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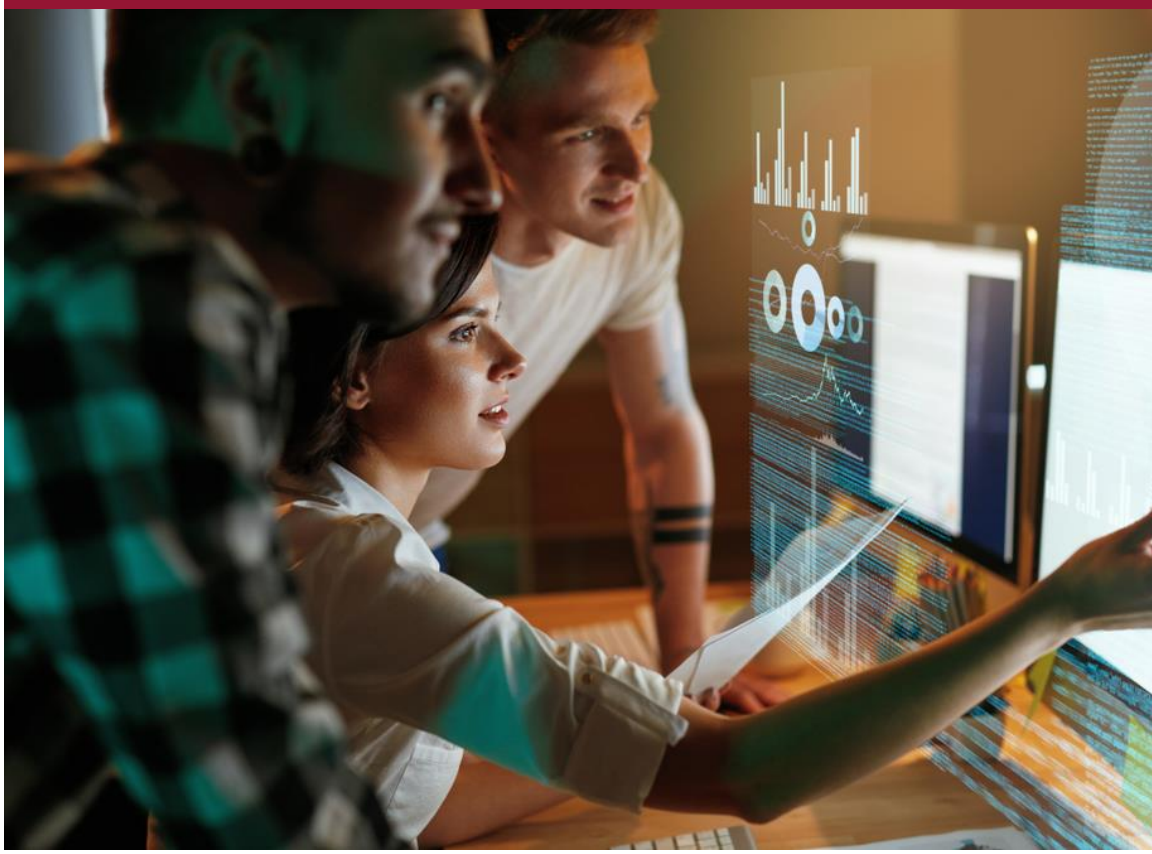
Future-Proofing Vocational Education for Manufacturing: Strategy, Collaboration Patterns and Learning Environment

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

WORKSHOP REPORT

Sixth expert workshop
Contract nr EASME/COSME/2017/004



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Executive summary

This document summarises the key points discussed at the sixth expert workshop focussing on "Future-proofing Vocational Education for Manufacturing: Strategy, Collaboration Patterns and Learning Environment", organised in Brussels on 17 September 2019 in the context of the "Curriculum Guidelines for KETs and AMT" initiative of the European Commission.

The results of our pan-European online survey indicated that the three elements of the AMT-related education & training system that require the most substantial change include Strategy, Collaboration, and Learning Environment. The workshop aimed to specifically focus on these three elements in the context of non-tertiary vocational education for Advanced Manufacturing. The workshop featured good practice examples and suggestions for specific measures and solutions for EU/national policy makers, education & training providers and other key stakeholder groups.

The outcome of the workshop will be used for fine-tuning 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:

- Education and training for the new age require a holistic approach, keeping in mind the bigger picture and fitting into the overall lifelong learning trajectory.
- Students need much more than knowledge; they need competencies, including skills, values, attitudes and mind-sets.
- For curriculum goals and learning outcomes, there is a need to shift from conventional qualification frameworks towards relevant personalised/personal learning.
- Students are change agents. They should be given a prominent role in co-creating curricula and designing learning experiences.
- Industry partners increasingly become educational, research and employment partners, by being engaged in the full student's learning experience, including curriculum strategy development.
- Different types of collaboration are needed, to ensure a multitude of experiential opportunities, including not only companies and other educational institutions, but also peers, community and machines.
- Education & training for the VUCA world require a Vision, Understanding, Commitment and Agility.
- There is a need to empower people at the local level rather than trying to push initiatives via top-down approach.
- The speed of change is accelerating rapidly. Education sector cannot keep up with this change on its own.
- Agility is one of the key principles of education in the new age.
- Working place is the most obvious place to start with when it comes to massive upskilling/reskilling efforts; educational institutions will only be able to catch up later.
- Scalability and sustainability are two critical factors determining impact and success of upskilling/reskilling initiatives.

1. Introduction

This document represents a workshop report for the expert workshop on "Future-proofing Vocational Education for Manufacturing: Strategy, Collaboration Patterns and Learning Environment". 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 17 September 2019. It is the final workshop out of the six workshops that were foreseen in the context of the abovementioned initiative.

Figure 1-1 Participants of the workshop

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

1.1. *Opening words,* André Richier, European Commission (Belgium)

The current initiative falls under the umbrella of the "Skills for Industry" theme, with the latter covering multiple topics related to upskilling and reskilling of the European workforce. It is also closely linked to the activities of the Blueprint for Sectoral Cooperation on Skills[1].

The Blueprint in its essence provides a framework for strategic cooperation between key stakeholders such as enterprises, trade unions, research and training institutions and public authorities in a given economic sector. It implies industry-led partnerships that develop sectoral skills strategies and concrete actions, such as new or updated vocational education and training. The overall goal is to help foster new opportunities for investment, innovation, growth and jobs[2].

The pilot implementations of the Blueprint started in January 2018 in the following sectors: automotive, maritime technology, textile, clothing, leather and footwear, space and tourism. The second wave of implementation started in January 2019 and included construction, steel, additive manufacturing, and maritime shipping. The third wave is expected to be launched in January 2020, and the selected sectors include microelectronics, batteries for electro-mobility, defence technologies, energy value-chain digitalisation, energy-

1 http://ec.europa.eu/growth/industry/policy/skills_en
2 https://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=8164&type=2&furtherPubs=yes

intensive industries, and bio-economy (new technologies in agriculture)[3]. The next wave has already been announced and it will cover software services, cybersecurity and blockchain.

Mr. André Richier invited all experts to provide their contributions to shape the agenda of the new Commission. The topic of skills is among the key priorities, and the new skills agenda is currently in the making.

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.

In 2017, EASME and DG GROW of the European Commission have launched an 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 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 initiative focusses on **VET, higher education and on-the-job training for AMT**. The objective is to offer educational and training institutions a source of inspiration, conceptual guidance and good practice examples. **The outcome of this initiative will play a prominent role in forming the EU policy making regarding upskilling of the AMT workforce.**

The key results of this initiative will be presented at the **final conference** in Brussels on 26 November 2019. The conference will focus on new solutions, best practices and policy measures that reflect the need to upskill and reskill European manufacturing professionals, and that would truly support learners, enterprises (particularly SMEs), and education & training providers in this challenge. *Dr. Kristina Dervojeda* invited the workshop participants to join the event and to disseminate information about it within the relevant networks of experts.

The results of a pan-European online survey, conducted in the first phase of this initiative, indicated that **the three elements of the AMT-related education & training system that require the most substantial change include**:

- **Strategy**: What are promising strategies and conceptual principles for developing a 21st Century curriculum for Advanced Manufacturing? (including strategies for assessing learner's needs, developing curriculum goals and intended learning outcomes);

- **Collaboration**: What are promising collaboration practices for facilitating the exchange of knowledge and resources with a view to improve the educational offer for Advanced Manufacturing? (e.g. engaging companies throughout the whole curriculum development & implementation trajectory, empowering learners to collaborate with each other and with the institution and community etc.);

- **Learning environment**: What types of environment lead to the most effective learning for Advanced Manufacturing? (e.g. stimulating multidisciplinary orientation, design thinking, team spirit, collective problem-solving, risk-taking behaviour, experimental approaches etc.).

To this end, the current workshop aimed to specifically focus on these three elements. These elements were further explored in the context of **non-tertiary vocational education for Advanced Manufacturing**. The workshop particularly aimed to offer a discussion platform to address key challenges and actions that

3 http://ec.europa.eu/growth/industry/policy/skills_en

would need to be introduced at the EU level, and identifying best practices. This workshop brought together key practitioners, researchers and policy makers active in the field of AMT education & training in Europe. **The outcome of the workshop will be used for fine-tuning the curriculum guidelines for education & training providers** active in the AMT domain.

2. Reshaping vocational education for Advanced Manufacturing: Towards future-proof workforce

The morning session of the workshop was continued by the presentation on key insights for curriculum guidelines, gathered in the context of non-tertiary vocational education.

2.1. *Curriculum Guidelines: Analytical Framework and Key Highlights,* Kristina Dervojeda, PwC (Netherlands)

Dr. Kristina Dervojeda highlighted the challenges of designing and implementing vocational education in the "VUCA" world. While the term emerged in late 1980s, it becomes increasingly popular among experts, specifically due to its ability to capture the sophisticated dynamics of the current world. VUCA stands for:

- **V**olatility: high speed of change in industry, market and the world in general; fluctuations in demand, turbulence, short time to markets;
- **U**ncertainty: different scenarios are possible, it is difficult to make predictions;
- **C**omplexity: the immense number of factors that need to be taken into account, with a high variety and complex relationships between them;
- **A**mbiguity: a need to deal with incomplete, contradicting or too inaccurate information to draw conclusions.

In order to survive and prosper in the VUCA world, there is a need for a strategic approach towards vocational education, based on the following elements:

- **V**ision: anticipating change; not just predicting but creating the future;
- **U**nderstanding: making informed decisions based on best available data;
- **C**ommitment: investing effort to transform vision into reality;
- **A**gility: adapting efficiently and fast to constantly changing circumstances.

The current initiative aims to produce **curriculum guidelines 4.0** 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.

When developing the curriculum guidelines, there is first a need to have a common definition of the curriculum. In our approach, we suggest to shift from a narrow perspective, viewing the curriculum as a list of subjects to be taught, towards a broader perspective, characterising **the curriculum as the overall learning experience of individuals (and groups) not only in schools, but throughout their professional lives**.

For the curriculum guidelines 4.0, we aim 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:** defining core values, commitments, opportunities, resources and capabilities of an educational/training institution;

(2) **Collaboration:** promoting practices that move beyond the typical institutional collaboration patterns and engaging individuals and communities;
(3) **Content:** defining the nature of educational content, including specific principles related to the actual content of the curricula;
(4) **Learning environment:** 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.;
(5) **Delivery mechanisms:** means by which learners experience and access education/training; special attention to technology-enabled learning;
(6) **Assessment:** identifying most appropriate forms of assessment, including advantages and disadvantages;
(7) **Recognition:** exploring appropriate formal and informal ways of recognition;
(8) **Quality:** identifying the determinants of education & training quality: what makes students' and employers' perception different?

As mentioned above, the three key elements that (based on stakeholder opinion) require the most substantial change include Strategy, Collaboration and Learning environment. *Dr. Kristina Dervojeda* presented the key highlights of the analysis for each of these elements.

Strategy

Education and training for the new age require a holistic approach, keeping in mind the bigger picture and fitting into the overall lifelong learning trajectory (so called **"Big Picture education"**).

Three types of needs should be considered:
- **Market/company needs** (employability)
- **Societal needs** (sustainability, ethics)
- **Learner needs/individual characteristics** (respecting diversity of learners' contexts and capacities), implying the need to engage learners in curriculum development.

Change in strategy can happen at three different levels (Kolmos A. et al. (2016)), from single improvements to complete transformations:
- **Add-on strategy**: changes at the level of a single course;
- **Integration strategy**: changes across many courses, implemented at a more systemic level and also integrated at an institutional level;
- **Re-building strategy**: fundamental changes in education implying rebuilding the whole curriculum, emerging types of schools.

The add-on strategy and integration strategy are the ones most commonly used, whereas the re-building strategy is at an emerging stage in most engineering education communities. Most engineering schools find it highly challenging to re-build an entire curriculum, so smaller changes are generally preferred (Kolmos A. et al. (2016)).

A shift can be observed from knowledge towards competencies that students should acquire for their personal development and for employment and inclusion in a knowledge society. Competencies include knowledge, skills, attitudes and values. Emerging concepts suggest adding a dimensions of **Mindsets**, e.g. Growth, Innovation, Ethics and Safety.

For curriculum goals and learning outcomes, there is a need to shift from conventional qualification frameworks towards relevant **personalised/personal learning**. Students are change agents.

Collaboration

Different types of collaboration are needed, to ensure a multitude of experiential opportunities, including:

- **Companies** (manufacturers, technology providers, start-ups)
- **Other educational institutions** (joint platforms, thematic networks etc.)
- **Peers** (peer-to-peer learning, e.g. Ecole 42, a teacher-less coding school in Paris)
- **Supporting structures** (industry associations, cluster organisations and similar) and governments
- **Community**
- **Human-robot interaction** etc.

Multiple forms of company engagement are possible and relevant, including:

- Internships/apprenticeships;
- Funding undergraduate scholarships and graduate research fellowships;
- Funding research;
- Student mentoring;
- Partnering in a campus research center or institute to help steer technology development;
- Participation in informational career events for students;
- Project banks, think tank competitions;
- Summer schools etc.

Industry partners increasingly become educational, research and employment partners, by being engaged in the full student's learning experience, including curriculum strategy development.

Finally, there is a need for creating effective **learning ecosystems**, engaging all key stakeholder groups. Such learning ecosystems need to cater the specific needs of individuals, groups, enterprises, value chains and clusters. Training developers need to form a prominent part of these ecosystems, building on close collaboration with all other key stakeholder groups, with a central role assigned to learners themselves. Such learning ecosystems could benefit from the offer of the centralised platforms, but would not be limited to those.

AI-augmented learning ecosystems and platforms need to facilitate access of learners to relevant personal learning solutions from any suitable possible sources. They would also need to include guidance, coaching, assistance, assessment, validation and certification of learning outcomes with developing personal learning and career paths in connection with attractive job opportunities during the whole professional career[4].

Learning environment

Learning environment can be organised in a myriad of ways, and it needs to stem from the strategy and the specific objectives/desired learning outcomes. Examples of **objectives** include stimulating multidisciplinary orientation, design thinking, creativity, team spirit, collective problem-solving, risk-taking behaviour, experimental approaches etc. It can require different **forms of reality** (i.e. physical, virtual, or mixed (augmented)). Multiple types of **methodologies** can be used and combined for achieving set objectives, such as Problem-driven learning, Project-based learning, Experience-based (experiential) learning, Collaborative learning, Technology-enabled learning etc.

The objectives and methodologies also define the most suitable ways of organising a learning environment, for example, in a form of a Learning/teaching factory, Design factory, Learning Lab, Living Lab, Innovation Hub, Makerspace etc.

2.2. *Discussion and feedback of participants*

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

The key points of the discussion included the following:

[4] PwC (2019) "Promoting Online Training Opportunities for the Workforce in Europe", Final Report

- Curriculum guidelines 4.0 need to ensure agility and thus should be regularly reconsidered and updated. Ideally, the guidelines would need to be made open for stakeholders in a form of an 'open source' approach, allowing for continuous comments, updates and additions.

- Curriculum guidelines 4.0 aim to offer key highlights, indicate a variety of possibilities and identify sources for more detailed information and inspiration. The guidelines by no means aim to serve as a standardised detailed recipe for organising education & training processes, as there is no one best way to approach it. The diversity of learner's needs and contexts per definition implies a need for multitude of approaches, which could also be combined in their own unique/customised education & training solutions.

- Curriculum guidelines 4.0 aim to specify, whenever possible, existing tools[5] that could be used for specific elements of the framework. It is, however, not the purpose of the current contract to develop any tools. Future initiatives could aim to develop an inventory of all available tools and materials and identify gaps where there would be a need for developing specific new tools. Such exploratory initiatives would be warmly welcomed by stakeholders, as the latter often report a high level of overlap of projects and initiatives happening at different levels (organisational, regional, country, EU), with many similar tools being developed in parallel with hardly any knowledge of other similar activities.

- The notion of competencies needs to be put central, while building on existing EU competency frameworks (e.g. ESCO database), tools and standards.

5 e.g. SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational Technologies) is a tool designed to help schools embed digital technologies into teaching, learning and student assessment, more information available at: https://ec.europa.eu/education/schools-go-digital/about-selfie_en

3. 21st Century Strategy, Collaboration Patterns and Learning Environment (Part 1)

The morning session continued with specific presentations featuring good practice examples with regard to the 21st Century Strategy, Collaboration Patters and Learning Environment. The session consisted of five presentations followed by a detailed discussion and feedback of participants.

3.1. *Collaborative platforms for Vocational Excellence: Co-creating skills ecosystems responsive to future skill needs*, Joao Santos, DG EMPL of the European Commission (Belgium)

Mr. Joao Santos presented the EU initiative on the "Centres of Vocational Excellence".

The combined effects of rapid technological change, digitalisation, climate change, circular economy, and new forms of work, call for innovative ideas to ensure that vocational training not only adapts to change, but is also at the forefront of mastering and driving this change. These developments are not only disrupting every aspect of work and life, but also creating opportunities for innovation and employment creation across all sectors. The capacity to innovate is increasingly becoming the key factor driving economic and social development.

VET policy makers are confronted with new challenges in anticipating and responding in due time to the fast changing skill needs of the labour market, and to the expectations of individuals. The "shelf-life" of skills is becoming increasingly short. To address this challenge, **VET institutions must become much more flexible and responsive to the need for renewing their offer**, companies have to become an active partner in designing and providing opportunities for work-based learning, and individuals have to embrace lifelong learning to maintain their employability, active citizenship and quality of life. The way we teach and learn has to be in tune with these new opportunities and challenges.

The "Centres of Vocational Excellence" is a new EU initiative aimed at addressing these challenges by adopting a systemic approach through which trans-national platforms of VET institutions actively contribute to co-create "**skills ecosystems**", together with a wide range of local/regional partners such as initial and continuing VET providers, tertiary education institutions including universities of applied sciences and polytechnics, research institutions, science parks, companies, chambers and their associations, social partners, sectoral skills councils, professional/sector associations, national and regional authorities and development agencies, public employment services, etc.

3.2. *Boosting Human Capital in the 21st Century by Cognitive Support and Load Remediation in Manufacturing Operations*, Dr. Annelies Raes and Pieter Vanneste, ITEC, imec research group at KU Leuven (Belgium)

Dr. Annelies Raes and Pieter Vanneste focussed on two relevant projects in which ITEC (imec research group at KU Leuven)[6] is involved.

The **Interreg project BHC21 "Boosting Human Capital in the 21st Century"**[7] aims to contribute to the development of more efficient and effective vocational training services for low-skilled people (LSP) in the 2 Seas region. To do so, the project is developing a generic 21st-century training model which:

6 https://www.kuleuven-kulak.be/nl/onderzoek/itec/projects/research-focus

a) makes use of innovative learning technologies (ILTs) and accompanying instructional design, tailored for easy adoption by Small and Medium-sized Enterprises (SMEs), and
b) integrates new recruitment and training approaches to increase the success rate of the training.

This model is developed bottom-up, through a process of co-creation in which employers, LSP, (public) vocational training organisations, knowledge institutes and public employment services are involved. The project brings together employee organisations and training centers, knowledge institutes and regional government to boost the learning motivation, skills and career competences of LSP and to stimulate a culture change among (manufacturing) SMEs regarding the investment in training of LSP.

The **imec-ICON project COSMO is about COgnitive Support in Manufacturing Operations**[8]. This project is based on the finding that immersive technologies such as virtual reality (VR) and augmented reality (AR) hold great potential for improving on-the-job training and support in manufacturing and industrial settings. However, research is needed to investigate the learning potential of these technologies, create personalised training solutions, lower costs for the development of content, and expand their applications. The COSMO project will therefore design, develop and evaluate effective, personalised and scalable AR and VR technologies for support and training in manufacturing operations.

A **study about the effect of augmented reality instructions as cognitive support during assembly tasks (Vanneste, Huang, Park, Raes, Depaepe, & Van den Noortgate (2019))**[9] suggests that AR technology has the potential to cognitively support operators during assembly tasks and can hence contribute to better quality. In addition, there is some evidence for AR to decrease stress levels, induce a higher degree of independence and a lower perceived complexity. However, AR does not always outperform paper instructions. Furthermore, the advantages of AR seem to disappear as more assembly attempts are undertaken, and the operator starts to master the task. No effect is observed in terms of productivity, physical effort or competence frustration. Cognitive skills and experience are found to play an important role towards several outcome variables. Next, it is important that benefits of a technology are interpreted in the light of the specific application.

Further research will focus on the improvement of the AR technology (corrective feedback via computer vision), will investigate study learning curves more deeply, and will examine personalised instructions.

3.3. *Didactic Formats for the Industrial Work of the Future – Concepts of the Future Work Lab*, Paul Schmidhäuser, Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany)

Mr. Paul Schmidhäuser presented the concepts of the Future Work Lab.

The progressing development of KETs and AMTs requires an educational program, which provides continuous educational offers. Different employees in different hierarchy levels have different knowledge requirements in the same technological field. To meet these requirements, **Learning Journeys** are an approach to use a modular educational model to fulfill these different needs. The Future Work Lab creates an environment where physical demonstrators can be used for the realisation of Learning Journeys.

3.4. *Scalable approaches to collaborate and learn manufacturing-related skills*, Bernd Rieth, Festo Didactic (Germany)

Mr. Bernd Rieth addressed the topic of scalable approaches to collaborate and learn manufacturing-related skills.

7 For more information and updates about the project see: https://www.interreg2seas.eu/en/boosting-human-capital-21st-century
8 For more information and updates about the project, see: https://www.imec-int.com/nl/what-we-offer/research-portfolio/cosmo
9 When referring to this work, please cite: Vanneste, P., Huang, Y., Park, J.Y., Raes, A., Depaepe, F., & Van den Noortgate, W. (2019). *The effect of augmented reality instructions as cognitive support during assembly tasks*. Paper presented at EARLI, the biennial Conference of the European Association for Research on Learning and Instruction, Aachen, Germany, 12-16 Aug 2019.

What do manufacturing professionals need to know and be able to do? What are the core competences of the future? How many of them in dedicated job roles are required? What profession do companies ask for? Do we need new vocational trades?

AMT and Industry 4.0 does change the landscape for vocational educated professionals. For sure, there will be a need for less of them in quantity, some of them highly educated. At the same time, further training in industry becomes more specific to products and processes applied. There is shift towards more "How to" rather than "Why is it", which leads to an educational gap between graduates and employees.

The presentation showed some scalable practical examples on **how vocational education and manufacturing professionals can join forces to foster employment and well-being of industries**. Close cooperation between industry and vocational schools leads to success, including opening schools for the qualification of employees. Further, networking among schools rather than singular school initiatives, applying interdisciplinary approaches including IT and Commercial trades, teamwork and game-based learning approaches in combination with close-to-reality learning factories and digital approaches with digital twins, AR and VR, all contribute to the challenge to educate and employ the 21st Century manufacturing professionals.

3.5. *METIS: MicroElectronics Training, Industry and Skills*, Emir Demircan, SEMI-Europe (Belgium)

Mr. Emir Demircan introduced the METIS project, covering the microelectronics ecosystem, multiple stakeholder groups and all educational levels (from high school to professional courses). It is a 4-year project with 4 million EUR of public funding. The key objectives of METIS include:

- Establishing an EU Microelectronics Observatory & monitoring key trends (technical, social, political) and their impact on businesses' skills needs;
- Providing education institutions with industry feedback on the needs of next generation microelectronics training;
- Innovative Learning: developing innovative curriculum & mechanisms of delivery (blended education: modular, work-based + online learning);
- Embedding sustainability & social responsibility policy principles at work;
- Supporting cross-border labour/student mobility in Europe.

The project will commence in November 2019.

3.6. *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:

- There is a need to empower people at the local level rather than trying to push initiatives via top-down approach.
- The speed of change is accelerating rapidly. Education sector cannot keep up with this change on its own.
- The number of people with vocational background in manufacturing is decreasing. State-of-the art factories often have just a few people in them; the majority of work is done by machines.
- In order to ensure impact and scale, funded projects need to be big.

- Agility is one of the key principles of education in the new age, given a rapid pace of change in the world.

- In order to stimulate companies to participate in Erasmus+ projects, there is a need to ensure the same eligibility as for research projects (e.g. Horizon 2020).

- Many companies do not even consider applying for Erasmus+, as they see EU funding as R&D funding, while Erasmus+ is essentially L&D funding. There is a need to create awareness among European companies about the opportunities offered by Erasmus+.

4.21st Century Strategy, Collaboration Patterns and Learning Environment (Part 2)

The afternoon session continued with specific presentations featuring good practice examples with regard to the 21st Century Strategy, Collaboration Patters and Learning Environment. The session consisted of seven presentations followed by a detailed discussion and feedback of participants.

4.1. *ADDLAB, Aalto Digital Design Laboratory for manufacturing*, Prof. Jouni Partanen, Aalto University (Finland)

Prof. Jouni Partanen presented ADDLAB - Aalto Digital Design Laboratory for manufacturing.

Aalto was established as a private, foundation-based university with the national mission of strengthening Finland's innovative capacity through first-class research, art and education. Aalto University is continuously assessing the quality of its research and artistic activities, and its societal impact. In the recent RAI2018 evaluation, external experts praised, for instance, the enthusiastic and collaborative work atmosphere, university's infrastructure, the tenure track career system and the student-driven entrepreneurial ecosystem.

ADDLAB is a research organisation initiated by the Aalto University's School of Engineering and the School of Arts, Design and Architecture in 2012. ADDLAB explores the potential of digital design and manufacturing technologies to create commercially viable, culturally relevant and societally valuable results. ADDLAB facilitates and takes part in **interdisciplinary dialogue**, aims to impact through thought, research and production, and actively collaborates with other departments within the university as well as with other industries, companies, researchers and experts. The **importance of industrial design** for entrepreneurial success was particularly emphasised during the presentation.

4.2. *SKILLNET: the new EU funded Skillman's strategy to develop a large network of CoVE with Earlall, Cumulus, IVETA and Eapril*, Giovanni Crisona, skillman.it/cscs.it (Italy)

Mr. Giovanni Crisona addressed the new EU funded Skillman's strategy to develop a large network of Centers of Vocational Excellence (CoVE).

Recently, the Skillman network has founded a horizontal strategic alliance with other networks of which it has become the leader for a policy-making initiative at the European level, planned for 2020-2021. At present, the Skillman.eu Alliance includes one of the world's largest international network of universities and design schools - Cumulus, based in Finland; the network of university professors - Eapril; the worldwide network of vocational training institutions and experts of TVET, based in the USA - IVETA; and the network of the EU regions - EARLALL based in Brussels.

The Skillman Alliance is constituted to gather the demands from the bottom, from companies and professionals in vocational training, and influence international and national policy choices that affect the development of skills for the manufacturing sector.

The combination of the members of the Alliance allow to encourage the creation of transnational and national VET providers' networks and partnerships to enable them to work together at the national and European levels and to improve the quality and efficiency of VET.

The Alliance aims to have an impact and relevance for learners and employers, and to build **cross-border cooperation** for VET quality and attractiveness. In the end, it **fosters communication, dissemination and support for implementation of the VET policy agenda at the EU and national levels**, to exchange knowledge, feedback and experience of policy implementation and sharing of best practices on VET excellence.

4.3. Interdisciplinary student-centred co-creation between vocational education and industry: practical principles to make it work, Gregor Cerinšek, Institute for Innovation and Development of University of Ljubljana (Slovenia)

Mr. Gregor Cerinšek addressed the topic of interdisciplinary student-centred co-creation between vocational education and industry.

In the contemporary world, which faces the challenges of the exponential growth of technology, two paradigms are shaping the way we see and perceive the development of our society. In the **utopian paradigm**, the technology and technological innovation are seen as something that will improve the society and solve all burning problems, from global warming to demographic challenges. On the contrary, the **dystopian model** suggests that technology will lead to the destruction of our civilization. Generally speaking, we can observe the presence of both paradigms also in the education system; relying on people as passive consumers of the technology on one hand side (more present in engineering education), and criticising all the development initiatives without offering suitable alternatives on the other (more present in social sciences and humanities).

The **PEOPLE model** (www.people-project.net) of interdisciplinary university-business co-creation challenges both paradigms and perceives **technology as something still unfinished, incomplete and always reshaped by the people (users)** who improvise and manipulate with it. Crucial innovation in technology development lies in the ability to understand **"what people will do with technology"** and not "what technology will do to people". This furthermore requires a shift in teaching and learning practices. The key intended learning outcome should not be the skills to design and develop technologies that will impose a desired behavioural change, neither the skills to create the need for these solutions. The taught skillset and competences should focus on involving people in the very beginning of the product, service, or system development process – opening-up the innovation opportunities through co-creation with the people and trying to understand how the existing behaviours could be the foundation for the societal and environmental change we aim to achieve.

The PEOPLE education model is based on the following **principles**:

(1) **Interdisciplinary and essentially collaborative**: bringing together different disciplines and expertise, where engineering works hand in hand with social sciences and humanities. Key guiding principle is "dare to see things from other perspectives than your own";

(2) **Multi-sectoral and multi-stakeholder**: involving industry professionals, university teachers and representatives of civil society and non-governmental organisations;

(3) **People as co-creators**: involved in all stages of product and service development process. Key guiding principle is "create with the people and not for them";

(4) **Rooted in ethnography**: as a methodology to collect, analyse and understand the data and to generate in-depth insights about peoples' behaviours, practices, and needs;

(5) **In dialogue with theory and bringing up ethical considerations**: understanding bigger contexts of emerging futures and world's challenges.

4.4. *Enabling remote experimentation for STEM students in the digital era*, Dr. Luis de la Torre Cubillo, U.N.E.D. (Spain)

Dr. Luis de la Torre Cubillo presented ways to enable remote experimentation for STEM students in the digital era.

The digital era has revolutionised the way we communicate, work, buy, etc. and continues doing so. In education, the digital era has also had a strong impact. Concepts such as online learning, distance teaching and open education have either appeared or become a more substantial reality than ever before. STEM education presents some particularities that make it a bigger challenge for Edtechs.

On the one hand, STEM students should face a good amount of lab work during their learning. On the other hand, traditional hands-on laboratories are expensive and have limited use hours, making difficult for students to actually spend much time with enough different laboratory systems. The remote use of such systems has already proven to provide a solution to this problem. However, enabling a controlled and secure access to lab equipment is neither easy nor fast.

This work presents the system used in UNED, a distance education university, called ENLARGE (rEmote coNtroLled Access to inteRnet of thinGs dEvices), **to easily allow the students to use the laboratory equipment remotely**.

4.5. *How to train 21st century skills in an online MBA program*, Prof. Nadine Roijakkers, Open University (Netherlands)

Prof. Nadine Roijakkers addressed the topic of how to train 21st century skills in an online MBA program.

When creating an (online) education program (such as yOUrMBA at the OUNL), it is crucial to determine (with a diverse set of stakeholders) the ideal profile of the professional you set out to train. Based on that profile, a program, courses, etc. can be designed.

An (online) education program needs to consist of different elements: core subjects that comprise the knowledge base of the professionals you train; 21st century themes that are variable (meaning that they are refreshed on a regular basis depending on trends in society and the working environment); training in the 21st century skills. These skills are trained as part of the tasks that professionals need to carry out in their practical environment. You create **an effective learning environment by combining content, educational expertise, and technology**. Learning technologies offer particularly effective opportunities for training content and skills in a controlled environment.

4.6. *Skills Strategy in Additive Manufacturing (SAM)*, Susana Nogueira, EWF (Portugal)

Ms. Susana Nogueira presented SAM (Skills Strategy in Additive Manufacturing) project[10].

Additive Manufacturing (AM) has been highlighted as one of the Key Enabling Technologies with major impact on economy in the past decade, creating competitiveness and long-term jobs, but also a varied array of new products and services that showed new possibilities for a wide range of industries.

[10] More information available at: skills4am.eu

The disruptive changes brought by AM, the shift into digitisation and a greener and circular economy leads society to the need for anticipating skills that respond to new and high-level professional activities, in line with industry's requirements and technological advancements.

Sector Skills Strategy for Additive Manufacturing (SAM), is a four-year blueprint project coordinated by the European Welding Federation (EWF) that addresses the lack of a strategic approach to predict and address skills needs in AM and the current fragmentation of the several AM landscape and initiatives at European, National and Regional levels. SAMs tackles the following challenges:

- Building a sector skills strategy for AM;
- Assessing and anticipating skills gaps and shortages in AM sector;
- Supporting the AM European Qualification System and fostering the wideness of its scope trough updated relevant data;
- (Re)designing professional profiles according to industry's requirements;
- Delivering training on time (within 6 months);
- Attracting young people to the sector and promoting gender balance;
- Strengthening partnerships among education, research and industry and encouraging creativity in companies and relevant educational and scientific institutions.

In a nutshell, to address the challenges for AM for the next decade, guaranteeing the sustainable and inclusive growth of the AM sector in Europe, SAM strategy encompasses the engagement of key organisations connected to Education and Industry. This European network will be responsible for the establishment of a centralised unit/Platform for AM skills assessment - the Observatory - and for the implementation of the European AM Qualification System and its national roll out.

4.7. Using social technologies as an enabler to foster 21th century skills, Geert Nijs, "VOV lerend netwerk" The Flemish association for corporate training and development professionals (Belgium)

Mr. Geert Nijs addressed the topic of social technologies as an enabler to foster 21th century skills.

We have to adopt new skills to keep up with an increasingly changing world. Not only to do our job, but even to be able to function in this modern society. Social technology is not new. Often it is still seen as "an additional feature", not fully integrated in the workplace of the future. Implementing this kind of tools is mostly done in a "button training" approach, with no attention to the (underlying) needed skills to get the maximum out of these tools.

Observations showed that by gradual and guided introduction of participants to this tools, the underlying future skills are also developed. This requires that participants are not using **social technology** as a replacement of e-mail, but **as part of their digital workplace to communicate, participate, learn and develop themselves**. The guided approach needs to challenge team or group members to participate in digital debates, (self) reflection challenges and finally even knowledge creation activities. In this approach social technology, the future workplace and future skills are forming a unity.

4.8. 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 role of designers in manufacturing becomes increasingly prominent, with a good chance that in the near future, there will be a need for more designers than technicians.
- There is a need for a shift from the notion of "working environment" towards the notion of "learning environment" (learning to work -> learning at work -> learning is work).
- Working place is the most obvious place to start with when it comes to massive upskilling/reskilling efforts; educational institutions will only be able to catch up later.
- There is a need to build on the intrinsic motivation of people to engage in learning.
- Students should be given a prominent role in co-creating curricula and designing learning experiences.
- Scalability and sustainability are two critical factors determining impact and success of upskilling/reskilling initiatives.

5. Wrapping up: Towards detailed proposals for curriculum guidelines

The closing session of the workshop aimed to address the final steps of the initiative.

5.1. Towards fine-tuned proposals for curriculum guidelines

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

5.2. Next steps

Dr. Kristina Dervojeda encouraged the participants to join the high-level conference that will be held in Brussels on 26 November 2019. The objective is to disseminate the final results, including the state-of-play analysis, best practices, curriculum guidelines and policy recommendations. It aims to inspire stakeholders at different levels to join forces and take further action.

Big picture education, problem-based and student-centric approaches, experiential learning, human-robot interactions, evolving forms of collaboration with industry, peers and community - these and other relevant issues will be discussed in the context of Curriculum Guidelines 4.0 or new ways of organising learning experiences of individuals and groups for the manufacturing industry. The conference will bring together the representatives of all key stakeholder groups, including academia, industry, policy makers, supporting structures and students.

FIGURE 5-1: Conference banner

The project team will keep the workshop participants informed about the key activities and outcomes of the initiative.

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	**Reshaping vocational education for Advanced Manufacturing: Towards future-proof workforce** • Vocational education in the 21st Century • Strategy, Collaboration and Learning Environment • Draft proposal for Curriculum Guidelines	*Kristina Dervojeda (PwC), Naveen Srivatsav (PwC)*
11:00 - 12:00	**21st Century Strategy, Collaboration Patterns and Learning Environment (Part 1)** • **Collaborative platforms for Vocational Excellence: Co-creating skills ecosystems responsive to future skill needs**, *Joao Santos*, DG EMPL of the European Commission (Belgium) • **Boosting Human Capital in the 21st Century by Cognitive Support and Load Remediation in Manufacturing Operations**, *Dr. Annelies Raes and Pieter Vanneste*, ITEC, imec research group at KU Leuven (Belgium) • **Didactic Formats for the Industrial Work of the Future – Concepts of the Future Work Lab**, *Paul Schmidhäuser*, Fraunhofer Institute for Manufacturing Engineering and Automation IPA (Germany) • **Scalable approaches to collaborate and learn manufacturing related skills**, *Bernd Rieth*, Festo Didactic (Germany) • **METIS**, *Emir Demircan*, SEMI-Europe (Belgium)	*Moderators: Kristina Dervojeda (PwC), Naveen Srivatsav (PwC)*
12:00 - 12:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Naveen Srivatsav (PwC)*
12:30 – 13:00	**LUNCH BREAK**	

13:00 - 15:00	**21st Century Strategy, Collaboration Patterns and Learning Environment (Part 2)** • **ADDLAB, Aalto Digital Design Laboratory for manufacturing**, *Prof. Jouni Partanen*, Aalto University (Finland) • **SKILLNET: the new EU funded Skillman's strategy to develop a large network of CoVE with Earlall, Cumulus, IVETA and Eapril**, *Giovanni Crisona*, skillman.it/cscs.it (Italy) • **Interdisciplinary student-centred co-creation between vocational education and industry: practical principles to make it work**, *Gregor Cerinšek*, Institute for Innovation and Development of University of Ljubljana (Slovenia) • **Enabling remote experimentation for STEM students in the digital area**, *Dr. Luis de la Torre Cubillo*, U.N.E.D. (Spain) • **How to train 21st century skills in an online MBA program**, *Nadine Roijakkers*, Open University (Netherlands) • **Skills Strategy in Additive Manufacturing (SAM)**, *Susana Nogueira*, EWF (Portugal) • **Using social technologies as an enabler to foster 21th century skills**, *Geert Nijs*, "VOV lerend netwerk" The Flemish association for corporate training and development professionals (Belgium)	*Moderators: Kristina Dervojeda (PwC), Naveen Srivatsav (PwC)*
15:00 – 15:30	**Discussion and feedback of participants**	*Moderators: Kristina Dervojeda (PwC), Naveen Srivatsav (PwC)*
15:30 - 16:00	**Wrapping up: Finalising 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.	*Joao Santos*	European Commission, DG EMPL	Belgium
2.	*Paul Schmidhäuser*	Fraunhofer Institute for Manufacturing Engineering and Automation IPA	Germany
3.	*Jouni Partanen*	Aalto University	Finland
4.	*Bernd Rieth*	Festo Didactic	Germany
5.	*Annelies Raes*	ITEC, imec research group at KU Leuven	Belgium
6.	*Pieter Vanneste*	ITEC, imec research group at KU Leuven	Belgium
7.	*Giovanni Crisona*	skillman.it/cscs.it	Italy
8.	*Gregor Cerinšek*	Institute for Innovation and Development of University of Ljubljana	Slovenia
9.	*Dr. Luis de la Torre Cubillo*	U.N.E.D.	Spain
10.	*Nadine Roijakkers*	Open University	Netherlands
11.	*Susana Nogueira*	EWF	Portugal
12.	*Geert Nijs*	"VOV lerend netwerk" The Flemish association for corporate training and development professionals	Belgium
13.	*Ahmad Bsiesy*	CIME Nanotech	France
14.	*Roger De Keersmaecker*	RDK Consulting & Coaching	Belgium
15.	*Gerard Mertens*	Open University	Netherlands
16.	*Anne-Françoise Cannella*	Service public de Wallonie	Belgium
17.	*Emir Demircan*	SEMI-Europe	Belgium
18.	*Marek Kysela*	SEMI-Europe	Belgium
19.	*Bert Adriaensen*	TEO - Teaching Each Other	Belgium
20.	*Werner Van den Broeck*	TEO - Teaching Each Other	Belgium
21.	*Ana Grigore*	European Commission, DG RTD	Belgium

Nr	Name	Organisation	Country
22.	*Anna Nikowska*	European Commission, DG EMPL	Belgium
23.	*André Richier*	European Commission, DG GROW	Belgium
24.	*Giovanna D'Addamio*	EASME	Belgium
25.	*Kristina Dervojeda*	PwC	Netherlands
26.	*Naveen Srivatsav*	PwC	Netherlands