

- Advanced Manufacturing.
- Digital and connected factory.
- Energies
- Biosciences and biotechnologies.

In the Basque country, the developed pedagogical framework is called **ETHAZI (High Performance Courses).** It implies the following aspects:

- A disruptive methodological change to adapt students to the professional profile that the industry needs to be competitive;
- Developing education & training ecosystems where **learners are put in the centre**, with the main focus on learning rather than teaching;
- The aim is to get the maximum learning potential of the students professional competences development (**technical skills + soft skills**);
- Teamwork, creativity, flexibility, digital skills, communication, social and personal responsibility, entrepreneurship etc. to be able to analyse, understand, synthesise, transmit, judge, decide etc.

The main features of the challenge-based collaborative learning (CBCL) include the following:

- **The master lectures are removed**. The traditional role of the teacher speaking/student listening disappears.
- **Students work in teams** solving different challenges.
- **Inter-modular programs**: the knowledge linked to different subjects is introduced to the students when it is required to solve the challenge.
- During the program, all the contents gathered in the curriculum are covered while the students solve the **challenges**.
- **Self-managed teachers**: the teachers are coordinated to assist and support the students when their expertise is needed.
- Technical and soft skills are evaluated in a **360º scheme**.
- Student's **individual learning speed** is respected. Each student develops his/her talent based on their background, experience and interests.

Complementary to CBCL, for the AMT, a pilot experience is being implemented in four VET centres in the Basque region. It implies the **integration of 4.0 enviroments in learning activities - SMART workshops at TVET centres** to get students and trainers used to work in "intelligent" environments.

The key **benefits** of the approach include the following:

- Students work in 4.0 environments so that they get used to new ways of working.
- Students, equipment and systems are connected throughout the entire process chain.
- All relevant information is available in real time for trainers and students.
- CBCL methodology is approached as an industrial process.

- Students progress can be monitored via individual traceability, based on accurate information for the evaluation plans.
- Exact information about machine use is available: information on machine working time, on/off and real machining time:
  - Accurate Maintenance planning;
  - Booking of machines, usage of the facilities;
  - Tool control; information available about who is using the tool, what machine, what task is carrying out, material, process; data for life analysis;
- Stock control.
- Cybersecurity managed in a local environment.
- Big data managed in a local environment.
- There is a showroom for SMEs and micro SMEs.

A key drawback implies that large investment is needed in hardware.

3.3. *SkillMan: Transnational platform of Centres of Vocational Excellence for the Advanced Manufacturing Sector*, Giovanni Crisonà, CSCS (Italy)

Mr. Giovanni Crisonà presented the objectives and key activities of the Skillman.eu initiative.

The original Skillman.eu mission implies the facilitation of the EU Skills Agenda and designing new learning pathways in the Advanced Manufacturing sector. It has been adjusted afterwards with a particular debate among the members, by adding the UNESCO 17 goals on sustainable development related, in particular, to the **ethical values** that connect the competences necessary for Advanced Manufacturing (AM) to the personal responsibility.

The AM technologies require different profiles provided with skills and ethical values that currently in both, the job market in general and in the industrial companies too, are still lacking in terms of numbers, knowledge and know-how. Different figures are required, from the design phase, up to the manufacturing technician to be committed, up to the technologically highly skilled people which have a global vision (from design, up to all the post processing), without forgetting, for example, the material experts on the different Additive Manufacturing portfolio[11].

The Skillman.eu members are convinced that the new Advanced Manufacturing technologies and the Additive Manufacturing in particular, will be more and more extended to all plants and on all manufacturing process level, since the initial prototyping phase up to the real mass production. The additive manufacturing technologies will also be adopted in the design and manufacturing of tools for the production process itself.

Thus, the current perspective and the objectives of the members of the Skillman.eu platform, regarding the new printing technologies in particular, includes two aspects that mainly fit also with supranational policies in the fields of education and training:

- the ethical issues that placed the Advanced Manufacturing sector skills to the attention of the Skillman.eu members due to the existing easy possibility to use low cost 3d printing system to make weapons, and

[11] Regarding education, one should not underestimate the added value of re-training existing workers. A key for the deployment of additive methods in Europe is not only teaching AM skills in the educational context, but also re-focusing skills of existing workers. See, for example, AMEC 2017 - http://www.cecimo.eu/site/additive-manufacturing/cecimo-conferences/amec/amec-takeaways/

- the need to approach the Advanced Manufacturing for a mass-market production to support a 'rapid European or international scale-up of innovative solutions'[12].

3.4. Discussion and feedback of participants

Dr. Kristina Dervojeda invited the workshop participants to express their feedback regarding the presentations given during the morning session. The key points of the discussion included the following:

- Special attention needs to be paid to the development of soft (or non-technical) skills. These skills can be developed when students work on hands-on challenges.

- The role of schools, teachers and trainers needs to be reconsidered, with the learning ecosystem built around learners.

    - Schools still play a crucial role. There is a need for a solid initial knowledge base, before one can start applying a "nugget approach". The role of the schools is thus to teach the basics, that can be further built on.

    - Learner and teacher roles become increasingly interchangeable.

- With these new approaches, graduates enter companies with already a few years of practical work experience.

- There is a high risk of developing unrealistic expectations regarding what students should know when they finish their studies. It is not possible to address every need. First of all, there is a need to develop good engineers, with strong technical skills, and also the relevant soft skills. Finding a good balance is key.

[12] LAB – FAB – APP — Investing in the European future we want, ISBN 978-92-79-70571-7, Luxembourg: Publications Office of the European Union, 2017

4. Teaching new skills and teaching skills in a new way (Part 2)

The afternoon session continued with specific presentations featuring good practice examples with regard to teaching new skills and teaching skills in a new way. The session consisted of six presentations followed by a detailed discussion and feedback of participants.

4.1. *The CNFM education action and its connection with the ACSIEL, French industrial union of semiconductor: increasing the quality and relevance of existing curricula*, Olivier Bonnaud, CNFM (France)

Prof. Olivier Bonnaud presented the education-related activities of the National Microelectronics Network (CNFM) and its connection with the ACSIEL, French industrial union of semiconductor companies.

CNMF was founded in 1981 with an objective to boost the Microelectronics industry facing a severe shortage in qualified people by:

- Increasing significantly the number of graduate students (Masters, engineers, PhD);
- Focussing on practical training using industrial tools;
- Establishing a network of common education centres: sharing cost & avoiding duplication;
- Setting up a National Steering Committee consisting of the representatives from universities, government and companies.

CNFM Network covers technical skills in **"Integrated Circuit (IC) Design, Fabrication, and Test"**:

- IC Fabrication in Clean Rooms: Toulouse, Grenoble Paris, Rennes, Orsay, Lille, Bordeaux;
- Embedded Systems, Smart sensors, HF electronics, optoelectronics;
- Design and Test of Integrated Circuits and Systems;
- State of-the-art CAD tools provider service in Montpellier.

CNFM provides a permanent link between the academic world and the industrial world. CNFM allows the pooling of technological platforms (process and CAD) accessible to all students, which allows them to acquire essential know-how. Because Electronics and Microelectronics are at the heart of the innovative objects (IoT), the training strategy aims to provide competence and know-how in microelectronics but also in all application fields.

The existence of **multidisciplinary platforms open to initial and Lifelong Learning training** allows meeting the needs of industry. The close link within the network between academia and industry makes it possible to jointly define learners' needs, build curricula adapted to the objectives with academic institutions, allow an opening to European and international cooperation, ensure learning that includes both the knowledge and know-how required for a successful 21st century industry.

The CNFM network's approach provides students with skills through practical training. This becomes essential as many knowledge acquisitions will be ensured by online tools and therefore without any practical experience. Thus, CNFM network provides this know-how.

On-the-job training is not easy to organise in a high-tech factory. Trainees must acquire a minimum technical background before entering such a plant. In the CNFM network centres, since conditions are close to the industrial environment, trainees are able to fulfil the job requirements. The acquisition of know-how on industrial tools and apprenticeship can be reinforced by end-of-study internships or dual supervision projects.

The CNFM approach fosters multidisciplinarity and the training platforms are open for a large spectrum of applications (e.g. Industry 4.0, Health, Environment, Transportation, Communications).

The applied curriculum framework implies the following:

- **Student-centric approach**: this approach is ensured by involving students in practical activities on the platforms. They must have initiatives that are validated by the practical work supervisors;
- **Problem-driven learning** is insured by the organisation of projects and internships on the platforms;
- **Collaborative learning and team working**: in practice, projects on platforms are organised by groups of students. They are required to share tasks and therefore coordinate their actions.
- **Self-assessment**: after each session on platforms, each student fills a questionnaire. This is mandatory for life-long learning sessions.

The CNFM network's strategy, which makes it possible to pool resources and maintain an adequacy with the needs of the socio-economic world, **can only be achieved by keeping platform equipment and study topics at the highest level**. The field of Microelectronics has been evolving rapidly for decades and training must also keep the pace.

Thus, this policy requires financial support to update the hardware and software that academic bodies currently have difficulty in acquiring, despite the pooling organised by the network, which makes it possible to limit the cost. It is necessary to consider at national and European levels that the needs of companies in training are specifically supported within the framework of industrial sectors with dedicated funding from both public bodies and private companies. **This network can be an example for wider organisation at the European level**.

4.2. People-centred development as a novel interdisciplinary and co-creative approach towards teaching and learning – examples of good practices from Erasmus+ and H2020 projects, Gregor Cerinšek, Institute for Innovation and Development of University of Ljubljana (IRI UL) (Slovenia)

Mr. Gregor Cerinšek addressed a topic of people-centred development as a novel interdisciplinary and co-creative approach towards teaching and learning.

The people-centred development approach in design and development aims **to make a move from the mind-set of engineers, designers and researchers to the specific needs and experiences of people**. In this approach, people play an important part in the innovation, design, co-creation, and testing of solutions.

The approach has been **tried by numerous international companies**. In the 1970s, Xerox relied on a people-centred approach to improve the usability of their first photocopying machine; in the 1990s, Boeing employed ethnography to design the 787 Dreamliner aircraft, and Microsoft used it to improve their operating system. In the new millennium, several other companies, including Intel, Google, General Motors, Motorola, Nissan, and Volvo, started to hire social scientists and use people-centred approaches for the design and development of their products and services. The approach has been further developed, implemented and tested in the frame of Erasmus+ Knowledge Alliance project PEOPLE (www.people-project.net), where experiments

take place with inter and transdisciplinary co-creation between students, their teachers and industry professionals working on real-life challenges of industry and society.

The approach can be divided into four basic steps. The first step is **identification**, where we define whose problems are actually being solved or who are the people in focus. In the second step, we carry out **research** and analyse their needs, using and combining different approaches, from interviews, focus groups and participant observation to surveys and experiments. In this way, we learn about people's everyday experiences, practices and habits to find out what they need and want. In this process, we do not perceive people as research subjects; instead, we treat them as colleagues and co-creators. We encourage them to creatively participate in decisions towards concrete solutions. The third step is **interpretation**. On the basis of research findings and in cooperation with the developers, we prepare recommendations for improving design. The key idea of people-centred design and development is that people can - and should be - included in this part of the design process as well, not only acting as informants to the researchers, but as partners in the creative process. There are a number of tools and techniques available that allow researchers, designers, and engineers to work with people throughout the design and development process. The fourth step, **design, development and testing**, assures optimal user experience. In this phase, when we already have a prototype of the product or service, the central question is why and how - and if at all - the newly created solutions are relevant, important and meaningful to people. We test the prototypes with people and use different techniques to assess their suitability, and overall people-friendliness. Based on the results, we prepare recommendations for improvement.

People-centred development is an **iterative process**, which means that we continuously return to users of products or services to repeatedly ask questions that shed light on how our solution meets their needs and desires. In addition to listening attentively, researchers observe what co-creators do and how they interact with technologies or each other, researchers might even live with research participants for a while to learn about their daily habits and practices. They use techniques that transform research participants into active co-creators or collaborators, they let them take the lead and they learn from them to find out how new solutions, products and services, co-created with the people and for the people, could improve their lives.

4.3. Examining the success of delivering Engineering Apprenticeships from Advanced to Degree level within a university run provision of the AMRC Training Centre, Wendy Miller, AMRC (United Kingdom)

Ms. Wendy Miller addressed the topic of Engineering Apprenticeships from Advanced to Degree level within a university run provision of the Advanced Manufacturing Research Centre (AMRC) Training Centre.

Education in Advanced Manufacturing requires the jobs and infrastructure to be able to offer a viable route. As with AMRC, significant funding was provided by both public and private means. In the Sheffield City Region in the UK, it has been recognised that the collaboration between academia and industry has brought about economic growth. It has been recognised by investment by big names such as Boeing, Rolls Royce and McLaren with manufacturing facilities in the area. Consequently, recognised by The University of Sheffield was the need to fill the skills gap and provide a workforce with the skills and knowledge to work with the emerging technologies and manufacturing techniques.

The development of the AMRC Training Centre has provided a route from Advanced to Degree Apprenticeships to address those needs. All apprentices at the Centre are employed, not only by larger global companies but also SMEs in the area. Case studies have shown the value that the apprentices are adding to their companies to provide practical improvements that have resulted in cost saving or more efficient businesses. Working with employers in curriculum development is essential to meet sustainable manufacturing requirements and address apprenticeship reform with the advance of 'Apprenticeship Standards' in the UK.

Since teaching staff at the AMRC are industry trained, they can relate the training and knowledge to the actual workplace, this goes hand in hand with well-resourced facilities to match those of industry. However, there is a necessity to train the experts in industry the art of teaching to facilitate not just subject specialism but also the

more affective and cognitive skills required to be flexible in the changing workplace of the 21st Century. This includes more active teaching methods to develop such skills as problem solving, learning to learn, independent and life-long learning rather than the more traditional didactic lecturing methods.

The practiced approaches include flipped learning, collaborative projects, and problem-based learning within planned 'learning' sessions that meet the needs of individuals to progress to their potential. Within these activities, the affective skills, such as resilience, effective communication, work ethic, responsibility and adaptability are embedded, practiced and reflected upon to be able to set targets for improvement. These are equally important to employers in the readiness to adapt to the acceleration of advanced technologies and different working practices and for the learners/apprentices to be successful in their workplaces.

4.4. *The EWF International Qualification System in Additive Manufacturing*, Adelaide Almeida, European Welding Federation (EWF) (Belgium)

Ms. Adelaide Almeida presented the EWF (European Welding Federation) International Qualification System in Additive Manufacturing (AM).

The EWF's approach to developing skills in AM implies connecting education with industry, and specifically developing qualifications and guidelines, creating alliances, assuring harmonisation of education & training, authorising education & training centres, monitoring industry skill needs, performing RTD activities and ensuring skill alignment with industry standards.

There is a clear need for an EU approach to address skills in AM. Specifically, there is fragmentation of the EU landscape in the provision of training in AM; there is also lack of comprehensive and common curricula to train AM personnel, as well as lack of schemes to re-qualify the existing workforce in manufacturing. Therefore, the AM European Qualification System, covering from the lowest (EQF level 4) to the highest level (EQF level 7), is a guarantee of a harmonised and national implementation, as well as Quality Assurance and industry focus.

The EMF Qualifications design follows a top-down approach, including the following questions:

- **Professional Profile**: What is the general description of this professional occupation?
- **Major Functions**: What job functions respond to the general description?
- **Basic Functions:** What are the necessary activities to comply with each job function?
- **Learning Outcomes:** What are the required knowledge and skills to perform these activities?

These questions, in turn, lead towards defining specific competence units defined in terms of learning outcomes, which can be taught, assessed and validated individually, enabling a more flexible and tailor-made training (modular and cumulative system).

EWF's work on the development of new Qualifications in Metal AM is in line with the standardisation activities currently in place by ISO/ASTM. The conclusions of this work are being referred back to ISO/TC 261/JG 74 Personnel Qualification, where EWF is the convenor.

New job profiles/qualifications have been developed for AM Operators and AM Engineers in 2018, and more qualifications will be created in 2019 for AM Designers, Supervisors and Inspectors.

4.5. *Competence framework for Additive Manufacturing*, Harald Egner/Martin Dury, the MTC (United Kingdom)

Dr. Harald Egner and *Mr. Martin Dury* presented the Competence Framework for AM.

Currently, the UK AM training offer consists of:

- A number of OEMs offering product training,
- A small number of training providers offering a list of introductory courses,
- A small number of Higher Education (HE) providers offering programs.

These do not contribute towards or form part of a National curriculum or accredited programme and are not aligned with an occupation. With regard to feeding the workplace with new skilled AM people, there are no apprenticeship programmes in AM. When it comes to upskilling the existing workplace in AM, there are no accredited CPD/short course curricula in AM. To take the first step in addressing this issue, the MTC/National Additive Manufacturing Centre are conducting a competence mapping project on behalf of Innovate UK.

The aim is to create a competency framework and corresponding training curriculum for the "ideal" person for every step of the process. Each person needs to be clear about the entire end-to-end process and their responsibility within the process. Having access to these skilled people will enable industry to exploit the value from AM.

The competence mapping project will invite experts from R&D/Catapults, OEMs, Business and Academia over 6 phases. The process will focus on discussing which roles are/should be involved with the entire AM design and production process when it comes to best practice. It will then capture which tasks each individual will do, which software or hardware they will use and what necessary underpinning knowledge, skill and behaviour they must have to do so. There will be different phases of mapping workshops held online with the type of process being discussed and the experts area of knowledge.

When aligned with the National Educational programmes, the frameworks show the possibility of a career in AM, from L3 to L7. These ideal frameworks will then be cross-referenced to any existing apprenticeship or engineering education programmes to identify any gaps that need filling. The draft frameworks will be shared with all stakeholders for review, feedback and ultimately result in a final version, ideally ratified and approved by all.

The competency frameworks will allow for defining which technical courses are needed for each job role. Some of these courses will already be in existence, such as the OEM (Original Equipment Manufacturer) product training, whilst some will not exist and therefore will be targeted for design by the MTC. This will create a matrix of technical courses relevant to each job role. This matrix will then be used to create the various curricula. The curricula will consist of courses provided by the MTC, OEMs, Academia and Certification bodies etc.

4.6. *Reflection as a skill and an approach to developing skills*, Carina Girvan, Cardiff University (United Kingdom)

Dr. Carina Girvan addressed the topic of reflection as a skill and an approach to developing skills.

When it comes to developing the 21st Century skills, two key challenges refer to the ways how to develop these skills and the ways how to evidence skill development. For example, providing opportunities to work in teams does not yet mean that students know how to effectively work in teams, nor that they will learn anything about effective teamwork. It is crucial to find ways to assess the development of specific skills.

Reflection is:

- Thinking deeply about something so that you are able to understand it more thoroughly;
- Taking a 'step away' from ourselves to gain perspective;
- Reviewing or replaying an action or interaction to make sure nothing has been overlooked;
- Being brutally honest with yourself about your part in something;
- Trying to find a clear way through something complicated;

- Finding connections and relationships, often between something abstract (such as a theory taught in a class) and something concrete (such as an incident, which occurred when working in a practical environment).

Reflection is a way of thinking and learning, and specifically:

- Gaining better understanding and awareness of the context;
- Analysing situation, actions – evidence;
- Making connections between theory and practice;
- Identifying a need for action/behaviour change.

Reflection is also time consuming, hard work, personal, lonely, scary (feelings of uncertainty) and difficult. It is also rewarding.

Reflection works when it is relevant, regular, rewarded & supported, and when something has gone wrong. Reflection is ideal for:

- Experiential learning;
- Work placements;
- Critical thinking/problem solving;
- Applying theory to practice;
- Team building;
- Distance education.

Regular reflection needs analysis, chart development, evidence learning, feedback, guidance and monitoring.

4.7. Discussion and feedback of participants

Dr. Kristina Dervojeda invited the workshop participants to express their feedback regarding the presentations given during the afternoon session. The key points of the discussion included the following:

- Students need to learn how to be self-critical, but at the same time stay self-confident.

- There is a need for a continuous dialogue between teacher and student. Students need to become part of the teaching process.

- Students need to be able to criticise other team members. It is a matter of trust and confidence.

- Reflection often does not have a priority for education & training institutions; hardly any attention is paid to it.

- It would be too risky to remove “traditional” lectures from education. Students also need to have good knowledge of theory.

5. Moving forward: conclusions and next steps

The closing session of the workshop aimed to address the detailed proposals for curriculum guidelines, summarise the key points of discussion and identify the next steps.

5.1. Towards detailed proposals for curriculum guidelines

The workshop participants were invited to submit their suggestions and share their experiences with regard to each of the abovementioned elements of the curriculum guidelines.

5.2. Next steps

The project team will keep the workshop participants informed about the key activities of the initiative, and further involve them in co-creating specific proposals for curriculum guidelines.

The workshop participants expressed their willingness to continue following the progress of the initiative and to provide additional suggestions and feedback, whenever needed.

Annex A: Workshop agenda

Workshop agenda

10:00 – 10:30	**Welcome and Introduction** • Workshop context, rationale and objectives • Introduction round of participants • Workshop setting and key expectations	*Giovanna D'Addamio (EASME, European Commission)* *Kristina Dervojeda (PwC)*
10:30 - 11:00	**Advanced Manufacturing for the 21st Century: implications for non-tertiary vocational education** • Skill needs of operators • Profile of a modern vocational learner • Curriculum Guidelines Framework	*Kristina Dervojeda (PwC)*
11:00 - 12:00	**Teaching new skills and teaching skills in a new way (Part 1)** • **Didactical Concepts for Future Training for Manufacturing**, *Reinhard Pittschellis*, Festo Didactic (Germany) • **Basque System of Vocational Training and examples**, *Jon Labaka*, TKNIKA, Basque Centre of Research and Applied Innovation in VET/*Unai Ziarsolo*, IEFPS MIGUEL ALTUNA (Spain) • **SkillMan: Transnational platform of Centres of Vocational Excellence for the Advanced Manufacturing Sector**, *Giovanni Crisonà*, CSCS (Italy)-> check link in Internet	*Moderators: Kristina Dervojeda (PwC), Marte Andresen (PwC)*
12:00 - 12:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Marte Andresen (PwC)*
12:30 – 13:00	**LUNCH BREAK**	
13:00 - 15:00	**Teaching new skills and teaching skills in a new way (Part 2)** • **The CNFM education action and its connection with the ACSIEL, French industrial union of semiconductor: increasing the quality and relevance of existing curricula**, *Olivier Bonnaud*, CNFM (France) • **People-centred development as a novel**	*Moderators: Kristina Dervojeda (PwC), Marte Andresen (PwC)*

	interdisciplinary and co-creative approach towards teaching and learning – examples of good practices from Erasmus+ and H2020 projects, *Gregor Cerinšek*, Institute for Innovation and Development of University of Ljubljana (IRI UL) (Slovenia) • **Examining the success of delivering Engineering Apprenticeships from Advanced to Degree level within a university run provision of the AMRC Training Centre**, *Wendy Miller*, AMRC (United Kingdom) • **The EWF International Qualification System in Additive Manufacturing**, *Adelaide Almeida*, European Welding Federation (EWF) (Belgium) • **Reflection as a skill and an approach to developing skills**, *Carina Girvan*, Cardiff University (United Kingdom) • **Competence framework for Additive Manufacturing**, *Harald Egner/Martin Dury*, the MTC (United Kingdom)	
15:00 – 15:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Marte Andresen (PwC)*
15:30 - 16:00	**Wrapping up: Towards detailed proposals for curriculum guidelines** • Moving forward: conclusions and next steps • Closing remarks	*Giovanna D'Addamio (EASME, European Commission), Kristina Dervojeda (PwC)*

Annex B: Workshop participants

Nr	Name	Organisation	Country
1.	*Reinhard Pittschellis*	Festo Didactic	Germany
2.	*Gregor Cerinšek*	Institute for Innovation and Development of University of Ljubljana (IRI UL)	Slovenia
3.	*Olivier Bonnaud*	CNFM	France
4.	*Wendy Miller*	AMRC	United Kingdom
5.	*Adelaide Almeida*	European Welding Federation (EWF)	Belgium
6.	*Carina Girvan*	Cardiff University	United Kingdom
7.	*Jon Labaka*	TKNIKA, Basque Centre of Research and Applied Innovation in VET	Spain
8.	*Unai Ziarsolo*	IEFPS MIGUEL ALTUNA	Spain
9.	*Harald Egner*	The MTC	United Kingdom
10.	*Martin Dury*	The MTC	United Kingdom
11.	*Ahmad Bsiesy*	CIME Nanotech	France
12.	*Valentina Chanina*	European Forum of Technical and Vocational Education and Training (EFVET)	Belgium
13.	*Joël Chevrier*	Grenoble University	France
14.	*Giovanni Crisona*	CSCS	Italy
15.	*Ana Grigore*	European Commission, DG RTD	Belgium
16.	*Lukas Borunsky*	European Commission, DG RTD	Belgium
17.	*Camila de Epalza Azqueta*	Delegation of the Basque Country to the EU	Belgium
18.	*Giovanna D'Addamio*	EASME	Belgium
19.	*Kristina Dervojeda*	PwC	Netherlands
20.	*Marte Andresen*	PwC	Netherlands