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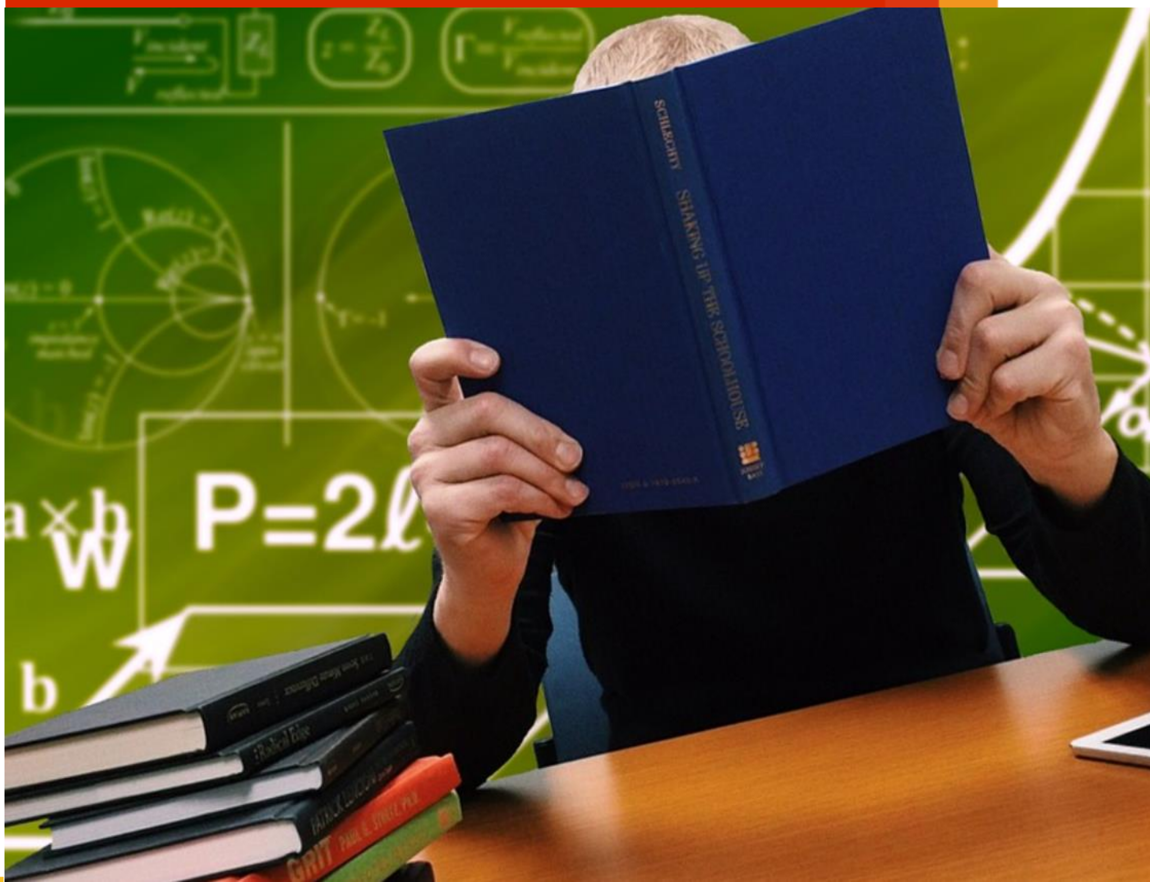
Expert workshop on "Aligning on-the-job training in Advanced Manufacturing with the 21st Century needs"

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

Second expert workshop

Contract nr EASME/COSME/2017/004

WORKSHOP REPORT



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Executive summary

This document summarises the key points discussed at the second expert workshop focussing on “Aligning on-the-job training in Advanced Manufacturing with the 21st Century needs”, organised in the context of the “Curriculum Guidelines for KETs and AMT” initiative of the European Commission.

The workshop addressed the initiatives aiming to improve curricula/learning strategies for on-the-job training in the field of Advanced Manufacturing Technologies. The workshop featured good practice examples and practical illustrations of the proposed solutions from employers, both large and small companies, as well as external training 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.

The workshop brought together key practitioners, researchers and policy makers active in the field of AMT training in Europe. 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 current initiative aims to extract suggestions for anticipatory work, and specifically with regard to the role of policy makers in reskilling/upskilling the workforce, with a particular attention to the questions of what needs to be done, who can/should do it and how to fund it.
- Informal learning plays an increasingly important role, and it should not be overlooked when addressing the topic of on-the-job training. Effective tools and approaches are needed to stimulate both formal and informal learning.
- It is crucial to stimulate the exchange of experiences and good practice examples. There is a need to evaluate the scalability and the sustainability of these good practice examples.
- The realities in which modern learning occurs need to be acknowledged, and specifically the fact that today’s employees are overwhelmed, distracted and impatient.
- 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.
- New skills require new job descriptions. This issue often remains overlooked.
- 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.
- Whereas digital learning spaces allow for embedded real-time assessment of the learning progress, the final impact assessment of a training course should never be done right after the course, as it is too early for evaluating the achievements and effects on the job.

1. Introduction

This document represents a workshop report for the expert workshop on “Aligning on-the-job training in Advanced Manufacturing with the 21st Century needs”. 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 18 September 2018. It is the second 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*, André Richier, DG GROW, European Commission (Belgium)

Mr. André Richier welcomed all the participants and emphasised that the current initiative aims to:

- Promote better policies, measures and initiatives at all levels on KETs and AMT skills by fostering transparency and increasing awareness;
- Facilitate the uptake by SMEs of these technologies, by strengthening the human capital and skills dimensions and providing efficient tools;
- Improve the relevance and quality of curricula for KETs and AMT skills development;
- Contribute to the further development and improvement of European and national initiatives on KETs and AMT skills, including synergies with the activities within the Blueprint for Sectoral Cooperation on Skills (additive manufacturing) and EIT Knowledge and Innovation Communities (Added-value manufacturing KIC).

The overall goal of this initiative is to help the Commission assess the current state of play and identify the key focus areas for future efforts.

The initiative will involve data collection and research, design of guidelines, testing and validation, taking into account industry and market needs, best practices, and contributions from key stakeholder groups. **The aim is to help likeminded people to find/co-develop solutions and to provide guidance for implementation**.

The **target groups** of this initiative are, on the one hand, higher education students and teachers, and on the other, workers and managers (especially those employed by SMEs) who need to acquire continuously new specialised skills related to KETs, and specifically AMT. The outcomes of this initiative will contribute to the goals set out in the European KETs Strategy and the New Skills Agenda, and specifically the related sectoral pilots foreseen in the Blueprint for sectoral cooperation on skills.

This initiative also implies setting up an informal **Key Stakeholder Group** (KSG), i.e. a pool of highly qualified external experts that will be engaged in the current initiative by means of workshops, interviews, surveys etc. These people will form the base of the pan-European thematic network.

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 following major developments[1]:

- ***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 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[2].

The number of jobs in manufacturing as a whole requiring high-level qualifications is projected to rise by 1.6 million (21%) by 2025[3], 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[4]. However, these estimates should be treated with caution, as the numbers vary per source/methodology.

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.

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[1] 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
[2] *Ibid.*
[3] 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
[4] *Ibid.*

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 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 Advanced Manufacturing Technologies**. 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, in turn, focused on the initiatives aiming **to improve curricula/learning strategies for on-the-job training in the field of Advanced Manufacturing Technologies**. The workshop featured good practice examples and practical illustrations of the proposed solutions from employers (both large and small companies, as well as external training 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.

2. *Advanced Manufacturing for the 21st Century: implications for on-the-job training*

The morning session of the workshop was continued by the presentation on the actual 21st Century needs when it comes to on-the-job training. 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)

Industrial robot shipments in Asia have an unprecedented rise in volumes. It is important to explore the growing role of **human-machine interaction** and how to prepare ourselves for it[5].

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)[6], 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.

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[5] Video by Wall Street Journal “The Robot Revolution: The New Age of Manufacturing”, published on 1 February 2018, available at: https://www.youtube.com/watch?v=HX6M4QunVmA

[6] 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 training** 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.

When addressing the topic of on-the-job training, it is crucial to keep in mind the realities in which **modern learning** occurs, including learners' jobs, habits, behaviours and preferences. An infographic developed by Bersin[7] in 2015 emphasises that today's employees are overwhelmed, distracted and impatient. Flexibility in what, where and how they learn becomes increasingly important. Modern learners want to learn from their peers and managers as much as from experts. They are taking more control over their own development. An estimate was made that 1% of a typical workweek is all that employees have to focus on training and development. The abovementioned realities have direct implications for on-the-job training and indicate the agility of modern learning, decentralisation of training activities and a growing importance of informal learning. With regard to informal learning, a quote was presented stating that "informal learning activities account for 96% of the time in which workers are engaged in activities from which they learn"[8].

[7] Bersin (2015) "Meet the modern learner" infographic, available at: https://mrmck.wordpress.com/2015/06/19/meet-the-modern-learner-infographic/

[8] Borghans, L., D. Fouarge, A. de Grip, and J. Van Thor. Werken en leren in Nederland. Maastricht University ROA-R-2014/3, 2014. Online at: http://roa.sbe.maastrichtuniversity.nl/roanew/wp- content/uploads/2014/05/ROA _ R _ 2014 _ 3.pdf

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 8 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 essence of these dimensions was addressed in more detail in the concluding session of the workshop.

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 morning session. The key points of the discussion included the following:

- The quoted estimate of 96% of all learning activities referring to the **informal learning** was met with some scepticism from the audience, especially when comparing it with the "golden ratio" of 70/20/10 (where 70% of learning comes from experience, 20% from exchanging with others, and 10% from formal learning). Nevertheless, the audience agreed that informal learning plays an increasingly important role and that it should not be overlooked when addressing the topic of on-the-job training. Focussing on formal learning alone would represent a too limited perspective. Effective tools and approaches are needed to stimulate both types of learning (formal and informal).

- The current initiative aims to extract suggestions for **anticipatory work**, and specifically with regard to the role of policy makers (EU and national/regional) in reskilling/upskilling the workforce. Besides addressing the question of what needs to be done, it is crucial to understand how it can be done, who can/should do it and what the associated budget requirements are.

- It is crucial to stimulate the **exchange of experiences and good practice examples**. One of the good practice examples refers to the activities of Agoria[9] that among others facilitates the transformation of companies into factories of the future.

- The **estimates** regarding the impact of automation on the number of jobs in manufacturing should be treated with caution. A recent study showed that by transforming into factories of the future, no jobs were lost in Belgium. Instead, new jobs were created.

[9] Belgium's largest employers' organisation and trade association. The companies represented by Agoria are active in 8 markets (Transport & Mobility Technology Solutions, Machine Construction & Production Systems Technology Solutions, Food & Beverage Technology Solutions, Healthcare Technology Solutions, Financial Services Technology Solutions, Sports & Entertainment Events Technology Solutions, Building & Urban Development Technology Solutions, Energy Technology Solutions) and 5 industries (Building Contracting & Technical Services Industries, Manufacturing Industries, Materials Industries, Aeronautics, Space, Security & Defence Industries, Digital Industries). From: https://en.wikipedia.org/wiki/Agoria

- The practitioners from the audience recognised the presented **realities of modern learners** (e.g. impatience). Their experience suggests that small modules that one can combine work best for learning.

3. Training new skills and training skills in a new way (Part 1)

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

3.1. *New skills needed for Advanced Manufacturing & new ways to teach these skills: The Festo perspective,* Björn Sautter, FESTO (Germany)

Mr. *Björn Sautter* presented the Festo perspective on training skills needed for Advanced Manufacturing.

Multifaceted factors will have an impact on future jobs and skills needs in the manufacturing industry. These factors range from new digital technologies to changing social and environmental awareness, which calls for more responsible production and consumption patterns in the 21st century. Thus, **a complete set of skills and competences is needed** for sustainable business success, going far beyond technology skills and including organisational, social & ethical aspects. In this respect, all the jobs and functions in manufacturing companies will be affected; i.e. it is not only "blue-collar" jobs, but also office work will be subjects of fundamental change.

The dynamically changing and challenging global business environment demands learning and agile companies, which calls for continuous and individual on-demand training/learning "on-the-job" of each employee. Thus, **new ways of teaching skills comprise among others the modularisation of the learning content ("learning nuggets")** which can be combined in individual learning paths. **New flexible learning spaces** are needed, which combine the advantages of theoretical and practical and respectively of virtual and real-world learning in a "problem-oriented and project-based approach" and in an attractive and motivating collective learning environment (including, for example, gamification, and supported by a comprehensive and flexible coordinating digital learning platform). Festo Didactic is currently working on such a digital learning platform for **adaptive blended learning** with multiple "learning nuggets" which can be assembled as needed and may thus be **adapted to individual learning paths**.

3.2. *Challenging the boundaries of manufacturing: Defining upskilling and reskilling,* Harald Egner, MTC - Manufacturing Technology Centre (United Kingdom)

Harald Egner presented the experience of the Manufacturing Technology Centre (MTC).

The MTC as a RTO (Research and Technology Organisation), with a focus on technology development and industrial scale-up of new technologies, has created an Innovation Ecosystem which includes the Advanced Manufacturing Training Centre (AMTC). Training & education has been recognised at the MTC as a main barrier for introducing new technologies into manufacturing on an industrial scale. This year, the AMTC has taken on the fourth round of manufacturing apprentices.

Some investigations have shown that the shortage of skilled workers in advanced manufacturing might be well above the predicted figures as they do not take into account that some of the current training content will become (or already is) obsolete and some of the current training/education might not be relevant for future jobs. New and emerging technologies will create further demand for skills on top of existing demand, but it is not taken into account as much as it should be. **This results in a skills gap that is likely to be a lot bigger than the so far "known" skills challenge**.

AMTC is responding to changing demands and trends from "off-the-job" to "on-the-job" training. Due to consultations of a Trailblazer group in the UK with employers, they would like to see max 20% "off the job" training in order to keep productivity up. **Employees prefer bespoke training and an "earn while you learn" approach**. This means flexibility to "roll on"/"roll off" training activities according to changing personal priorities in the career life cycle and work/life balance.

The AMTC covers two main areas:

- Apprentice education to receive knowledge and skills in emerging technologies, including digital skills and Industry 4.0: It creates a pipeline of future-proof talent. The intake for apprentices in the MTC programme has doubled in 2018 to 80 apprentices.
- Training of existing workforce; these activities include:
  - Re-skilling; aiming at new technologies on existing national qualification levels 2 and 3;
  - Up-skilling; aiming to bring employees from a level 2 to level 3 or through "Degree apprenticeships" to move them from a level 3 up to level 7 (Master degree);
  - Multi-skilling; aiming to add complementary skills to the existing portfolio. This are mainly interdisciplinary skills (e.g. mechatronics).

In line with changes in demand and expectations, AMTC has a bespoke training delivery including Face-to-face training with experts, Virtual classroom, eLearning and bespoke training sessions in the MTC workshop. MTC training is based on "Competence Frameworks" for job roles describing required skills, knowledge and behaviour. Bespoke training solutions for companies include consultation and advice on their aspirations and CPD (Continuous Professional Development) strategy.

In Additive Manufacturing (AM), for example, AMTC so far has developed 8 competence frameworks across the entire AM process ("end to end"), across all current AM materials (metal, polymer, ceramics) and across disciplines (production, material, inspection/quality). This is resulting in 8 curricula and 80 courses delivered through a collaborative approach between AMTC/MTC, universities and technology providers. This information is made available to industry via the "MTC LEARNING HUB" platform.

On a national level, the MTC is involved in all leading skills activities such as Trailblazer groups (representation from sectors, qualification standards; industry driven), the Industrial Strategy – Skills pillar and "Made Smarter" Skills group (digitalisation of the UK manufacturing). In addition, MTC is supporting UK companies in the efficient use of the "Apprenticeship Levy" utilising the levy not only for 16 -18 years old traditional apprentices, but also for 19+ adult apprenticeships with qualified coursework in parallel to their "day job".

The offering of the Advanced Manufacturing Training centre is based on some unique features:

- **Close industry partnership**, which is based on the industrial membership model of the MTC with over 100 industrial members, who pay significant membership fees. Further industrial "Patrons" are supporting AMTC and together with members feed in actual demand from industry.

- **MTC employing apprentices**: this is a model which differentiates MTC from other professional training providers. The model is supported and sponsored by Lloyds Bank. Through the employment, MTC is taking the risk for year 1 & 2 of the apprenticeship. In year 3 & 4 companies, particularly smaller companies can come in and take over apprentices which then can add value straight away when joining their companies.

- **Future focus of AMTC through MTC**: as MTC is working on and scaling up latest and emerging technologies, AMTC is directly linked to new technologies at an early stage. Furthermore, AMTC does benefit from centres and hubs hosted at the MTC such as the National Centre for AM UK, DRAMA (Digital Reconfigurable AM for Aerospace, a pilot production and learning factory) etc.

- **Access to infrastructure for new and emerging technologies:** as MTC is doing industrial scale-up with industrial scale equipment, it can provide a "state of the art" environment for training purposes. This includes approx. 25 AM machines (not all owned by MTC), over 30 robots in a wide variety of applications and furthermore machines and tools for joining, metrology, NDT, digital tools etc.

Since AMTC is embedded in the wider MTC Innovation Ecosystem, it has a unique strength in training & education for advanced manufacturing. This strength is complemented by professional personnel experienced in vocational training and the founder universities in academic training.

3.3. *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:

- There is a need for a dedicated learning platform that would comprehensively combine a wide range of relevant courses (in different formats) and link them to specific learning paths. Policy makers could play a role in coordinating/facilitating the process of creating and maintaining such a platform. LinkedIn is currently developing a similar kind of platform, however not explicitly focussing on advanced manufacturing.
    - There is a need to make sure this platform not only offers specific courses, but also provides some overall guidance to learners with regard to their learning paths.
    - There is also a need to establish a mechanism to guarantee a sufficient level of quality of the educational offer on such a platform. An agreement needs to be reached on certain standards. Alternative approaches to accreditation could also be explored (e.g. opinion of learners).
    - A central role in developing and maintaining such platform(s) could belong to industry/sector associations.
- Many people have an outdated perception of the manufacturing domain, associating it with dark, "oily and dirty environments".
- Many people get qualified for jobs that do not exist anymore.
- There is a need for a clear plan (training strategy). A skills strategy needs to be aligned with a company and business strategy.
- A concern was expressed that in the context of skills-related initiatives, "there is a lot of talking about people, not to people".
- New skills require new job descriptions. This issue often remains overlooked.
- There is no need to be "overeducated", but workers need to be motivated.

4. Training new skills and training 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 five presentations followed by a detailed discussion and feedback of participants.

4.1. *ZIGGZAGG Additive Manufacturing & the staff of the future,* Jo De Groote, Ziggzagg (Belgium)

Mr. Jo De Groote presented the experiences of Ziggzagg in the context of Additive Manufacturing (AM) and the staff of the future.

To realise the full potential of AM, manufacturing organisations need to focus on developing a capable and skilled AM staff. Well-trained talent (engineers) is critical to maximising the impact of AM technologies. **There is high demand for new skills and capabilities, both technical and managerial.** Everyone is struggling to find the skilled workers. AM technologies have their impact on the supply chain and product design. With growing demand, there are growing expectations from the AM staff.

Manufacturing companies start to increasingly focus on AM, and they need to offer on-the-job training to their engineers. Addressing all issues is crucial to implement and scale AM. This soaring demand for skilled staff is not exclusive to AM. **Companies from all kinds of sectors are "fishing in the same talent pool"** (and specifically in IBO[10] (Individuele Beroepsopleiding VDAB) meaning an Individual Job Training).

There is lack of AM-specific training programs. There are only two educational institutions in Belgium that explicitly train specialists in AM (plastics). Creating an AM 'culture' takes time, while training employees remains costly and time consuming.

Specific **recommendations** for the future include the following:

- Set up some regional and national AM innovation centers with the help from the machine builders and the industry;
- Keep IP and newly acquired knowledge in house;
- Constantly rethink and adapt your organisation to the demanding B to B (to C) market;
- Keep contact with your competitors (e.g. via Agoria), and try to set up standard requirements for AM employees;
- In order to create a proven technology, set up standards and certifications.

[10] These individual job training programs are meant for people who have been unemployed. The programs are financed by government.

4.2. *Industry 4.0 Challenge: Empowering Metalworkers for Smart Factories of the Future (4CHANGE)*, Agne Kudarauskiene, Engineering Industries Association of Lithuania LINPRA (Lithuania)

Ms. Agne Kudarauskiene addressed the topic of the workshop from a perspective of 4CHANGE[11] project, funded by Erasmus+ program.

The overall **goal of the project** is to tackle skills gaps of metalworkers by designing and delivering a new targeted VET programme based on the current and future skills demand in the metalworking sector, and by developing a self-adaptive work-based learning system in combination with coaching.

The current and future **skills demand** in the metalworking sector will consist of these specific industrial requirements:

- Advanced technology and digital skills due to increased need for engineers instead of manual workers;
- Robotics and CNC operation skills due to technology-driven innovation;
- Social and entrepreneurial skills due to a need for highly motivated workforce to stay competitive;
- Green skills due to promotion of energy efficiency.

Educational products developed during this project can be used not only in VET but also during on-the-job training in manufacturing companies.

The main activities of the project include making comparative analysis of qualification standards (QSs), drawing up a model qualification standard and a model VET programme[12], designing training material for learners and trainers, developing and piloting e-learning platform and multimedia.

4.3. *The Teaching Factory: A novel manufacturing education approach*, Konstantinos Georgoulias, Laboratory for Manufacturing Systems and Automation (LMS) of University of Patras (Greece)

Dr. Konstantinos Georgoulias presented a concept of a Teaching Factory, **aiming to integrate the real factory environment with the classroom**.

The Teaching Factory (TF) concept has its origins in the medical sciences discipline and specifically in the paradigm of the teaching hospitals, namely the medical schools operating in parallel with hospitals. TF has emerged as a promising paradigm for integrating the learning and working environments. It is a non-geographically anchored learning "space" interconnecting remotely located engineering and student teams that work together on real-life projects.

TF is facilitated by advanced ICTs and high-grade industrial didactic equipment and operates as a bi-directional knowledge communication channel "bringing" the real factory to the classroom and the academic lab to the factory. The technological topics are independent of the Teaching Factory's operation and can be accordingly updated to provide the necessary knowledge foundation addressing the needs of manufacturing at any given time. Context and content modular configurations allow learning and training on multiple study contents, engaging different factory facilities, engineering activities, delivery mechanisms and academic practices.

The **"factory-to-classroom" TF operation mode** aims at transferring the real production environment to the classroom and allow students to be trained by addressing appropriate real-life engineering problems. The actual production site is used to enhance the teaching activity with the knowledge and experience existing in the processes of every day industrial practice. The **"lab-to-factory" TF operation mode** aims to transfer

[11] http://change4industry.eu/

[12] Developed Galaxy model qualification standard and VET curriculum for metalworkers' professional profile that is adapted to the industry environment and aligned according to the requirements of legal framework of each country.

knowledge from academia to industry. Industrial-grade or didactic equipment in the academic facilities is used as test-beds and demonstrators for new technological concepts that are to be validated and introduced to industrial practice.

The TF paradigm has been assessed based on real-life applications together with industrial organisations. Applications indicatively included the line balancing of a new production area and the planning of a material kitting area in a construction equipment factory, the validation of a new integration and control architecture for industrial robots in an automation company, designing a Multi-Technology Platform that combines a milling working center with a robotic arm equipped with a laser-head for a machine shop etc. The applications have demonstrated and verified the TF potential to bring together the manufacturing learning and working environments.

4.4. *Action-based learning in the engineering curricula at Politecnico di Milano*, Marcello Urgo, Manufacturing and Production Systems Lab of Politecnico di Milano (Italy)

Prof. Marcello Urgo addressed the topic of action-based learning in the engineering curricula.

In 2015, the Management Engineering Course at Politecnico di Milano underwent a significant reshaping of the Master Degrees' curriculum to improve education in management and industrial engineering. The design of the new curriculum grounded on the following main drivers:

- **Action-based learning**: all the curricula have to include an action-based learning activity. Nine laboratory courses have been established with the aim at providing the students the possibility to work in practice on a scientific and technological area (Advanced Manufacturing, Supply Chain Management, Sustainable Operations Management and Social Innovation, International Business, Digital Businesss and Market Innovation etc.);

- **Internationalisation**: all the Master Degrees curricula are thought in English to improve the skills of the Italian students to act in an international environment, increase the share of international students, allow the possibility for international professors to teach courses in English;

- **Soft skills**: provide students the possibility to interact in curricular and extracurricular activities to test and improve their soft skills.

The track on Advanced Manufacturing in the Management Engineering Master Degree provides the student the possibility to take part in the "**Production for Made in Italy Laboratory**". The learning objectives of the Laboratory include:

- Analysing and modelling a real industrial problem in a real environment, understanding the relevant elements and influencing factors, defining proper modelling hypotheses, collecting information and data;
- Selecting and applying industrial engineering methodologies to a real industrial case coping with incomplete and/or unreliable information and data;
- Working and cooperating in a team and interacting with a company;
- Planning and managing their work grounding on the intermediate results and the evolution of the context;
- Explaining, communicating and motivating the work done.

Some possible limits in its applicability and scalability inlclude collaboration with industry, technical relevance of the problems, and proximity with industry (virtual/digital factory).

4.5. *Zooming into Curriculum Guidelines Framework,* Kristina Dervojeda, PwC (Netherlands)

Dr. Kristina Dervojeda provided a detailed overview of the elements of the Curriculum Guidelines Framework. The analytical framework that will be forming a base for collecting and framing relevant data and developing guidelines, consists of 8 distinctive, but interrelated dimensions:

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

Strategy (1) refers to defining core values, commitments, opportunities, resources and capabilities of an educational/training institution with respect to developing a 21st century curriculum for AMT. The focus will be put on the conceptual aspects of the educational offer. Specifically, the elements of strategy include assessing learner's needs, developing curriculum goals and intended learning outcomes.

Collaboration (2) refers to connecting individuals and institutions by facilitating the exchange of practices and resources with a view to improve the educational offer. Special attention will be paid to practices that move beyond the typical institutional collaboration patterns and engaging individuals and communities. We also aim to address practices that empower learners to collaborate with each other and with the institution and community in order to produce knowledge, define their unique learning paths and achieve their goals.

The nature of educational **content (3)** includes multiple factors, such as degree of familiarity (from very familiar to novel), degree of learner engagement (from intellectual activity to behavioural activity), degree of anticipated change (from making learners aware of information to influencing their personal values), and degree of complexity (from easily understandable to very complicated). This dimension also includes specific principles related to the actual content of the curricula (syllabus design principles).

Learning environment (4) includes types of environment that is created during the program, e.g. stimulating multidisciplinary orientation, design thinking, team spirit, collective problem-solving, risk-taking behaviour, experimental approaches etc.

Delivery mechanisms (5) refer to the means by which learners experience and access education/training, and include in-person delivery where teachers/trainers and learners interact face-to-face (e.g. lectures, seminars, workshops); electronic delivery (synchronous and asynchronous), and blended delivery (education that combines multiple types of delivery). Here, we aim at addressing the role of technology-enabled learning, including traditional e-learning, MOOCS, SPOCs, mLearning, gaming, virtual and augmented reality, AI solutions etc.

We also aim at exploring the most appropriate forms of **assessment (6)**, e.g. self-assessment through which students learn to monitor and evaluate their own learning (trains the ability to be reflective and self-critical). peer assessment, in which students provide feedback on each other's learning, tutor/institutional assessment, in which the assessment is performed based on the judgement of tutor or standardised assessment test, other alternative forms of assessment.

Recognition (7) refers to the process, usually carried out by an accredited institution, of issuing a certificate, diploma or title which has formal value; and the process of formally acknowledging and accepting credentials, such as a badge, a certificate, a diploma or title issued by a third-party institution. Within this dimension, we aim at exploring appropriate formal and informal ways of recognition.

Finally, we aim to explore the **quality (8)** dimensions of an educational offer, by looking at:

- *efficacy* (fitness for purpose of the object/concept being assessed),
- *impact* (the extent to which an educational offer proves effective),
- *availability* (this is a pre-condition for efficacy and impact to be achieved, it includes concepts such as transparency and ease-of-access),
- *accuracy* (is a measure of precision and absence of errors, of a particular process or object), and
- *excellence* (compares the quality of an object or concept to its peers, and to its quality-potential).

4.6. 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:

- Whereas digital learning spaces allow for embedded real-time assessment of the learning progress, the final impact assessment should never be done right after the course, as it is too early for evaluating the achievements and effects on the job.

- Learner satisfaction is different from customer satisfaction.

- On-the-job training needs to be “protected” (ensure that no data is leaked) and “tailored” to the needs of the company.

- There is a need to evaluate the scalability and the sustainability of good practice examples.

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. A template for inputs will be developed by the project team and disseminated among the experts.

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	*André Richier (DG GROW, European Commission)* *Kristina Dervojeda (PwC)*
10:30 - 11:00	**Advanced Manufacturing for the 21st Century: implications for on-the-job training** • Key findings from the initial state-of-play analysis • Profile of a modern on-the-job learner • Curriculum Guidelines Framework	*Kristina Dervojeda (PwC)*
11:00 - 12:00	**Training new skills and training skills in a new way (Part 1)** • **New skills needed for Advanced Manufacturing & new ways to teach these skills: The Festo perspective**, *Björn Sautter*, FESTO (Germany) • **Challenging the boundaries of manufacturing: Defining upskilling and reskilling**, *Harald Egner/Christian Warden*, MTC - Manufacturing Technology Centre (United Kingdom)	*Moderators: Kristina Dervojeda (PwC), Erisa Gruda (PwC)*
12:00 - 12:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Erisa Gruda (PwC)*
12:30 – 13:00	**LUNCH BREAK**	
13:00 - 15:00	**Training new skills and training skills in a new way (Part 2)** • **ZIGGZAGG Additive Manufacturing & the staff of the future**, *Jo De Groote*, Ziggzagg (Belgium) • **Industry 4.0 Challenge: Empowering Metalworkers for Smart Factories of the Future (4CHANGE)**, *Agne Kudarauskiene*, Engineering Industries Association of Lithuania LINPRA (Lithuania) • **The Teaching Factory: A novel manufacturing education approach**, *Konstantinos Georgoulias*, Laboratory for Manufacturing Systems and Automation (LMS)	*Moderators: Kristina Dervojeda (PwC), Erisa Gruda (PwC)*

	of University of Patras (Greece) • **Action-based learning in the engineering curricula at Politecnico di Milano**, *Marcello Urgo*, Manufacturing and Production Systems Lab of Politecnico di Milano (Italy) • **Zooming into Curriculum Guidelines Framework**, *Kristina Dervojeda*, PwC (Netherlands)	
15:00 – 15:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Erisa Gruda (PwC)*
15:30 - 16:00	**Wrapping up: Towards detailed proposals for curriculum guidelines** • Moving forward: conclusions and next steps • Closing remarks	*André Richier (DG GROW, European Commission), Kristina Dervojeda (PwC)*

Annex B: Workshop participants

Nr	Name	Organisation	Country
1.	*Jivka Outcharova*	Karlsruhe Institute of Technology (KIT)	Germany
2.	*Ahmad Bsiesy*	CIME Nanotech	France
3.	*Annelies Raes*	Research group ITEC (imec - KU Leuven)	Belgium
4.	*Agne Kudarauskiene*	Engineering Industries Association of Lithuania LINPRA	Lithuania
5.	*Björn Sautter*	FESTO	Germany
6.	*Harald Egner*	MTC	United Kingdom
7.	*Jo De Groote*	Ziggzagg	Belgium
8.	*Roger De Keersmaecker*	RDK Consulting & Coaching	Belgium
9.	*Marcello Urgo*	Politecnico Di Milano	Italy
10.	*Chris Decubber*	EFFRA	Belgium
11.	*Mirko Scholz*	imec academy	Belgium
12.	*Damir Glas*	CECIMO	Belgium
13.	*Konstantinos Georgoulias*	University of Patras	Greece
14.	*Giovanna Daddamio*	EASME	Belgium
15.	*André Richier*	European Commission, DG GROW	Belgium
16.	*Ana Grigore*	European Commission, DG RTD	Belgium
17.	*Kristina Dervojeda*	PwC	Netherlands
18.	*Erisa Gruda*	PwC	Netherlands