EXAM 4.0

THE EXCELLENT ADVANCED MANUFACTURING 4.0

Protocol of exploitation of CLF by SMEs

Piloting the Advanced Manufacturing workshop 4.0

06

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EXAM 4.0 partners:

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Introduction

The EXAM 4.0 platform aims at becoming the European reference platform for knowledge generation and exchange, innovation, collaboration and service provision for VET/HVET centres and companies working in Advanced Manufacturing. The Exam 4.0 platform is an unparalleled partner for manufacturing companies, institutions and teachers, students and alumni to excel in the digital age.

Following the piloting process of Advanced Manufacturing Labs for H/VET through the Collaborative Learning Factory (hereafter CLF), the EXAM4.0 partners have generated a number of reports documenting the work we have carried out. The structure of the piloting process is as follows, where each “ball” refers to a specific report:

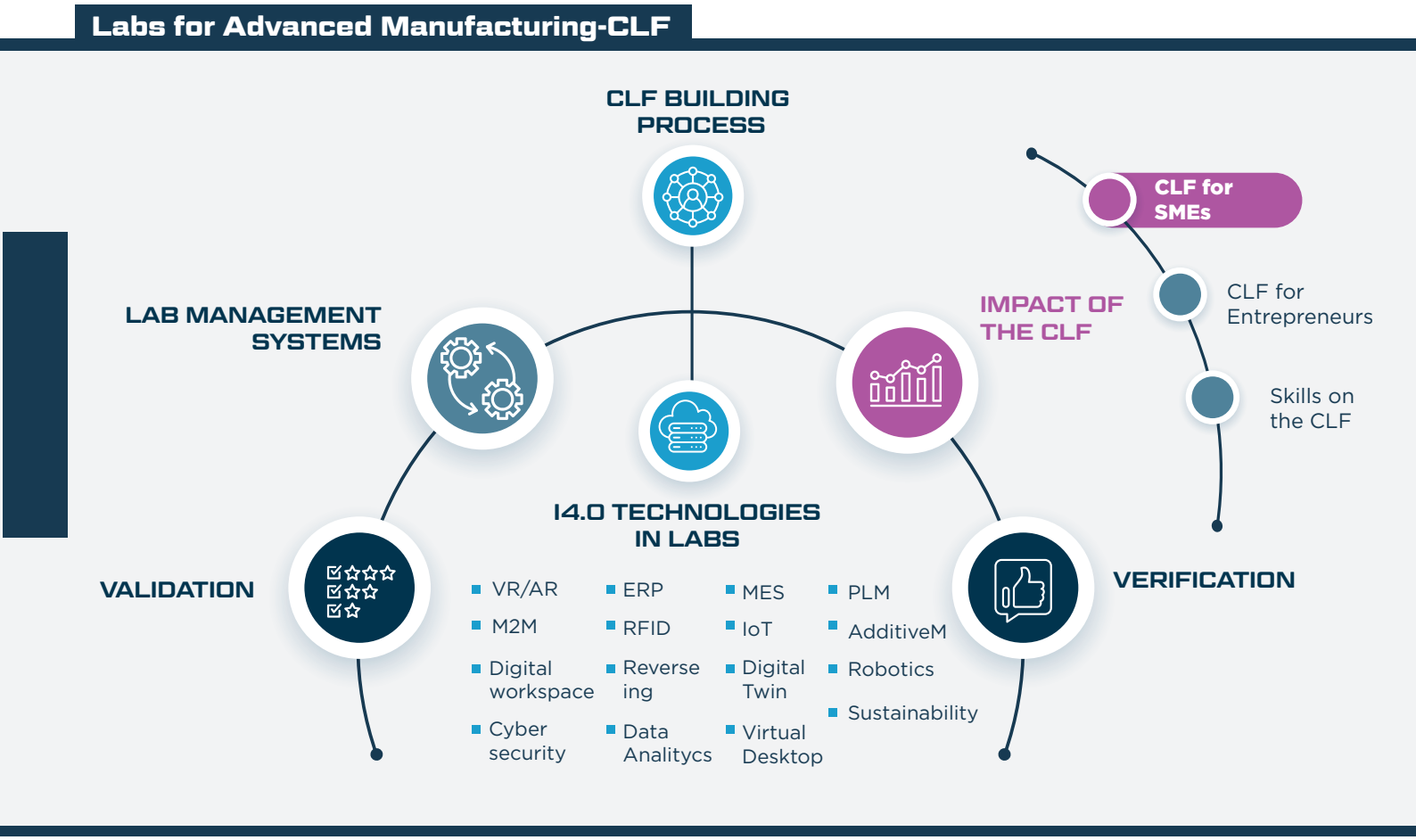


Figure 1: Piloting process of Advanced Manufacturing Labs. Source: EXAM4.0

This report, **Protocol of exploitation of CLF by SMEs**, is part of the impact side of the approach, specifically, impact of CLF for SMEs, as shown in figure 1

For Small and Medium Enterprises (SMEs) the network bundles industry knowledge and technology expertise with information on skills needs and training demands, as well as on new job profiles and the corresponding new qualification requirements. Together with institutions, expert groups around specific I4.0 technical trends, it forms a unique ecosystem to deliver insights in new trends, skills mismatches and life-long learning opportunities with Micro-credentials. With this platform SMEs are supported in their transformation while creating an exceptional professional environment for exceptional people.

In this document, a protocol for SMEs is described. With the contribution of the partner companies and based on existing programmes of some project partners, this protocol explains how SMEs in the Advanced Manufacturing can benefit from the Collaborative Learning Factory. SMEs are facilitated in the innovation process, product development, training, guidance on trends in technology and collaboration with (international) partners in the community

The main elements in which the SMEs are supported are:

- Innovation: Support on technical problem solving with innovative proposals
- Entrepreneurship
- Management and responsibilities, e.g. contracts or agreements and confidentiality aspects
- Training and Workforce upskilling
- Guidance on trends, technologies, skills detection
- Collaboration on internationalisation

1 Challenges of SMEs in the Advanced Manufacturing

Manufacturing is among the key driving forces of the European economy. It provides about 20% of all jobs in Europe (above 30 million) and generates a turnover of about €7 000 billion in 25 industrial sectors and over 2 million companies, dominated by SMEs.

The EU Advanced Manufacturing sector needs innovation-driven transformations in order to reach more competitive, sustainable and modern production. Numerous examples of SMEs have successfully transformed their business by adopting digital and key enabling technologies and business models. These companies boosted their growth or strongly recovered after difficult times. Improved quality of products and services, reduced production lead time, improved resource efficiency and employees' productivity are important drivers for companies to invest and transform their business.

But many SMEs struggle to embrace the Industry 4.0 revolution. The uptake of advanced manufacturing solutions by them remains a challenge, due to high cost of investments in AM acquisition and lack of financial resources and lack of skilled personnel to adopt relevant technologies and business models.

The Exam 4.0 platform provides targeted support to help SMEs to move towards smart and sustainable production. This is done by ensuring them to have easy access to a regional access point with state-of-the art facilities, access to financial support and close cooperation with VET institutes.

2 How the CLF supports the SMEs

The network of Collaborative Learning Factories can support SMEs in adoption and adaptation of knowledge for value (also known as innovation) by solving technical problems, implementing concept proving's, etc, always in a very practical way. CLF's are about combining existing knowledge to create new value. In order to reinforce that essential role (to adopt and adapt knowledge), VET centres need to be in place also when we come to facilities, equipment and of course, digital transformation level. The EXAM4.0 CLF concept makes it possible to demonstrate the capabilities and applicabilities of different I4.0 key enabling technologies, in many cases anticipating SMEs. EXAM4.0 labs also help with the technological update of the teachers and trainers and upskilling of the staff.

The resources that an SME can have are in many cases rather limited. It is not easy for many SMEs to have access to the latest trends and opportunities that I4.0 is bringing. Even being aware of those novelties, it is not easy to try those new technologies and concepts while taking production forward. Required investments are also to be considered. Considering the CLF's and our support to SMEs in those technical services, it is essential that the labs of the VET centres can serve as a demonstrator of improvements that SMEs can apply. It would be very enriching if training centres could test new technologies and technological applications and after teaching SMEs, they could apply what interests them most without having made a large investment of time and money in advance. Supported by expert teachers with knowledge of technologies or conditions to tackle digitization processes, training centres could facilitate the digital transformation process of companies with which, for the most part, they already have relationships of trust.

Part of the collaboration is to try and make the equipment and facilities of the Vocational Training centres available to companies, together with the "expertise" of teaching staff, specialized in multiple areas.

3 Innovation projects that boost SMEs

Vocational Training acts as a "lever" of transformation that will accelerate the transition towards “the triple transition" technological-digital, energetic-ecological, and social and health, whose four pillars are; scientific excellence, industrial technological leadership, open innovation and talent. The Collaborative Learning Factories (CLFs) develop innovation projects that boost small and medium-sized companies (SMEs onwards) by improving their competitiveness and building around them systems to create and apply knowledge. Innovation is promoted in SMEs through collaboration, establishing priorities, undertaking technological innovation projects of product and process, facilitating talent development, and creating strategic environments.

Within the CLF’s collaboration projects with companies are developed to respond to scientific-technological updating, using the resources available to the centres and the technologies implemented in the companies. The objective of the CLF in this matter is to bring the technological reality of the companies closer and make specific contributions from professional training to the value chain of the companies, to optimise and improve their production processes and the products they manufacture.

Within the current economic context, driving innovation is essential to guarantee competitiveness for a company. CLFs allow improving products and processes through its specialised offering, thus accessing new markets thanks to more excellent added value. To this end, VET centres provide SMEs with the equipment and facilities in the CLFs Network and the teachers’ expertise, who are specialised in several different areas.

To increase the sharing of information and the valorisation process, CLFs work with open code, so there is no issue sharing information with the company. The company is empowered to learn from the centre and for the centre to learn from the company.

The innovation projects within the CLFs are innovation and improvement services developed in collaboration with companies, adapting to their needs by taking advantage of each strategic setting's potential, based on the trust provided by working within a network. Furthermore, organisational assessment adapted to each company’s reality is offered to companies and methodological tools to implement innovation plans or creative dynamics, supporting them when participating in contests for grants related to innovation.

The goal is to develop applied innovation projects with companies to respond to bringing the teaching staff up to date in terms of science and technology, promoting innovation both in SMEs and in VET centres.

4 Collaboration with SMEs

The development of collaborative projects with SMEs is divided in four main steps:

1.Identification of the collaboration project

Companies approach the centres, thanks to the pre-existing relationship or the centres approach companies, offering their services by meeting with companies, identifying their needs and possible ideating projects for collaboration.

2.Definition of the collaboration project

A project is specified, to meet the detected needs by centres defining the project (participants, resources, teams, deadlines, etc.) to conclude with a budget that is agreed upon and signed with the company.

3.Development of the collaboration project

The project is kicked off, with monitoring throughout the entire process. When both parties meet their commitments, the service is invoiced and concluded. The project is closed, and an analysis of the objectives' compliance and the degree of satisfaction is measured.

4.Knowledge transfer

The collaboration project is disseminated, making the internal and external transfer in the terms agreed with the company. The knowledge and experience gained during the project are distributed in the centre, making it possible to update teachers and students' knowledge. Dissemination of the contents to the company is done by transferring all the knowledge acquired in the project.

5 Contribution to Training and Workforce upskilling

One of the main ideas that have to be underlined is that all the collaboration projects held inside the CLF's have to be innovative and so have to be challenging for the VET teachers participating in it. The growing demand and evolution of the manufacturing processes and the integration of the new technologies of Industry 4.0 into the market, with Advanced Manufacturing as one of the fundamental pillars, provide the machine tool industry and its users with a wide range of design and production possibilities. Using automation, additive manufacturing and the advantages of process simulators, you will be able to test and produce prototypes and materials, optimise manufacturing processes and carry out industrialisation tests, manufacturing pre-production versions of new products.

Given the growing requirements and evolution of manufacturing processes, the CLFs can help analyse existing processes, suggest and perform actions to achieve improvements, reduce manufacturing time, adapt machines, etc. The teachers can also simulate alternative operations and procedures to avoid interference with the production line and analyse the results to confirm or reject hypotheses. Furthermore, the VET centres can consider, design and test completely innovative processes (Digital Twin). The CLF can carry out the preliminary study, including the appropriate tests to confirm the efficacy and stability of the new alternative.

6 ROLE of VET staff and students within the CLF

As said before, the VET staff plays a fundamental role in CLF, being the main actor that connects the real market where the companies fight for their everyday life and the students who need to be prepared for their future. The evolution and updating of Vocational training students and teaching staff is the idea that makes the CLF different from any other enterprise or private company that could give similar services. The point is the transfer of knowledge. Once each collaboration project is accomplished, the knowledge acquired during the work's realisation is transferred to the students and the rest of the VET staff. Several options have been designed, such as challenges for Challenge Based Learning, class presentations, didactic units, videos, symposiums and congresses for the teaching body etc.

7 USE CASES DESCRIPTION

In this chapter use cases are described how SMEs make use of the CLF. The first use case is from TKGUNE in Spain and the second use case is from 10XL in The Netherlands.

7.1. Use case TKGUNE

In the field related to Industry 4.0 and Advanced Manufacturing, techniques and methods such as Machine Tool, Additive Manufacturing, Mechanical Manufacturing, Forging and Stamping Automation are held.

Some of the projects carried out during the last years are:

- **AUTOMATION**

  - **DESIGN, MANUFACTURE AND ASSEMBLY OF AN AUTOMATED APPARATUS FOR THE PERFORATION AND SEALING OF A COVER:** In response to the requirement of the company for the automating of the perforation process of the plastic cover and the subsequent heat-sealing of the special filter, the design, manufacture and assembly of an automated apparatus that performs the perforation and sealing of the cover has been carried out.

  - **OPTIMISATION SYSTEM FOR THE DRYING PROCESS OF TXAPELAS (TRADITIONAL BERETS)**: A company needs to manufacture txapelas (berets) with a new material. To do this, the cutting geometry of a cutter is designed to cut an edge in the moulds and the performance with a next generation material is verified.

  - **DESIGN AND MANUFACTURE OF A MACHINE IN A MOULDING PROCESS:** Due to the health problems that can be caused to workers when manually removing the wedges from a mould, a new machine has been designed and manufactured to automate the process.

  - **DESIGN OF THE AUTOMATION OF THE TRANSFER OF A PART FROM ONE PLACE TO ANOTHER:** In a machine press in the automotive industry, the transfer from one station to another of the part produced by cold stamping is designed so that it is synchronised with the timing of the press.

- **FORGING AND STAMPING**
  - **VALIDATION OF THE FORGING TOOL FOR AN AUTOMOTIVE COMPONENT THROUGH FEM SIMULATION**. The stresses and the distribution of forces arising in the forging process have been evaluated for the design of the tool produced by the company to assess the suitability of the design.
- **ADDITIVE MANUFACTURING**
  - **USE OF ADDITIVE MANUFACTURING CLADDING, WAAM, and SLM TECHNOLOGIES,** starting from scratch, producing new parts, repairing high added value parts, and coat of parts and adding material onto a base.
- **5-AXIS MACHINING**
  - **5-AXIS MACHINING** of a part for the rear brake of a bicycle.

7.2. Use case 10XL in the Sustainability Factory

10XL prints functional products up to 6 meters with thermoplastics. They have already built up a track record in this for various industries from maritime- to the furniture industry. **The advantages of getting started with 3D printing are countless, including:**

- Cost savings in the field of logistics and distribution
- Failure cost reduction
- Clear stock management
- Easy to make model adjustments (also a few pieces)
- Fast delivery
- Domestic production
- Sustainable production technique (minimum amount of waste and reuse of the material)
- Unlimited freedom of form
- Weight reduction design

Description use case additive manufacturing process / challenges

As mentioned, 10XL focuses on the production of functional products, from single pieces to series of more than 100 pieces. Process control is essential when printing functional products. This allows us to guarantee consistent quality. Sufficient process control also paves the way for completely unmanned printing. However, we want to go further. By introducing a closed-loop system, we will adjust the process parameters in real time, i.e. during the printing process. First, the robot 'sees' that the quality of the print can be improved. The robot then adjusts the parameters of the actuators (flow / temperature / cooling) and finally the result of these actions is measured.

The challenges to be tackled in the use case are huge. But if 10-XL continues with this, it will be possible to print and thus produce 24 hours a day, 7 days a week. This also makes it possible to do this without people. **For this it is important to tackle the challenges that also come along:**

- Remote maintenance
- Maintenance data available everywhere and online
- Dashboard definition with KPIs
- Remotely control robots

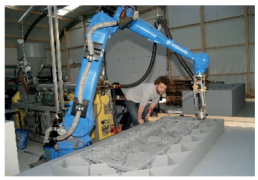
Why the learning factory?

The Sustainability Factory fieldlab contains various knowledge elements (sensor technology and actuator knowledge) that 10-XL can use to further develop their additive manufacturing process. **The components with which the technology is expanded and tested are:**

- **“Seeing” the 3D object**
  - Tactile feelers
  - IR Camera systems
  - Flow meters
- **Comparing the current properties of the print with the desired properties**
  - Setting up a parameterized print database
- **Control actuators that adjust the current properties**
  - IR lamps
  - Cooling systems
  - Extruder flow

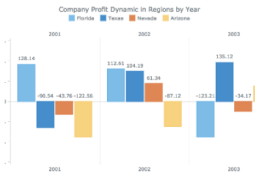
Student projects use case

The student will work on different aspects in the project:

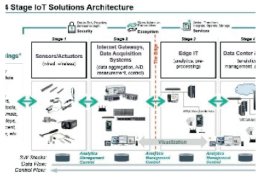


3D PRINTER CONTROL

SEEING THE 3D OBJECT



ICT DATA COMPAREMENT



ADJUST CONTROL ACTUATORS

Figure 2: participation of students in Sustainability factory Lab. Source: DVC

Each student team will work on the mentioned challenges in the different sub-projects and learn / develop on the following subjects:

Project Use Case	Students (VET 4 level)	10XL knowledge + VET 5-8 level
3D printer control	How to program the 3D printer and is it connected to the feeder. How does the X / Y / Z configuration work connected to the motors?	Which are the parameters that can be changed and used to control the printer more precisely.
“Seeing” the 3D object	Which camera systems are there in the market and can they be connected to the 3D printer?	Analyzing what quality criteria are for the 3D scanning of the object
Comparing the current properties of the print with the desired properties	Executing the material tests Analyzing the material results	Making the test protocols.
Setting up a parameterized print database	Configuring and maintaining the print database	Configuring and maintaining the print database
Control actuators that adjust the current properties	Heating and cooling connection and placement near the 3D printing robot. Executing the test protocols.	Knowledge about heating and cooling the materials. Making the test protocols to be executed.

The DaVinci College students from Smart Technology, Engineering and ICT are needed for this use case. Also students from higher VET levels will be needed for the more complex handling and analyses.

8 Conclusions

From what has been seen so far, it can be concluded that the CLF approach for advanced manufacturing workshops in VET also adds value to the technological services and relationships that these centres have with SMEs.

Beside the contributions of CLFs as training spaces and novel methodological approaches, SMEs in the Advanced Manufacturing can benefit from Collaborative Learning Factory as shown in the 2 study cases.

Through the CLF and by extension through the EXAM4.0 platform, SMEs can be facilitated in the innovation process, product development, training, and guidance on trends in technology and collaboration with (international) partners in the community.

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