THE EXCELLENT ADVANCED MANUFACTURING 4.0

Report on skills acquired by the students taking part in the piloting

Piloting the Advanced Manufacturing workshop 4.0

08

EXAM 4.0
THE EXCELLENT ADVANCED MANUFACTURING 4.0

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EXAM 4.0 partners:

TKNIKA – Basque VET Applied Research Centre, CIFP Miguel Altuna, DHBW Heilbronn – Duale Hochschule Baden-Württemberg, Curt Nicolin High School, Da Vinci College, AFM – Spanish Association of Machine Tool Industries, 10XL, and EARLALL – European Association of Regional & Local Authorities for Lifelong Learning.

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1 Introduction

1.1 Background information

EXAM 4.0, defines and describes the main features a lab for Advanced Manufacturing (hereafter AM) education should have (EXAM4.0, 2020). It also proposes the technological and competence frameworks for Advanced Manufacturing education in VET (EXAM4.0 Framework, 2020). Based on those descriptions, the so-called EXAM4.0 Collaborative Learning Factory (CLF) has been defined to pilot the mentioned frameworks and concepts. Deliverable 5.4 gives a full description of the pilot, where in this report the focus is on the skills acquired by the students, as part of the impact side of the approach. (see figure 1)

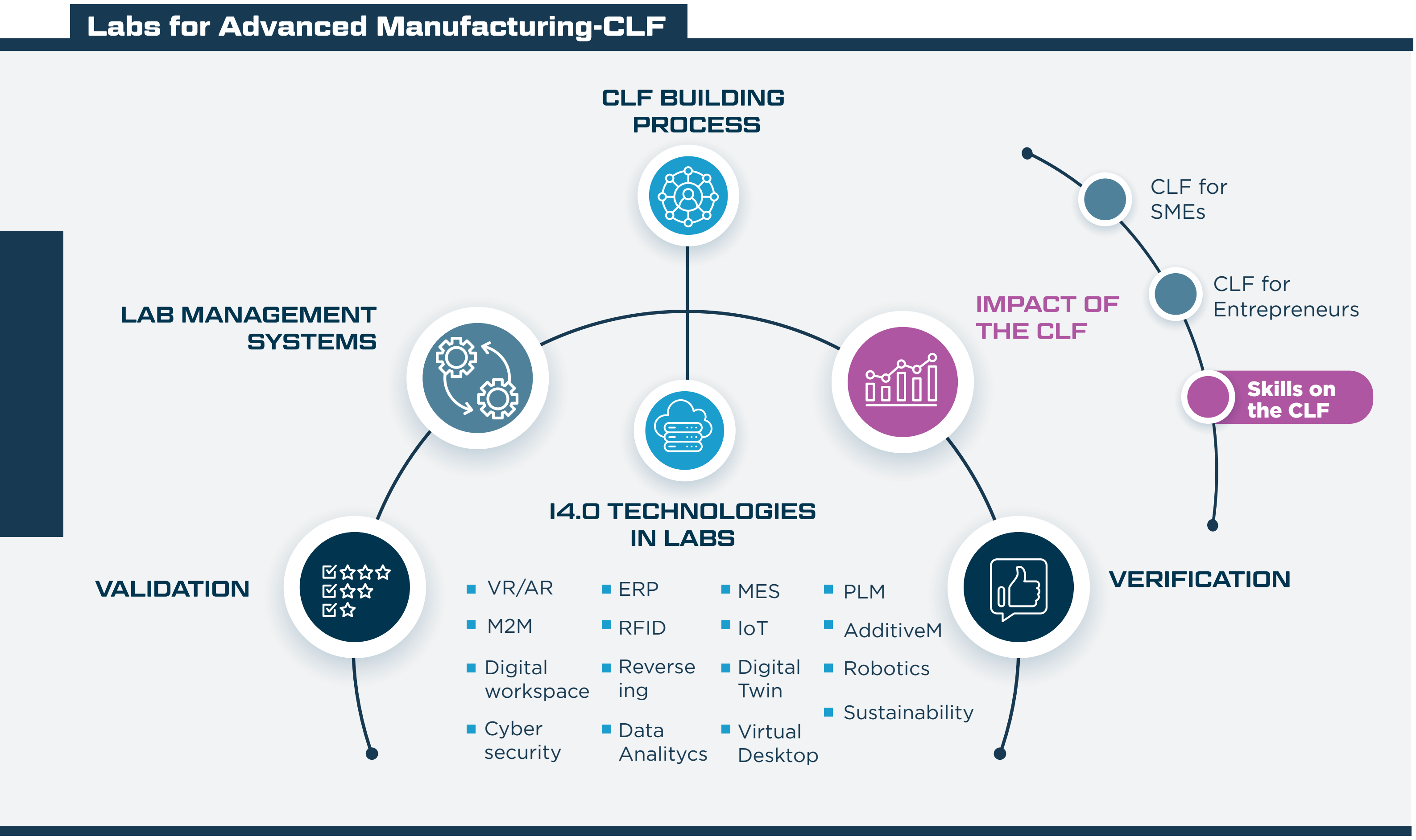

Figure 1: Piloting process of Advanced Manufacturing Labs. Source: EXAM4.0

In paragraph 1.2 the theoretical framework about the organisational model, conceptual model and relevant competences is described.

Chapter 2 gives an overview of what a Collaborative Learning Factory (CLF) is and in chapter 3 the learning methodology that is used in the CLF's is explained. The examples of CLF's involved in the Exam pilot, including the link to the relevant competences and skills acquired, are described in chapter 4. Finally chapter 5 contains a short description of the execution of the pilot and the skills impact.

1.2. Theoretical framework

The aim of this analysis is to identify contributions from the EXAM 4.0 project to promote, expand and improve the application of the CLF model in the framework of the development of Industry 4.0.

Organisational model

The identification of the competences [1] needed for Advanced Manufacturing (AM) workers [2] is based on a multilevel organisation, in line with the work of the European Commission (Figure 2).

Briefly [3] , we can state that the competence needs for workers in the "factory of the future" in AM are based on the following characteristics:

- understanding of the changes brought about by the new paradigm of Advanced Manufacturing in terms of strategic positioning of the company, flexibility to produce in a personalised way, interdisciplinary and inter-area work within the company, "smartisation" of processes and resources, etc.
- automation of manual, routine work, in particular all dangerous and/or hazardous work;
- access to real-time information about a given situation in order to perform a task efficiently;

• greater responsibility and decision-making power, with leaner organisational structures;

• more flexibility in terms of time and space for the working day and a better work-life balance;

• work in different types of teams: short/long-term, on-site/virtual, internal/with other organisations (including some international ones);

• control and monitoring of production processes through the analysis of data and information from devices;

• intra- and inter-organisational cooperation, with increased communication in a variety of media;

• active use of advanced digital technologies: collaborative robotics, internet of things, analytics, etc.;

• optimised human-machine interfaces that allow the worker to make informed decisions in less time;

• increased collaboration with research centres, universities, etc. given the interdisciplinary nature of digital production.

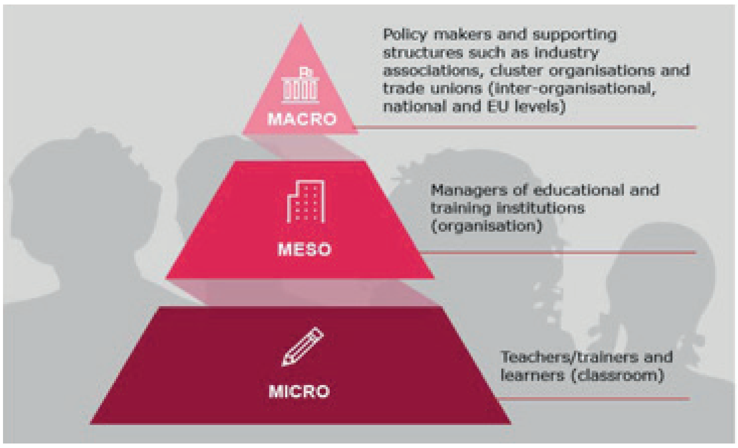

Figure 2. Levels of organisation in AM Source: European Commission (2020: 26)

[1.] *The next subsection describes in a meaningful way what and how competences are understood in the EXAM 4.0 model, and therefore in this document.*

[2.] *In general, the neutral term the "worker" or the "workers" will be used to group together all the people who are employed, or will be employed, in the field of work of AM.*

[3.] *More information on this topic can be found in section 3.1.2. Manufacturing professionals 4.0 of the European Commission (2020: 43-45).*

Therefore, the key skills or competences that will be most significant include: knowledge and data management skills; multidisciplinary understanding of the organisation, its processes and technologies used; use of digital devices and interfaces; IT security and data protection; methodologies for real-time decision-making. Key non-technical skills for the factory of the future include adaptability/flexibility, communication skills, teamwork skills, self-management and a focus on continuous improvement and lifelong learning.

For the purpose of this document, we can draw two observations from this first category, Organisational Model, which, while they are not new, are clearly enhanced.

The first observation is that, from a training point of view, a contextual re-reading of the macro-, meso- and micro-levels is necessary in order to guide and/or update AM-related curriculum developments, aligning them with emerging needs. At the macro level, it is up to the national and regional administrations, business organisations, inter-institutional bodies, etc. to set the guidelines, allocate the necessary resources, monitor and evaluate the changes, etc. This is in addition to providing the spaces, with the corresponding resources and suitably trained teachers, to train the people that Industry 4.0 (hereinafter, “I4.0”) requires/will require.

At the meso level, it is the educational organisations, school associations, teachers' groups, etc. that will have to promote and stimulate actions both in terms of facilities and spaces and the clear understanding and participation of teachers and pupils in the new ways and means of developing the competences required in new AM settings. In this regard, the educational and training organisations themselves will have to change and promote a comprehensive perspective of the centre, in which the different areas, departments, etc. actively participate, in a similar way to the transformation that is taking place in AM companies.

Accordingly, and in line with the two previous levels, it is up to teachers, students, workers in training, school networks, trade unions, teacher networks, etc. to develop and adopt in practice the new ways of doing, sharing and collaborating according to the needs of I4.0. As you can see, there are organisations, such as research centres, technology centres, universities, alumni groups, etc., that can participate, depending on the needs and dynamics at one or more of the levels mentioned above, in order to facilitate, reinforce and evaluate the actions developed.

Conceptual model and reference competences

The discussion on what is understood by competence is long and possibly endless, as it depends on multiple factors (context in which it is found - labour, educational, socio-educational setting, theories on learning, etc.). Therefore, we will start from the definition of competence that the project takes from Bartram, for whom competences are defined as sets of behaviours that are instrumental in the delivery of desired results (European Commission, 2020: 24).

The assumed model is based on both the work of the European Commission (2020) and the proposal by Prifti, Knigge, Kienegger and Krcmar (2017) - also called the Prifti Model. In identifying the competences required for I4.0, three occupational areas are involved: information systems, computer science and engineering, with the assumption that future working conditions will entail an increase in interdisciplinary approaches as well as non-technical competences or soft skills. **Based on this, the EXAM 4.0 Competence Model for employees in AM involves six categories of competences related to:**

- Technical issues
- Quality, risk and safety
- Management and Entrepreneurship
- Communication
- Innovation
- Emotional intelligence

Figure 3 summarises the main components of these categories [4].

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

Figure 3 Categories of AM competences Source: EXAM 4.0 (2020a: 31)

[4] *Further details on the competences included in each of the above categories can be found in the chapter EXAM 4.0 Competence Model (EXAM 4.0, 2020a: 33-34), or more extensively in section 3.1.1. Skill requirements for high-tech professionals (European Commission (2020: 39-43).*

Most of the competences included in the above categories are relevant to the three occupational areas in which Industry 4.0 is specifically developed, although some of them may be more specific to one or two of these areas (this is particularly the case for those in the category of technical competences).

In turn, the EXAM 4.0 competence model differentiates between general and specific competences (Figure 4). General competences refer to those competences that are required by all employees working in an Advanced Manufacturing environment regardless of their job profiles, fields or qualifications.

Specific competences are placed in the category of technical competences, referring to certain job profiles or fields (lab skills, scalability or life cycle analysis, computer-aided design, etc.), or in the category of management and entrepreneurship competences (management of personal or financial resources, deal negotiation and IP management, etc.). While it is not possible for this document to identify and narrow down the set of technical competences required in AM, it is clear that they will be different according to the different levels at which workers are placed according to the European Qualifications Framework (therefore, specific competences at EQF3 level will be different from those at the EQF4, or EQF5 level). It is also clear that clearly specific management and entrepreneurial skills (people management, resource management, design and promotion of innovation projects, etc.) are normally related to jobs at EQF [5] level 6 (or higher), although they can also be started at previous levels.

[5.] *Further details on the competences included in each of the above categories can be found in the chapter EXAM 4.0 Competence Model (EXAM 4.0, 2020a: 33-34), or more extensively in section 3.1.1. Skill requirements for high-tech professionals (European Commission (2020: 39-43).*

	TECHNICAL	QUALITY, RISK & SAFETY	MANAGEMENT	COMMUNICATION	INNOVATION	EMOTIONAL INTELLIGENCE
GENERAL COMPETENCIES	Knowledge in STEM ICT skills Programming Coding Computer skills Design methodology Systems analysis Data management skills Ability to interact with human-machine interfaces Interdisciplinary understanding (processes/ technologies / organisations) Manufacturing skills Modelling & simulation	Quality management Health & security Industrial hygiene Equipment safety Emergency response & management Data security ethics	Strategic analysis Analytical thinking Technology strategy Marketing Customer orientation Project Management Time Management Teamwork & ability to work in interdisciplinary environments Change management Risk management Leadership	Interpersonal skills Verbal communication Written communication Presentation skills Public communication Virtual collaboration Ability to deal with conflicts	Integration skills Continuous experimentation Complex problem solving Creativity Abstraction ability Critical thinking Transfer skills Collaborative thinking	Flexibility & Adaptability Responsibility Stress tolerance Ability to thrive on failures Work-life balance Self-control & discipline Decision making Mindset towards lifelong learning & continuous improvement Self management & organisation Cooperation & collaboration skills Intercultural competencies Structured & systematic working approach
SPECIFIC COMPETENCIES	Life cycle analysis Scalability analysis Specific lab skills Computer aided manufacturing/ engineering		Management of Personal resources Management of financial resources IP management Deal negotiation skills			

Figure 4 General and specific competences in AM Source: EXAM 4.0 (2020a: 35

Given the scope of the occupational areas concerned—information systems, computer science and engineering—we can anticipate that Industry 4.0 will have a direct impact on the different Cycles (particularly those of the Intermediate and Higher Levels) and Specialisations of the Families of: Electricity and Electronics, Mechanical Manufacturing, Computer and Communications and Installation and Maintenance. The technologies involved will also have an application and an impact, to a greater or lesser extent, on the whole of VET.

2 Definition/Key features of Collaborative Learning Factories

In line with the work of Abele et al. (2015) and the European Commission (2020), the most basic approach to the concept of learning factory (hereafter "LF") is to understand it as a learning setting that comes very close to a professional environment. Moreover, the adjective "collaborative" seeks to reinforce the idea of collaborative work, as this is one of the main requirements for workers in today's complex world, as pointed out by the European Commission (2020: 42):

> *"a highly complex multidisciplinary nature of the high-tech domains requires intensive teamwork and active collaboration of multiple people/teams/organisations simultaneously [...] The required competencies can be to a different extent present in different individuals, that, in turn, need to work together and complement each other. The high-tech domains thus heavily rely on "smart" combinations of people with a wide range of profiles".*

In relation to the two terms that constitute the expression, there is a general consensus on the following ideas:

- Learning factories are about implementing practical solutions to challenges, leaving aside or reducing theoretical abstractions.

- The term "learning" proposes the building of an experiential educational setting, where the accepted truth to be applied is "learning by doing" in order to develop students' professional skills.

- The term "factories" suggests gearing work settings to production environments, to be as realistic as possible and take into account the use of technology currently in use in the industry.

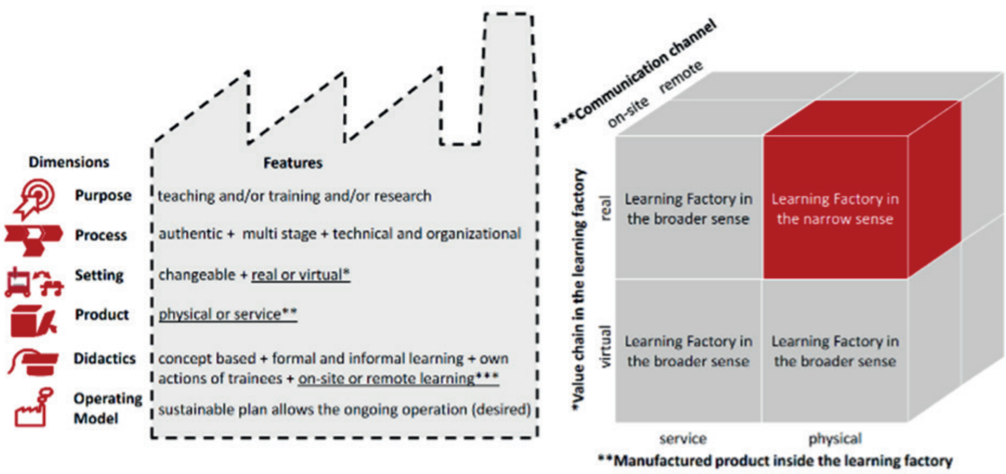

Figure 5. Key features and variants of Learning Factories Source: Abele et al. (2015: 2)

From the initial definition, there emerge a great number of varying interpretations in practice. An initial approach to the diversity of LF that can be found comes from taking into consideration different aspects with their corresponding characteristics. Figure 5 describes these aspects (left-hand side), while showing an approach to LF in a broader or narrow sense (right-hand side), based on three variables: value chain, manufactured product and communication channel. These in turn are based on three of the characteristics described above: scenario (real or virtual), product (physical or service), didactics (on-site or remote).

The strict interpretation of the concept of learning factories places us in a practical setting relating to the production of a physical product, which generates a value chain and where interactions between people take place in an on-site environment.

The 4.0 concept associated with production systems provides other development settings that broaden the interpretation of the concept to include the generation of services that can produce virtual value chains and where interactions can be conducted remotely.

All these elements have been developed in work groups, and as a result a morphology is proposed, which is dynamic, and that tries to accommodate the diverse range of learning factories that are being developed. This morphology is configured on the basis of seven structural dimensions:

- Operating model
- Purpose and targets
- Process
- Setting
- Product
- Didactics
- Metrics

From these, multiple variants can be developed, as shown in Figure 6

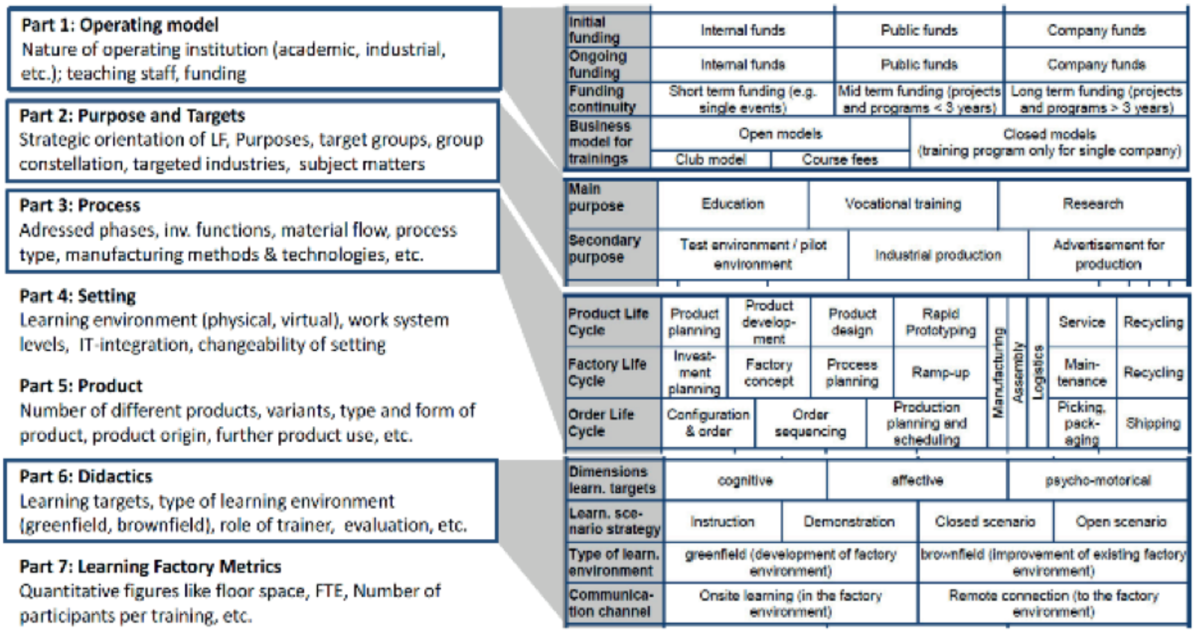

Figure 6 Variants of learning factories based on their seven dimensions
Source: Abele et al. (2015: 3)

However, as you can see in the figure the options are varied, and Abele et al. (2015) identify six types as being the most widespread:

- Learning Factory I: industrial application scenario.
- Learning Factory II: academic application scenario.
- Learning Factory III: remote learning scenario.
- Learning Factory IV: changeability research scenario.
- Learning Factory V: consultancy application scenario.
- Learning Factory VI: demonstration scenario.

3 Learning Methodology

The final goal of the EXAM 4.0 CLF is to train people in advanced manufacturing. So far, we have described and referenced the most technological and operational part of the CLF. All this deployment pursues a didactic objective.

We have worked on the analysis of the equipment and technologies needed in the CLF in parallel with the target competences. We have the aforementioned technological and competency frameworks included in WP2, where the way to define and measure the collection of skills and attributes necessary to carry out specific tasks, in many cases emerging tasks due to digital transformation, are included.

With the CLF we aim to create the scenario where learners acquire these pre-determined competences. Therefore, the competences that we want to work on in the CLF strongly specifies the implementation of the CLF

When we talk about CLF didactification, we are referring to the adaptation of technological contents and ways of learning to ensure that certain students achieve predefined skills.

The complexity of the CLF model lies, among other factors, in the fact that we are working together on the competences of students with different educational systems. It should be remembered that the CLF is made up of training centres in 4 countries. **Therefore, we must work the didactic nature of CLFs on at least two levels:**

- The regional level, where each training centre adapts the new characteristics of CLFs to the programmes, curricula and competences included in their education systems.

- The consortium level, where it is necessary to reach a consensus on the competences to be worked on collaboratively in the CLF so that all the agents involved can then integrate them into their respective national systems.

The didactification of the CLF includes for both levels, creating didactic solutions where we work on the predefined competences for advanced manufacturing.

These didactic solutions will include aspects such as:

- Creation of specific contents
- Modularization of contents in order to achieve flexibility
- Delivery mechanisms/Learning method according to contents, target audience: e.g. active methodologies, gamification, micro-learnings, mobile learnings, digital twins for training, pbl, cbl...

- Work methodologies for join tasks among international students
- Learning pathways aimed at specific occupations
- Updating of curricula and training programmes
- Creation of new courses
- Assessment systems
- Accreditation and micro-credentialing systems

In the EXAM4.0 piloting phase, we have focused on evaluating the impact of the CLFs at regional level. That is to say, to evaluate the impact of implementing a CLF on the didactic aspects of the training programmes involved.

Framework for curriculum development

Although the EXAM 4.0 project approaches various training aspects to be considered for the development of the required competences , the European Commission's proposal (2020) to define the guidelines for curriculum development for training in the context of Industry 4.0 allows us to take a broader view, in which, in turn, we can integrate the proposals of the EXAM 4.0 project.

Figure 7 summarises the different elements that enable the design of relevant curricula for people's learning throughout their professional lives. The eight elements presented should be understood as interconnected and interrelated for training in the I4.0 ecosystem. **These elements are:**

(1) Strategy;

(2) Collaboration;

(3) Content;

(4) Learning Environment;

(5) Delivery mechanisms;

(6) Assessment;

(7) Recognition

(8) Quality.

Figure 7 Framework for Curriculum Development Source: European Commission (2020: 16)

The analysis carried out by the expert groups focuses mainly on the first four elements, while making a general reference to the other four. Briefly, we can describe them as follows:

Strategy

The strategy makes it possible to face the future in a targeted and proactive manner. The main points to be considered in this section are the following:

- Prepare students for lifelong learning;
- Offer a "big picture education" geared towards the labour market;
- Taking into account not only market/business needs, but also social needs and student/personal needs;
- Move from knowledge to the competences that students should acquire for their personal development and for employment and inclusion in a knowledge society;
- Develop a degree of orientation towards Growth, Innovation, Ethics and Security;
- Offer relevant personalised and personalised learning;
- See students as agents of change and actively involve them in the development and implementation of the curriculum.needs;

- Incorporate non-technical disciplines into the curriculum in order to develop transversal competences and a mindset that goes beyond technical expertise;
- Pay special attention to issues of ethics, social inclusion, diversity and sustainability (e.g. by incorporating sustainable development);
- Offer a holistic view of product and system life cycles;
- Teach students and workers how to acquire knowledge from the growing “sea” of data;
- Teach students and workers to be aware of their health, safety and ergonomics at work.

Collaboration

Moving towards a lifelong learning paradigm involves broadening forms of collaboration to ensure new opportunities for practice and experimentation. The main points to be considered in this section are the following:

- Further increase university-industry collaboration;
- Recognise the role (educational, research, employer) of companies, and ensure their involvement in students' learning experiences;
- Create more opportunities to exchange experiences with other educational institutions;
- Facilitate peer-to-peer learning;
- Create effective learning ecosystems involving all stakeholders;
- Move from human-machine interaction to human-machine collaboration as an evolving form of collaboration.

Content

This element includes the specific content necessary for the development of I4.0, which, as of today, is thought to be structured around the processes and technologies shown in Figure 8. The main points to be considered in this section are the following:

- Improve the technical components of the curriculum to adapt to new knowledge and needs;
- Incorporate non-technical disciplines into the curriculum in order to develop transversal competences and a mindset that goes beyond technical expertise;

• Pay special attention to issues of ethics, social inclusion, diversity and sustainability (e.g. by incorporating sustainable development);

• Offer a holistic view of product and system life cycles;

• Teach students and workers how to acquire knowledge from the growing "sea" of data;

• Teach students and workers to be aware of their health, safety and ergonomics at work.

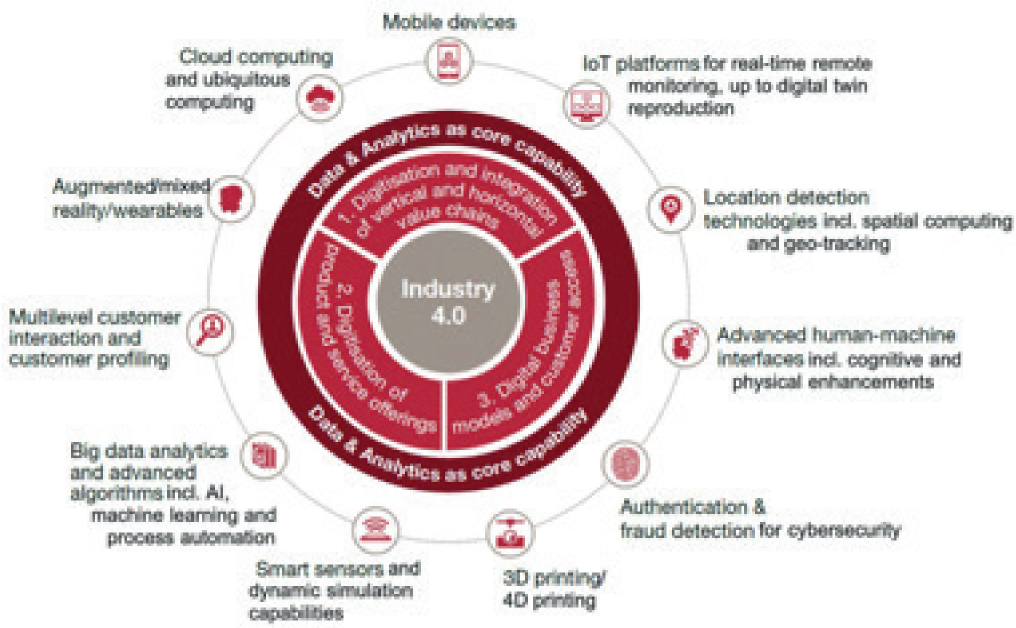

Figure 8 Technologies and processes for Industry 4.0 Source: European Commission (2020: 13)

Learning environments

The learning environment—physical, virtual or hybrid—can be organised in many different ways and should be aligned with the learning strategy and the learning outcomes to be achieved. The main points to be considered in this section are the following:

• Improve the technical components of the curriculum to adapt to new knowledge and needs;

• Apply problem-based learning, allowing students to work on real-life problems;

• Produce a learning environment that stimulates creativity, the development of one's own opinions and differing interpretations;

- Create a culture that accepts possible failures and develops the capacity to turn these failures into valuable learning experiences;
- Create learning environments that can offer experiences that are relevant to real world working conditions;
- Encourage collaborative learning by providing appropriate physical spaces and virtual platforms for various forms of collaboration, including collaboration with peers, industry partners, the community, etc.
- Stimulate technology-enabled learning by encouraging the use of software and technology applications for learning.

Remaining elements of the Framework

The remaining elements of the framework include Delivery Mechanisms, Assessment, Recognition and Quality. Delivery mechanisms refer to the means through which learners experience and access education/training, and include face-to-face, virtual and hybrid activities. The analysis also involves EXAMining relevant forms of assessment and recognition. Finally, the analysis of the determining factors of the quality of education and training is also addressed[7.] .

[7.] *More information on these aspects can be found in section 5.7. Remaining elements of the framework of the European Commission (2020: 138-144).*

Pros and Cons of the CLF as an educational method

From the experience generated in the EXAM 4.0 project, we can identify the pros and cons of this proposal:

Pros of learning factories as an educational method:

- It is a definitive method for teaching I4.0 technologies.
- Learning factories use realistic situations.
- Learning factories include learning by doing.
- If a virtual learning factory is created, it is possible to map larger factory structures.
- Most learning factories do produce products because they simulate a real value chain, which could result in revenue from selling these products.
- It is possible to merge classes because a Learning Factory will replicate a real production environment. In this way, classes can work with different tasks, but towards the same production goal.
- The same quality requirements as in real production.

Cons of Learning Factories as an educational method

- A learning factory simulates real industry production; industry is developing at a high pace and learning factories will therefore quickly become obsolete. It is hard work to maintain a learning factory.
- It is difficult and time-consuming to map entire factories or networks to create a learning factory.
- There is a lack of mobility in learning factories as production depends on certain machines.

4 Examples of CLF's of Industry 4.0

In this chapter the following labs as part of Collaborative Learning Factories involved in the Exam4.0 pilot are described.

Machining Lab–
Curt Nicolin Gymnasiet

Machining Lab -
Miguel Altuna

Smart Lab –
Da Vinci College

Machining Lab – Curt Nicolin Gymnasiet

The Machining Lab is a large facility, divided into different sub-sections. The Lab include technologies such as additive manufacturing, robotics, CNC-machines, M2M and AR-technologies used to improve the education. The Lab does also have sub-section with more traditional manufacturing methods, such as welding. The different technologies are used within different educational programmes, but sometimes they are integrated in collaboration projects that includes all technologies. Students develops expertise skills within the technologies that are related to their programme, but also basic knowledge of the other technologies.

EQF 4: Service and Maintenance Technology“, “Product and Machinery”, “Welding technique”, “Electricity and Energy Programme” and “Technical Production”.

EQF 5: “TE4 Technical Production” and “TE4 Design and Product Development”.

Prerequisites: none if student of the education

Language: Swedish

Members: Students of the school and adults in trainings

According to the European qualification framework (EQF) learning outcomes of level 4 skills refers to a variety of cognitive and practical skills required to solve specific problems in the relevant work or study area.

Learning outcomes of level 5 skills refers to comprehensive cognitive and practical skills required to develop creative solutions for abstract problems.

Functional/(technical skills:	Methodological skills:
Linked thinking IT knowledge Project management Quality management Industrial hygiene	Analytical thinking Strategical thinking Collaborative thinking Presentation skills
Social skills:	**Personality skills:**
Communication skills Ability to be critical Ability to deal with conflicts Leadership	Innovation Creativity Flexibility Self-organization Determination

Methodology of LAB:

In the beginning of each study programme the teachers will educate through guided exercises with. Later on, when the students have obtained a basic knowledge, the Lab works as a learning environment for different projects. E.g. production projects with prototypes, programming of robots and much more. Automation of 3D-printing through a collaborative robot and M2M.

A teacher supervises a group of maximum 15 students. Some study-programs have up to 30 students, that work at the same time in the lab, but then 3 teachers are assigned to that class.

Duration:

It depends on the programme and during what time of the course. Most programmes have education in the lab weekly, and on these weeks the students spend most of their days in the lab.

Validity:

validity is guaranteed through cooperation and interaction with the business community and our partner companies. On the one hand we carry out assignments with and for the business community that have to do with Advanced Manufacturing, and we have good connections with the companies through internships. Our students do internships at the partner companies, as well as abroad for 1-2 weeks.

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Miguel Altuna’s Machining Lab

Miguel Altuna’s Machining Lab is a 2000m2 in which 165 students can work at the same time and it was opened in 2019. The general objective is to plan, schedule and control the manufacturing by machining and assembly of capital goods, based on the documentation of the process and the specifications of the products to be manufactured, ensuring the quality of management and products, as well as the supervision of the systems of prevention of labor risks and environmental protection. All of this incorporating digitization skills and industry 4.0 methodologies that more clearly align with the demands of the industry.

To achieve this goal the space is divided into 8 different cells which are made up of 86 different machines. The cells that we can find are: CNC, Lathes, Millings, END, Grinding, Metal forming, Mechanical Assembly and Electrical Assembly.

Training courses, duration and level:

- **Mechanical Manufacturing:** year 1,2 **EQF 5**
- **Industrial Mechatronics:** year 1,2 **EQF 5**
- **Design in Mechanical Manufacturing:** year 1, 2 **EQF 5**
- **Machining:** year 1, 2 **EQF 4**
- **Smant Manufacturing Especialization** course **EQF 5+**
- **Design and Production of Cold Forging Processes:** year 1 **EQF 5+**
- **Upskilling programs for employees.** A catalogue of 25 different courses is available. Courses can be taylor made for specific companies. Usually without prerequistes
- **Training courses for unemployment:** 10 courses per year for low skilled people. No prerequisites

Prerequisites: Depends on programs. Prerequisites vary from EQF4/5/5+

Language: Basque and Espanish. Some topics in English

Members: students of the college and Associate SME's

According to the European qualification framework (EQF) learning outcomes of level 4 and 5, skills refer to medium and high skills, demonstrating medium to high knowledgde of the concept of innovation, required to solve medium to high problems in a specialised field of work or study.

Functional/(technical skills: knowledge of materials knowledge of mechanical processes knowledge of machines Knowledge of digitalization	**Methodological skills:** Individual works Work together in project teams Solve challenges in a project Follow the right steps in a project
Social skills: attitude and behavior collaborate with others	**Personality skills:** curious creative implication autonomy communication

Methodology of the LAB:

The working method in the lab is guided exercises in the beginning (year 1) mainly made of teaching material/projects and exercises. In the middle of the year 1 and year 2, the lab is mainly used as a space for resolving challenges during projects.

In the project-based methodology, different parts of different assemblies are manufactured and assembled. These jobs are usually done in groups.

A teacher supervises a group of maximum 24 students. Normally with more than 12 students the main teacher has the help of another teacher for a few hours.

Duration:

EQF4: 1 year 33 weeks, 12 hours a week and 2 year 22 weeks, 12 hours a week

EQF5: 1year 33 weeks, 6 hours a week and 2 year 22 weeks, 6 hours a week

Lab is also used for innovation projects (applied research, services to industry, join projects with other VET centers, etc.) during the schoolyear

Upcoming dates: From september to june for the main course. Projects on demand

Validity (to whom the lab is valid):

validity is guaranteed through cooperation and interaction with the business community. On the one hand we carry out assignments with and for the business community and on the other hand there is the connection we have in the field of internships. Both our students do internships in the companies, but so do our teachers.

Consecutive Lab Courses:

Guided lessons and practice to manufacturing for the industry

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Smart Lab Da Vinci College

In the Smart Lab there is room for students to work on new developments and prototyping. This is done with the help of microcontrollers such as Arduino, ESP 32, but also with sensors, actuators. Through the assignments they do they learn the basics of programming. They also learn about hardware and how electronics work. All of these elements are important to the 21st century technician. 3D printing and laser cutting is available just around the corner, so that promising prototyping can actually be started.

Raspberry Pi's and home automation also play an important role. The Smart Lab is the spider in the web of a number of other labs in our DZHF. All disciplines come together here.

Smart Technology: year 1, 2, 3

Mechatronics: year 1,2

Computer Science: year 1

Prerequisites: none, if student of the education

Language: Dutch and English

Members: students of the college

According to the European qualification framework (EQF) learning outcomes of level 3 and 4, skills refer to basic and medium skills, demonstrating basic to medium knowledgde of the concept of innovation, required to solve basic to medium problems in a specialised field of work or study

Functional/(technical skills:

- knowledge of materials
- knowledge of eletronics
- knowledge of sensors and actuator

Methodological skills:

- Work together in projectteams
- Follow the right steps in a project

Social skills:

- attitude and behavior
- collaborate with others

Personality skills:

- curious
- creative
- openminded

Methodology of LAB:

working method in the lab: guided exercises in the beginning (year 1). In that case, use is mainly made of teaching material/projects and exercises with Arduinos. In higher grades, the lab is mainly used as a project space for prototyping during projects.

A teacher supervises a group of maximum 24 students.

Duration:

20 weeks, 3 hours a week

Lab is also used for projects during the schoolyear

Upcoming dates: september and february for the main course. Projects on demand

Validity:

Validity is guaranteed through cooperation and interaction with the business community. On the one hand we carry out assignments with and for the business community that have to do with Smart Technology and on the other hand there is the connection we have in the field of internships. Both our students do internships in the companies, but so do our teachers.

Consecutive Lab Courses:

Guided lessons and practice to designing and prototyping for the industry

Level 5 and 6 eduaction in Smart Technology.

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5 Pilot execution

5.1 Pilot aim and approach

The aim of the pilot was to build a robot car together. By doing this we were able to gain experience in designing, building and assembling a complete product, with the different parts being developed or produced by different partners.

The expectation prior to the pilot was that this simple product can be made easily. But it was important to properly coordinate the (computer) systems, equipment and materials to be used.

The EXAM 4.0 partners combined the labs from each center to create a collaborative learning factory. This learning factory is to be used for three main purposes.

1. Providing an industry 4.0 learning environment usable by future partners of the platform.
2. Piloting the implementation of advanced manufacturing key enabling technologies.
3. To show the concept of the CLF by producing the EXAM robot.

Each center implemented a certain number of technologies in their lab, ensuring that all relevant technologies were covered. All centers also contributed to the production of the EXAM robot that was created within the CLF. The partners had a collaborative approach, combining the labs from the different centers into one Collaborative Learning Factory. With assistance from the implemented technologies each partner contributed to the CLF and production of the robot with their core business, but also supported the other activities in the production chain. The CLF approach ensures quality exchange of data and information between the partners, making it a high end education environment.

Product Design

The development and production of a product was discussed during the first meeting regarding the process. The idea was to create a robot/car, the process would include all elements of a production such as product design, process engineering, products assembling, PLM and IT. To have the possibility to fulfill the process it is necessary to implement key enabling technologies in the LABs that will be used for the CLF and also to ensure exceptional communication.

A detailed description of the pilot execution is to be found in report 5.4.

5.2 Impact on skills

The Collaborative Learning Factories are clear examples of an approach to the complex reality that Industry 4.0 brings with it, both in their organisation (at the level of the Centre, teaching staff, specialities, groups of students, etc.) and in the methodological aspects that are developed within them. These are geared towards a real approach, duly placed in context, to problems and issues that arise in the day-to-day reality of the world of work.

Therefore, the Learning Factories approach allows, through the analysis and reflection of/on educational-training practices, the implementation of projects, challenges, problematic situations, etc. that must be solved collaboratively among the students of a group or class, or belonging to several specialities, or even to different educational centres.

The aim of the Exam4.0 Pilot of the Collaborative Learning Factories was to show how these environments can be a meaningful place for students to develop the skills necessary for Industry 4.0. Although the project team had a good plan of approach and state-of-the-art facilities available, due to Covid we were not able to make use of them the way it was planned.

The project team was able to complete the whole process from design, produce and assemble the Robot, but with very little student involvement. Therefore it was not possible to prove the skills' impact on a larger scale. The students involved were positive about the project and their tasks and we believe that they learned some relevant skills. Furthermore there was no cooperation between students from different countries.

THE EXCELLENT ADVANCED MANUFACTURING 4.0