

Verification of Advanced Manufacturing Labs (CLF), identifying local SMEs as partners of the EXAM4.0 Hub

Piloting the Advanced Manufacturing workshop 4.0



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The Cooperative Learning factory pursues the objective to implement a model that guides the actions and transform the existing national labs of partner institutions towards a Collaborative Learning Factory. In the CLF, a novel way of dealing with I4.0 competences was tested and experimented by introducing required future skills and competences in a practice-oriented manufacturing process.

So far, companies have partially participated in the CLF at this point. For example, technology providers may have implemented equipment and software in the approach such as PLM, Digital twins, IoT platforms, etc. In this case, the providers serve as suppliers. However, the Cooperative Learning Factory has not yet been tested in a programme for lifelong learning and training employees and students in the different labs.

In the future, companies will benefit from the results and products of the CLF, for example by hiring students who have used and participated in the CLF for instance or by using the CLF for their own DUAL training processes, in house learning and lifelong learning programmes. Moreover, learning factory developed in the course of EXAM4.0 can serve as a technology demonstrator and be used for applied innovation and technical services.

As part of the project, companies were asked about the design and structure of the Cooperative Learning Factory (CLF) and the AM Workshop, as well as their relevance for the companies. In the process, various companies were identified that would like to participate in the CLF as partners.

In use-cases the representatives of the companies described how cooperation and participation can look like and which advantages the CLF and international cooperation of the learners represent. However, the use-cases also contain risks that CLF represents for companies and suggestions from the representatives as to which competence requirements need to be covered in the labs in order to meet company demands.



#### The EXAM4.0 Hub implies three pillars:

- Exam 4.0 Platform
- Exam4.0 Learning factories and Labs
- Learning and education of Advanced Manufacturing

The objective of the Hub is to provide services within those pillars for different stakeholder groups referring to institutions, learners and companies. Within the EXAM4.0 project, different services and activities have been developed to offer to representatives of the stakeholder groups.

#### The services implied in the pillars are categorized and refer to:

- Technology, knowledge and data services
- Tools and Methodologies
- Events and News

In order to identify the most relevant services and activities to provide in the labs, trainings and on the platform, companies, learners and institutional representatives were surveyed and participated in workshops that have taken place online between June and August 2021.

In total, **41** representatives of stakeholder groups participated in the online workshops and did fill in the survey, among **18 employees from large companies** and **23 representatives of H/VET institutions.** 

The results of this study do not represent quantitative but rather qualitative research. However, the selected participants of companies and institutions are sufficiently enough to obtain and represent relevant information to be included in WP5.1 of EXAM4.0

Furthermore, the participant's also indicated the importance of the different Hub pillars. Regarding the second pillar pertaining the AM workshop and collaborative learning factory (CLF), the participating representatives estimated an high importance of it.



#### **Cooperative Learning Factory – CLF**

The CLF is a learning scenario set up and piloted by 4 VET/HVET centres. The project offers multiple advantages and chances for employers and companies. By participating in the CLF, companies can establish contacts with students and future graduates to recruit talented and skilled employees. The courses can also be used by employees to upskill themselves or update their competences. Short training courses can also be implemented in the EXAM4.0learning factory or provided as in-house trainings with videos or short instructions. Moreover, companies can propose and evaluate technical contents according to their demands, so employees and trainers are trained on how to use and handle new technologies that are or will be implemented in companies. Another benefit this cooperation project offers for companies refer to learning factories as technology demonstrators. Companies can use local learning factories and labs of participating institutions and enterprises to test certain technologies, applications, or systems to implement them later in their own processes. As a result, partners provide use cases for the CLF that focus on implementing and using technologies.

The CLF is not only beneficial for companies, but students and institutions can also profit from the collaboration project.

Regarding learners, the cooperative learning factory provides an opportunity for practice oriented and work-based learning for students to train relevant and required future competences for working in an advanced manufacturing environment. Companies as suppliers implement new technologies in the different labs, so students can learn how to use and handle technologies and application. In addition, also teachers and staff can be trained in the use of new technologies.

Furthermore, the collaboration and close communication between institutions and companies facilitates adapting curricula and learning contents accordingly to company demands. This enables institutions to better prepare future graduates and potential employees.



The changing and worsening situation in the partner countries due to Covid-19 has contributed to the difficulty in creating use cases and acquiring company representatives. Due to reintroduced lock-downs and restrictions also in the working environment, the acquisition of participants and company representatives in this work package was made much more difficult. Although the partners made great efforts to reach company representatives and to acquire them for use cases by contacting them several times by email and phone calls, ten use cases have been generated so far. In the future, however, more use cases are to be created and published by companies. As discussed with a participant in the interview, an implementation of the EXAM4.0 CLF is planned in the summer within the framework of a summer school, in which various companies will also participate with their labs and applications/equipment. In this way, further use cases can be added in the coming year as to how companies can be integrated into the CLF.

Use Cases 1

#### NAME OF COMPANY:

Torquesales, Engineering Office for Drive Technology and Sales (Germany)

### 1. How do you foresee your participation in the labs/CLF? What aim do you pursue in participating in the CLF?

In the field of communication, the company could provide guides on how to communicate and intercultural competences. In order to prevent cultural misunderstanding and creating an enjoyable working environment, mutual understanding of the international project partners, teamwork and cooperation should be fostered. Moreover, it will be important for the participants to dismantle obstacle and biases at the beginning. This could contribute to being open-minded towards new ideas or for example transferring ideas and approaches of partner onto own environment, e.g. adding sensors to robot to measure ice layer of frozen lake can be adapted in Germany to measure thickness of walls.

#### 2. What benefits do you see for your company by participating in the CLF?

In the course of the project, intercultural training of students & learners can be fostered. The CLF enables students to participate in a joint learning experience and getting to know other cultures, mindsets & approaches, broaden their mind.

# 3. With the labs, we have integrated the type of work-based learning to train relevant competences. Which core competences trained in the labs will meet the needs of your company?

• The project enhances obtaining skills such as a fault tolerance culture and reaction to faults. Not only should they know how to prevent failure, but also and more importantly how to cope with failure and solve problems, being open mindset towards failures. Therefore, measures should be taken and taught in advance, e.g. time buffer,

• Intercultural competences and taking into account cultural/regional phrasing, actions, etc., are important in a working environment of the future. Furthermore, working independently and agile working as well as competences such as responsibility, reliability, complex/problem solving skills and time management present demanded skills on the labour market.

# 4. Regarding the CLF, what other contents should be added to the current CLF configuration?

- Quality management
- Project management
- Risk analysis
- Knowledge of processes and single steps, e.g. logistics, supply chain, quality, specification

• Resilience: working in projects can lead to stress and pressure especially if there were made faults and time is running low. However, cost orientation does not always present the best approach, risks have to be taken in order to obtain good results or enhanced results.

#### 5. What challenges does the participation in the CLF pose for your company?

Communication & miscommunication present the highest risk in this project as well as time management and thus stress tolerance. It is important to keep all participants integrated and on board/track e.g., with regular communication, updates on state and motivation. Due to the decentralization of the project partners and labs, frustration and a lack of motivation present another risk of the project, Therefore, regular meetings and close communication will be key.

### 6. What advantage does international cooperation between the labs offer your company?

- Horizontal & vertical networking in companies and along supply chain
- International interdependencies
- Understanding of whole processes
- Cultural intelligence: know how to interact between intercultural colleagues, how to interpret phrasing and communication
- Evidence based networking and constructive network building
- Can learn from partners to be more venturesomely also regarding technologies and testing different approaches and applications
- Fosters self-reflection and continuous communication

#### Use Case 2

#### NAME OF COMPANY:

Forcam (Germany)

### **1.** How do you foresee your participation in the labs/CLF? What aim do you pursue in participating in the CLF?

Integrating the MS Software in the project. By participating, companies and especially SMEs can collaborate and with other companies and enterprises. Moreover, they can establish contacts and develop networks. The project offers the service of organising the processes and production for companies

#### 2. What benefits do you see for your company by participating in the CLF?

Companies can establish contacts to students, learners and well-prepared graduates as potential employees of the future. Furthermore, companies can cooperate & collaborate with other companies and SMEs. In addition to functional competences, students of economy have a chance to work on real life problems and practical projects.

# 3. With the labs, we have integrated the type of work-based learning to train relevant competences. Which core competences trained in the labs will meet the needs of your company?

A continuous flow of information is crucial in and working environment. Communication between employees and different hierarchies must be comprehensive and targeted. Specialisation of employees provoke difficulties in understanding e.g., special terms that are used in different departments but are not known by others. Furthermore, process thinking is important to gain a system view and knowing processes and approaches. In addition, thinking in teams is also very important as well as interdisciplinary competences to find links between different fields and contents.

# 4. Regarding the CLF, what other contents should be added to the current CLF configuration?

- Process thinking
- Giving targeted information, general comprehension
- Process of value-added chain, to teach different steps of value creation of the project

#### 5. What challenges does the participation in the CLF pose for your company?

Marketing of the project will be crucial. A risk of the CLF is to only be known in the university context; however, the project presents multiple advantages for students as well as companies and enterprises and to win potential customers and principals.

### 6. What advantage does international cooperation between the labs offer your company?

• Represents real life experience and working life for students

#### Use Case 3

NAME OF COMPANY:

AFM Cluster (Spain)

### 1. How do you foresee the potential participation of your organization on the CLF? What aim would you pursue in participating in the CLF?

AFM CLUSTER considers it necessary to be involved in projects such as the CLF. Within the constantly changing environment that we are experiencing; it is also necessary to innovate in training issues. Having educational centres that have learning factories and having them connected to other European educational centres, allows students to acquire highly valuable skills. The field of digitization in advanced manufacturing requires developing competencies that CLFs can help achieve. One of AFM CLUSTER's strategic challenges in the field of people is to have well-prepared people. For this, it is essential the involvement of AFM CLUSTER in projects that are aimed at improving the training of people and improving the training available, both for young people and active professionals.

# 2. How the curriculums worked out in the CLF are improving the competences of the students? Any suggestions for the CLF in order to bring closer those competences to the needs of your organization or your associate companies?

The CLF-s replicate an advanced manufacturing workshop within the training centre. This allows students to develop skills that they will need when they enter the labour market. So, the jump to the labour market is easier.

In Spain, the CLF concept is still new, so it is difficult to assess the degree of improvement it entails or to suggest modifications to suit needs. The CLFs themselves are a great improvement and it will be necessary to advance in their development in order to be able to assess the degree of improvement and suggest modifications.

# **3. Regarding the CLF, is there a lack of equipment for an active student participation considering your organization's needs?**

One of the difficulties of the CLF-s is the high degree of investment involved in replicating a 4.0 workshop within a school. If the model is successful, the training centres will have to be equipped with the appropriate machinery and technology so that they can have CLF-s where their students can train.

# 4. Regarding the CLF, what other contents should you add to the current CLF configuration?

As it is a new initiative, I believe that it is necessary to advance in the use of CLF-s in order to be able to assess the content that is being taught and to be able to propose new ones if that is the case.

In addition to the content necessary to acquire technical and digital skills, it will also be necessary to address transversal skills, such as commitment, teamwork, autonomy, responsibility, etc.

#### 5. What benefits do you see for your organization in the CLF?

The sector will have people trained in interconnected workshops and with state-of-the-art machinery. This will allow us to have trained people in highly digitized environments.

As the CLF-s are advanced 4.0 workshops, they will be able to help companies when making investments, since they will serve as digitized pilot workshops. Companies will be able to see the benefits of digitized 4.0 workshops in order to implement the improvements in their own companies.

By having the CLF-s with state-of-the-art machinery, companies will be able to request projects and advice for the improvement of production processes. In this way, when developing projects to improve production processes, teachers will acquire skills that they can apply to their own students, improving the educational level and adapting it to the needs of the environment.

# 6. What challenges does the CLF pose for your organization or your associate companies?

The challenge is for the sector as a whole to also advance in the digitization of its workshops and to have state-of-the-art machinery. It is essential to have schools with facilities and technology of this type, so that in this way companies also advance on that path.

### 7. How can the methodology for promoting international collaboration among students in the CLF be described?

Promoting international collaboration between students is essential. The skills that students will acquire by developing collaborative projects with other international students will allow them to be prepared for the development of similar projects with foreign collaborators in the future.

#### Use Case 4

#### NAME OF COMPANY:

Reser (Spain)

# **1.** How do you foresee the potential participation of your organization on the CLF? What aim would you pursue in participating in the CLF?

Reser's participation in the CLF would be seen as consultancy firm to set up and scale the CLF. Furthermore, we can participate in developing new features together with VET centres staff and students. Our goal participating would be on the one hand to share our expertise with the educational bodies and on the other hand to trial new solutions in the CLF environment

# 2. How the curriculums worked out in the CLF are improving the competences of the students? Any suggestions for the CLF in order to bring closer those competences to the needs of your organization or your associate companies?

The curricula developed in the CLF are improving the several competencies required in Industry 4.0. These competencies save time in training within the company since the use of the technology used in the company has already been done previously in the centre.

In order to bring the competencies closer to the needs of my company, the CLF would have to be flexible enough to be able to adapt to the industrial processes implemented there in order to let space for trial advanced complex features on the CLF environment.

### 3. Regarding the CLF, is there a lack of equipment for an active student participation considering your organization's needs?

The setting of some of the labs that compose the CLF are scalable enough to implement new equipment. It si possible to add more layers of complexity to the base that already is set up. Normally rather high investments are required; however, there are also low cost solutions that can work very well for education purposes. I would add that as important as the equipment is to have a way of working that helps to internalise the fundamental concepts of I4.0. Analytical capacity, data analysis, critical thinking. I consider it more important to understand WHY and FOR WHAT we need a certain solution than HOW this solution is built.

# 4. Regarding the CLF, what other contents should you add to the current CLF configuration?

As I have understood the CLF, there is a complexity in setting up the method for exchanging data and information. I understand that common solutions would be needed, i. e IoT platforms, business collaborative platforms (3d experience, team centre or others). It is also very important to work hard on the security. Common cybersecurity system must be implemented, apart from those locally implemented.

The potential of virtualization, and above all digital twining of the CLF can be a very interesting approach as well.

#### 5. What benefits do you see for your organization in the CLF?

First of all, it helps in creating I4.0 culture. In this way, the reluctance to change within the company is reduced, since people understand the reason for the change. On the other hand, it saves training times in new technologies.

On the other hand, the fact of being able to test new technologies in a real environment makes it clear to us which technologies are necessary for us without the fear of a large investment without knowing what benefits it will bring us.

### 6. What challenges does the CLF pose for your organization or your associate companies?

The CLF is thought of as a generic approach to advanced manufacturing. When very specific solutions or competences are required, the CLF hardly will adopt then due to the huge range of solutions available nowadays, and more that will come.

I would also add the cultural and language barriers that can take place when working with international organizations.

# 7. How can the methodology for promoting international collaboration among students in the CLF be described?

It seems to me a very innovative methodology since, in addition to bringing the use of new technologies closer to I4.0, it enables us to work on international and communication skills.

#### **Use Case 5**

#### NAME OF COMPANY:

Construcciones Metálicas Lazpiur (Spain)

### **1.** How do you foresee the potential participation of your organization on the CLF? What aim would you pursue in participating in the CLF?

At Lazpiur we see that our participation would begin with the participation of managers from different areas of the company. In this way, an analysis could be made of what is wanted in the company and train said managers in the culture of Industry 4.0.

Once those responsible are clear about the way forward, work will be done in different parts with the other workers. On the other hand, in turn, improvements could be implemented in the company.

# 2. How the curriculums worked out in the CLF are improving the competences of the students? Any suggestions for the CLF in order to bring closer those competences to the needs of your organization or your associate companies?

The curricula developed in the CLF are helping to meet the needs that were had regarding Industry 4.0. It gives the possibility of improving the skills necessary for the digital transformation that we are developing.

In order to bring the skills closer to the needs of my company, the CLF would have to be able to replicate the problems or needs that we have in the company. In this way, workers could be trained in these needs.

## **3. Regarding the CLF, is there a lack of equipment for an active student participation considering your organization's needs?**

Considering the needs of my company, I think that the unit traceability part of the pieces would have to be worked a little more (where is each piece, in which manufacturing process it is, when is it supposed to be sent to the customer ...)

A greater concretion of Augmented Reality in maintenance would be interesting.

# 4. Regarding the CLF, what other contents should you add to the current CLF configuration?

I think that taking into account our reality, it would be interesting to add the traceability and data collection part. Minimum requirements for the communications architecture and the cybersecurity that this entails.

#### 5. What benefits do you see for your organization in the CLF?

First of all, it helps to understand what Industry 4.0 is. In this way, managers such as workers can begin to understand what can be achieved and why it is necessary for us to evolve in that line.

On the other hand, we can do certain practices of these technologies without having to make a large investment of technology and time in our company. In this way we have the possibility of incorporating the technology that we believe appropriate with a lower risk and trained workers.

### 6. What challenges does the CLF pose for your organization or your associate companies?

The CLF has made us realize that we are late in digital transformation. We have to start evolving to be competitive.

It is very interesting to see that the centres are aligned with the strategy of the companies and that they are also technologically trained so that we can do tests.

# 7. How can the methodology for promoting international collaboration among students in the CLF be described?

That students have the possibility of being able to work internationally helps us a lot. On the one hand, they will be able to see how they work elsewhere and import those improvements. On the other hand, it breaks the fear of working with other people in another language and makes it easier to find volunteers when sending people to work in other countries.

#### **Use Case 6**

#### NAME OF COMPANY:

Refa (Germany)

#### 1. What benefits do you see for your company by participating in the CLF?

With the help of the CLF network, know-how can be transferred. SMEs in particular, which do not have their own development or research department integrated into the company, can benefit from this. Process and product know-how of the different companies can be transferred. For example, in the production of injection moulding, companies can get to know the different procedures and exchange information about economic production possibilities. In addition, employees can be qualified in the various laboratories.

# 2. With the labs, we have integrated the type of work-based learning to train relevant competences. Which core competences trained in the labs will meet the needs of your company?

Communication, leadership and cooperation. In addition, future graduates should have a basic technical knowledge, as the company's specialised technical knowledge can only be acquired on-work. However, an understanding of production processes, quality management and handling processes is important

# 3. What advantage does international cooperation between the labs offer your company?

International competences are elementarily important. More and more companies are operating internationally. Young engineers need to be able to work in Germany today and in another country tomorrow and to deal with people and situations accordingly. Intercultural competences are therefore elementarily important competences for future employees.

#### **Use Case 7**

#### NAME OF COMPANY:

TurnMill AB / Finspångs Finmekaniska AB (Sweden)

### 1.-How do you foresee your participation in the labs/CLF? What aim do you pursue in participating in the CLF?

We could learn from work and managing regarding coordination of production processes that involves responsibility at different locations.

#### 2. What benefits do you see for your company by participating in the CLF?

Collaboration with other companies, and schools, would help to get new insight and gain new experience.

3. With the labs, we have integrated the type of work-based learning to train relevant competences. Which core competences are necessary in the labs in order to meet the needs of your company?

Planning, purchasing, order management, forwarding, transportation, preparation, production technology, quality control.

## 4. Regarding the CLF, what other contents should be added to the current CLF configuration?

Two things are important, and these are regarding function and arrangement. These are:

1. Important that the different partners are exchanging data and information and also analysing this data.

2. Two different manufacturers could produce different products at different location and then merge/assemble them or the production could be made sequentially. This should be done in order to produce products more efficiently and produce in half the time.

#### 5. What challenges does the participation in the CLF pose for your company?

Physical meetings are a problem, and it is also difficult to contribute with a lot of participants from the company to the CLF. Time in general is the problem, our company have a lot of other projects that we work in.

#### **Use Case 8**

#### NAME OF COMPANY:

Siemens Energy AB, 61282 Finspång (Sweden)

# **1.-How do you foresee your participation in the labs/CLF? What aim do you pursue in participating in the CLF?**

As a part of our strategy for digitalization for Additive Manufacturing we will soon take the step from the level "Learning Workshop" to "Intelligent Workshop". To be able to test Remote Manufacturing (with additive manufacturing or not) in a test environment is of great value for us, especially if Siemens and Siemens Energy could equip the test environment with digital solutions.

#### 2. What benefits do you see for your company by participating in the CLF?

We are already working 100% international every day of the week, so this would not benefit us in more than before. However, we would like to use the CLF as a test environment for digital solutions. It is also a good thing to meet others, yet unknown people and organisations on the market.

3. With the labs, we have integrated the type of work-based learning to train relevant competences. Which core competences are necessary in the labs in order to meet the needs of your company?

"Remote AM Operator"; "Remote Manufacturing Engineer": "Connectivity and InfoSec Technician"

### 4. Regarding the CLF, what other contents should be added to the current CLF configuration?

Focus on digital systems that monitor and control regular (traditional and additive) manufacturing machines.

It is very important with a continuous traceability of all goods, powder, decisions, commands, results (otherwise we will not be able to use it anyway!).

Measuring from distance with for example 3D-scanning.

Chemical analyses of powder composition (metal powder for 3D-printing) with an XRF-gun.

#### 5. What challenges does the participation in the CLF pose for your company?

Export control (ECC) – and Intellectual Property (IP) restrictions of real components (=must then be dummy components).

Agreements between all participant so we can talk and discuss safely and openly.

#### Use Case 9

#### NAME OF COMPANY:

Tornilleria Deba (Spain)

# 1. How do you foresee the potential participation of your organization on the CLF? What aim would you pursue in participating in the CLF?

The CLF provides an ideal scenario in which to develop real case-based training in our company, we could provide real projects for students to work on. We understand that our company's employees will be better prepared if their training is carried out based on real problems similar to those they may encounter in reality.

At the same time, the CLF can serve as a test bed for the implementation of certain technologies of interest to our company.

# 2. How the curriculums worked out in the CLF are improving the competences of the students? Any suggestions for the CLF in order to bring closer those competences to the needs of your organization or your associate companies?

At T.Deba we understand that nowadays transversal competences such as critical thinking, adaptability, interoperability, teamwork etc. are gaining importance. We see that these skills are reinforced thanks to the CLF.

On the other hand, if students acquire digital competences from the moment of their training, when they join our company, they will have an elaborated digital culture base and they will contribute to our digital transformation process.

### **3. Regarding the CLF, is there a lack of equipment for an active student participation considering your organization's needs?**

Our manufacturing process is very specific, so the more elements of the manufacturing process are integrated into the CLF, the better it will be for us. We also understand that it is not possible to cover all types of machinery in a CLF. It is true that the current equipment allows for many activities. We consider it appropriate to further expand the CLF in line with the current concept.

# 4. Regarding the CLF, what other contents should you add to the current CLF configuration?

As mentioned above, the acquisition of complex machinery designed for production requires large investments that cannot be amortised in a training centre. For such complex processes, virtualisation seems to be a suitable solution. By means of simulations and even digital models of machines and industrial processes, students can become much more familiar with our industrial reality.

Furthermore, for us the integration of online quality assurance is an interesting application. Today, there are advanced solutions for online quality control integrated in centralised systems which seem to be applicable to the CLF concept:

It seems that the field of maintenance has not been worked on too much in the current CLF. It would be interesting to reinforce this area. Smart maintenance is an important level for the digitalisation of a company.

#### 5. What benefits do you see for your organization in the CLF?

The CLF approaches training from a perspective that is much closer to the business reality than traditional training. For us, it is important that the people who come to our company, whether as trainees, in dual training or subsequently hired, have already internalised how a company works. I believe that the CLF achieves this global vision of the production chain and the importance of each step.

Secondly, there is digitalisation. We are still at a very early stage in the digitalisation of our company, so we appreciate all the previous work that has been done in this direction.

Finally, the CLF can serve as an inspiration for our own digitisation, both technologically and in the creation of a digital culture.

# 6. What challenges does the CLF pose for your organization or your associate companies?

The way of working in a CLF is an evolution of the more traditional way of working. The people in the company in continuous training and upskilling processes may need a change of mentality to adapt to the CLF; however, this is not something that worries us too much, as the CLF may in turn be close to these same workers due to its "industrial" approach.

Perhaps the difficulty of integrating the specific technologies that we use could be a handicap.

# 7. How can the methodology for promoting international collaboration among students in the CLF be described?

In our case, we do not have subsidiaries in other countries, so we do not have experience in international collaboration at the level of people in production, apart from the commercial and technical work associated with the export of our products.

Even so, from our point of view, it is very important for trainees to experience this international collaboration, as in the future this type of relationship will be much more common than in the current situation.

#### Use Case 10

#### NAME OF COMPANY:

SMC (Spain)

# **1.** How do you foresee the potential participation of your organization on the CLF? What aim would you pursue in participating in the CLF?

The CLF concept is aligned with different products that SMC manufactures so there are many different opportunities to collaborate in it. Examples include the development of technologies to apply, collaboration in the development of content, adaptation of CLFs to the training needs of SMC's people, etc.

The "Collaborative" concept developed in the EXAM4.0 CLF, where geographically distributed organizations can interact, is an aspect that SMC wants to further develop for its products. We are currently working on this connected and collaborative character for some of the SMC solutions.

# 2. How the curriculums worked out in the CLF are improving the competences of the students? Any suggestions for the CLF in order to bring closer those competences to the needs of your organization or your associate companies?

The CLF will improve the competences of people with VET profiles that we recruit either through DUAL or internship programs: The holistic approach of the CLF and the digitalized working environment it proposes seems to us to be a great contribution to the competences of VET students. Soft skills are also enriched through this approach.

### **3. Regarding the CLF, is there a lack of equipment for an active student participation considering your organization's needs?**

The labs taking part in the CLF are relatively well equipped. The interesting thing about the CLF concept is that it is scalable, i.e. technology and complexity can be added according to the needs and possibilities of each organization.

It is also possible to use didactic equipment for certain tasks and more industrial machines for others, thus combining them into a single process.

### 4. Regarding the CLF, what other contents should you add to the current CLF configuration?

The current configuration, being a pilot, is an initial base. The possibilities to add elements are very large. Depending on the direction and the target audience, the contents will vary. However, the CLF approach seems flexible enough to adapt or add content as needed.

#### 5. What benefits do you see for your organization in the CLF?

As mentioned before, taking part in the CLF can be beneficial from the business perspective as it can contribute in our business development, or at least in improving some of our product and services. The CLF can be also beneficial to enhance the competences of the people we are hiring and of the current workforce.

### 6. What challenges does the CLF pose for your organization or your associate companies?

In our opinion, the CLF poses two major challenges:

On the one hand, the administrative barriers involved in working in collaboration between countries with different education systems. There may be differences that make it difficult to work smoothly and that will need to be considered.

On the other hand, there is the operational management of the CLF. An initiative of this caliber needs strong leadership. The group leading the CLF needs to set up a clear, precise, and efficient operational management so that all participants understand and perform their tasks properly.

As for the technologies to be used and their integration, it is not seen as an insurmountable barrier; there are technical solutions available today that are mature enough to be used in the CLF.

# 7. How can the methodology for promoting international collaboration among students in the CLF be described?

The collaborative concept of the CLF is one of its strengths. Today's markets will increasingly require international work teams, so the more this aspect is worked on in the educational process, the better prepared people will be.

#### Conclusion

The company representatives see great potential for their companies in participating in the CLF as well as for learners, who can be better prepared for future demands of the world of work and contribute to digital transformation processes of companies. Making contacts, the intensive exchange with others and cultural competences present great benefits for participants. Core competences mentioned by representatives are already included in the EXAM4.0 Competence Model, which presents a key part in the integrated courses of the labs. Competences such as interdisciplinary understanding and skills as well as transversal skills such as teamwork, reliability, commitment, and autonomy are relevant for future employees and meet company needs. Moreover, regarding competences referring to management, companies estimated quality management and project management as important competences to be acquired, while risk analysis, stress tolerance and resilience will be vital for students and future employees. Furthermore, the representatives also pointed out further contents that should be added and considered in the labs, for example process thinking, skills referring to supply chain management, targeted communication, agile working and dealing with failure. Cybersecurity will also be crucial for the collaborative projects of the CLF.

**Communication and miscommunication** present the highest risks of this project according to companies. The labs and EXAM4.0 learning factory should also be scalable and easily adaptable regarding future developments and new emerging technologies. Participants also mentioned concerns regarding the intellectual property. Administrative barriers can evoke difficulties regarding the exchange of information between partners as well as the comparability and scalability of data generated in different education systems can also present an obstacle of the CLF. Furthermore, learners' motivation is also a high risk due to decentralized labs with international locations, and keeping every participant on board. However, the international approach and character of this collaborative learning factory is the main advantage for students to acquire intercultural competences and intelligence, getting to know different approaches and perspectives.

Representatives of companies also pointed out **the practice-oriented approach of the CLF** and problems close to business realities with which students can gain experience. In terms of companies, participating learners present well prepared and skilled potential employees, who are experienced with working in international, interdisciplinary teams and have experience of agile working and evidence-based networking. Participants of the CLF, trained in highly digitized environment can serve as digitized pilots and help creating an I4.0 culture. This will be important to reduce and prevent resistance towards change and new technologies in companies. In addition, the representatives stated that another important advantage of CLF for companies is that **technologies can be tested in advance** before investing and implementing in them.

Finally there are interesting remarks on the **challenges from an operational point of view:** On the one hand, the **administrative barriers involved in working in collaboration between countries with different education systems.** There may be differences that make it difficult to work smoothly and that will need to be considered.

On the other hand, there is the **operational management of the CLF**. An initiative of this calibre needs strong leadership. The group leading the CLF needs to set up a clear, precise, and efficient operational management so that all participants understand and perform their tasks properly.

As a conclusion, the companies participating in the pilot validation of advanced manufacturing labs in VET/HVET consider this initiative an important contribution to the adaptation of VET to the requirements of Industry 4.0. The potential of the CLF proposed in EXAM 4.0 as a tool to work on and reinforce the skills required in Advanced Manufacturing is confirmed.

