WORKING PAPER

Future of manufacturing

Jules Verne Manufacturing Academy – France

Company initiatives to align apprenticeships to advanced manufacturing

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Eurofound reference number: WPFOMEEF18057

Related reports: This company report is one of the 14 company reports conducted in the framework of the project Future of Manufacturing in Europe by wmp consult – WilkeMaack GmbH and partners.

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This is a publication from *The Future of Manufacturing in Europe (FOME)* project.

FOME is a Pilot Project proposed by the European Parliament and delegated to Eurofound by the European Commission (DG GROW).

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Contents

Introduction

Scope of the research

This case study report is part of the study 'Policy developments and practices of apprenticeships in selected EU Member States and world competing regions' carried out in five EU (Denmark, Germany, France, Ireland and Italy) and two non-EU countries (Australia and USA). The study is conducted in the frame of the Pilot Project 'The Future of Manufacturing' (FOME), proposed by the European Parliament and delegated to Eurofound by the European Commission (DG Internal Market, Industry, Entrepreneurship and SMEs).

One of the objectives of this study is to provide an analytical overview of apprenticeship systems in the selected countries and to review changes to the current systems following labour market shifts, changes in employment, career and mobility patterns and technological and structural change. Particular emphasis is placed on the impact of new technologies and the need for a high skilled and adaptable workforce in manufacturing and advanced manufacturing. This research is carried out in response to the increasing interest in apprenticeships among policy makers to tackle skills mismatches but also to integrate young people into the labour market. The appeal of apprenticeships is also growing particularly in a context where new technologies are transforming work organisation and production processes across all sectors, particularly manufacturing. The findings from this research will feed the policy discussions around the role of apprenticeships for the future of manufacturing and inform policy making in the context of current or planned reform of apprenticeship systems and the necessary links to be established between education/training and industrial policies.

For general information on advanced manufacturing and the apprenticeship system in France, the case study report builds on the information contained in the national report on apprenticeships in the advanced manufacturing industry in France that was elaborated during the first phase of the study (Eurofound, 2018).

The case at a glance

This study focuses on an innovative local partnership between industrial research and apprenticeship to develop the skills of the industry of the future. This partnership aims to create a dual training school for the industry of the future. This school, called 'Jules Verne Manufacturing Academy' (JVMA), will open in less than two years but already educational actors and industrialists cooperate in this Region (Loire-Atlantique *département* in the Western part of France).

This initiative is supported by the Technological Research Institute (IRT) Jules Verne and the professional organisation UIMM (*Unions des industries et des métiers de la métallurgie*, Union of engineering industries and trades). Local authorities and companies created the IRT Jules Verne in 2013 as part of the government's program 'Investment for the future'. Its objective is to strengthen the competitiveness of strategic industrial sectors through the application of advanced or disruptive technologies in their manufacturing.[1] Research, development and the transfer of new technologies to industry are the two main activities of the IRT. This centre has quickly become a

[1] In 2014, a first list of 34 strategic sectors was elaborated. The most relevant of them for advanced manufacturing are innovative transport, digitalisation, robots, connected items, digital health, big date, cloud computing, connected objects, innovative textile, cybersecurity, nanoelectronics, embedded software and systems, electric propulsion satellite, etc.

reference in the field of advanced technologies, with more than twenty patents filed by the IRT. There exist eight IRTs in France, all having the same objective to create bridges between research and industry. Research projects led by the IRT Jules Verne are developed by companies and co-financed by the State. The fields of research are robotics/collaborative robotics and augmented reality, the numerical simulation of structures and processes and the innovative processing of composite and metals.

In 2015, the IRT launched the so-called 'Jules Verne Manufacturing Academy' or JVMA. It aims to train apprentices for these technologies. This school will open in 2019. Its goal is to create 1,000 teaching places, half of which will be reserved for apprentices from local schools. The other half will be reserved for students pursuing university curricula. This new school aims to pool the technological equipment of the high-level IRT with a dozen dual training institutions. These institutions will be able to relocate their training within this school to benefit from this technological equipment.

Before the opening of the school, the partners of this project started to adapt the local training offer to the anticipated technological evolutions. About 20 qualifications have been identified and adapted since 2015. A dozen diplomas have been adapted with the support of the IRT. In addition, the IRT is working to improve the attractiveness of apprenticeships in industrial trades. An initiative has been launched since 2013 which consists of organizing an annual meeting between young people looking for an apprenticeship contract and businesses in the region. In 3 years, this has made it possible to create 1,000 work-study contracts (either through apprenticeship or 'professionalisation' contracts[2]) in industry.

Assessment of the case study against selection criteria

As regards the four different forms of adaptation of apprenticeship that are addressed by the research[3], the case concerns the type c) creation of company apprenticeship/training programmes, and d) organisation of apprenticeships/training in (regional) clusters. It fulfils all the designated selection criteria.

Structure of the report

The report is divided into three parts: a general part with background information, (including context factors; a descriptive part which outlines the set-up and implementation process; and an evaluative part which deals with outcomes and impact. In a final section, the initiative is viewed in a broader perspective and in relation to the continued development of apprenticeships in the advanced manufacturing sector, and relevant conclusions are drawn – also in the light of subsequent developments.

[2] In France, the word *alternance* globally refers to dual training. It comprises apprenticeship which in the French context specifically refers to young people in initial vocational training (through apprenticeship contracts combining work in company and learning in CFAs – apprenticeship training centres) and professionalisation contracts open to anyone without no condition of age (though the most often concerning young people) in the continuous vocational system. Professionalisation contracts are organised around training/educational institutions (high schools, universities, etc.).

[3] These are: (a) modernisation of a specific occupation; (b) creation of new occupations/emerging occupations; (c) creation of a company apprenticeship / training programme; and (d) organisation of apprenticeships/training in (regional) clusters.

1 Context factors

1.1 Regional/sectoral and/or company-specific set-up

The Loire Atlantique region is characterized by a strong presence of industry compared with other French regions. It is the second most industrialised region with 16.4% of industrial jobs against 12% on average in France. Engineering[4] , the manufacture of transport equipment (aeronautics, nautical and naval industry, and automobile), chemicals and agribusiness are the most important activities. There are a large number of national industrial groups such as Airbus with two large production sites (5,500 employees), STX shipyards, Areva, Dassault, PSA (Peugeot-Citroën), Safran, DAHER, Beneteau, EDF, etc., but also a dense fabric of SMEs that work in industrial subcontracting for large companies. There are also SMEs in industrial services (engineering, digital solutions, etc.) working with large groups.

Industrial production is much stronger in the region compared with the national average. As a result, demand for skills is stronger. This results in the lowest regional unemployment rate in France, but also labour shortages in certain industrial occupations, particularly in the assembly trades (boiler-making, welding and machining). The offer of dual training seems insufficient in these professions and apprenticeship often suffers from a negative image here, as in the rest of the country. The take up rate of apprenticeship places in certain industrial sectors does not exceed 60%. Improving the image of industrial learning is therefore one of the priorities of local actors. However, compared with the French average, the region shows a higher growth in the number of apprentices. It increased by 5.8% in the region between 2010 and 2016, as compared with 0.9% in France. Given the region's industrial specialisation in high technology products (aerospace, shipbuilding, electronics, mechanical industries, etc.), the demand for higher learning has increased more strongly in the region (+ 39% in the region against + 29% in France).

1.2 Relevance of dual apprenticeship

The actors interviewed in the context of this study unanimously consider dual training as the best way to meet the needs of industrial companies and also an important way to combat youth unemployment. For companies, dual training leads to the development of skills that are actually used by companies. As stated by the head of an apprentice training centre (CFA, *centre de formation d'apprentis*), 'knowledge acquired through dual training (*alternance*) is the closest to the company.' Companies supplement the training of graduates with internal training to make them directly operational, for instance in maintenance. Dual training looks quite effective, especially for two types of companies. First, those experiencing rapid development with immediate needs are in operational workforce. Second, those affected by recent developments in technologies requiring new skills to support their transformation. The latter type of companies is generally composed of subcontractors for large industrial groups that impose the use of new technologies (for example, innovative composite materials for aeronautics and the automotive industry). For these companies, acquiring skills through higher apprenticeships[5] is the most effective way to meet the requirements of industrial contractors.

In practice, the general system of dual training (*alternance*) and in particular the apprenticeship system is however not always optimal. In some industrial sectors, for instance in engineering, there is a lack of candidates because of the general negative image of the occupations in this sector. In addition, there are administrative difficulties in adapting the training offer for financial

[4] More precisely metal and mechanical manufacturing excluding transport equipment.

[5] Apprenticeship in post-graduate curricula, in particular in engineering.

reasons. Also, the coordination of actors is complex. There are sometimes divergent interests between the various actors, especially between local authorities. There is sometimes competition between the different actors to attract training centres. The challenge for elected representatives, especially in rural or semi-rural areas, is to offer possibilities for families to ensure that their children are trained locally, as a trained workforce helps maintain and develop local businesses.

1.3 Needs and challenges related to manufacturing and advanced manufacturing

Major technological developments in the local productive fabric include robotisation, digitization, innovative composite materials and additive manufacturing. These developments concern four major industries: aeronautics, naval and nautical industries, land transport equipment and energy.

In 2005, companies in these sectors joined to create a competitiveness cluster, the so-called EMC2 (abbreviation for *Ensembles Métalliques et Composites Complexes* – Engineering Groupings and Complex Composites), which aims to create an innovation-friendly ecosystem. The IRT Jules Verne, which is also supported by the same manufacturers, has oriented its research projects towards the technological evolutions of these industrial sectors. These evolutions have deeply transformed the traditional industrial trades and have brought new jobs. Among the transformed professions are welding, machining-adjusting and industrial boiler-making. These are the engineering work processes that today require new skills due to new automated processes being introduced, such as cobotic welding, innovative metal machining, or non-destructive testing of the quality of machined products. For example, two robots have been developed by researchers working at the IRT Jules Verne, one in aeronautics for machining and the other in the shipbuilding industry for welding; these are collaborative robots (cobots) that work with humans. It requires new and high-level skills to work in these trades assisted by robots. More generally, the digitalisation of factories requires adapting the skills of a large number of workers and technicians. For example, sensors that measure the degradation of machines and tools require new skills of workers in reading and understanding the measurements digitized by these sensors.

2 General information on the case

Background and reasons of initiating the practice

The IRT was created under the government program 'Program of Investment for the Future' or PIA, launched in 2013 and relaunched in 2015. In total, this program represents a public investment of 22 billion euros. In this context, 2 billion euros have been earmarked for the creation of eight IRTs in France. These structures are platforms of research and innovation where researchers from public and private laboratories (companies) collaborate.

The IRT Jules Verne was created at the initiative of industrialists in the region. It is the manufacturers and the competitiveness cluster EMC2 that defined the orientation of this institute according to local industrial issues. It is dedicated to industrial research in advanced production technologies for composite, metallic and hybrid structures. This technological orientation is related to the technological developments experienced by the partner companies (Airbus, STX, Daher, Areva, Dassault, PSA, Safran, etc.). The reasons that led the industrialists to participate in this project is the need to pool research and development efforts in cross-cutting areas, such as robotics, innovative materials and additive manufacturing.

The originality of this initiative is the fact that the research projects supported by the IRT are decided by the companies themselves. In fact, for a research project to be supported by the IRT, it must be supported by at least two companies in a technological field that presents a common challenge to these companies – that is, a challenge in terms of innovation (developing new processes or new products). The IRT will then expand the partnership to other companies to give it greater stability (funding, researchers and leading experts). The cost of the project is co-financed by the participating companies and the IRT equally (50-50). In addition, the IRT provides the research teams involved in this project with high-level technological facilities and equipment.

In connection with those technological areas that present a common challenge to companies in local industries, the IRT plans to organize and develop dual apprenticeships for the industry of the future. The project has two stages:

- Adaptation of the supply of training. The first step is to establish advanced cooperation with current training organisations (mainly CFAs[6], vocational schools and higher education institutions) in order to adapt their training. This means developing training, in phase with local business needs in the industry, in terms of content and training methodologies.
- Creation of a proper 'dual training' school. The second step is to create a school dedicated to dual training (called Jules Verne Manufacturing Academy or JVMA – box 1) offering 20 diplomas, some of which are currently provided by the various training institutions. The school aims to pool partner institutions with the high-level technological equipment currently used by the IRT for its research and other equipment, with an investment of € 6 million.

This interlinkage between research in advanced technologies and dual apprenticeship training in industrial trades is a unique initiative in France, according to representatives of IRT management. Its specificity lies in the fact that several institutions including CFAs are involved in this model. The large-scale cooperation between applied research and work-study training is likely to create an ecosystem conducive to learning in industry. As noted by the training manager of the professional organisation UIMM, 'the ‘industry of the future’ label improves the image of jobs in

[6] *Centres de formation en apprentissage* or apprenticeship training centers, i.e. schools for young people in apprenticeship contracts.

industry amongst young people and teachers'. In addition, this cooperation allows training institutions to anticipate future skills needs that may appear with innovations developed by the IRT. They will then be more responsive to the need to adapt their training offer to the technological developments identified.

Box 1. The Jules Verne Manufacturing Academy

JVMA is a dual training school that will open in 2019. The initial project was launched in 2015. The school will be managed jointly by the region and the Jules Verne IRT. 1,000 students, half of them following dual training courses. A part of these students will be directly enrolled in this school and another part will be students from 10 partner institutions. These partner institutions will relocate their training within the JVMA to benefit from its advanced technological equipment. The initial project investment is estimated at 25 million € of which half in technological equipment: numerical control systems, industrial robots and cobots, 3D printers, robotic injection presses, injection machines of capacity grades, etc. This equipment will be installed in a factory-school to create an environment similar to that to be found in industry. Training will focus on the latest technologies in assembly, welding, bonding and robotics, modelling, process simulation, production management, plant organisation, etc.

In 2017, the project was downsized by the new regional government elected at the end of 2015 due to cost reasons. From then on, this project is now being taken over by the professional engineering organisation (UIMM) which will set up its own training centre (called AFPI, *Association de formation professionnelle de l'industrie* or Industry Vocational Training Association) in the premises of the JVMA. This training organisation is a CFA of 1,000 apprentice students in the trades of the industry. The idea of pooling the technological equipment of the IRT is maintained. The 10 training institutions in the region will benefit from this equipment but less than originally planned. The big winner of this change is the AFPI training centre which will have at its disposal a modern site of 3,000 m2 and advanced technological equipment.

General and detailed objectives and expected results

The general objective of the IRT is to develop advanced technologies to improve the competitiveness of local industry and ultimately to create new industries of the future. The founders of this project have defined three industrial areas that frame the research roadmap of the IRT:

- Robotics – collaborative robotics (‘cobotics’) and augmented reality
- Innovative composite and metal materials - additive manufacturing
- Simulation and numerical modelling of structures and processes.

From this main general objective, other effects are expected. The first is to create sustainable cooperation in the field of industrial research with the pooling of resources: between companies from different sectors and between companies and the academic world.
The other expected effect of the IRT is the transfer of technology throughout the region's industry. Companies, especially SMEs, will be offered IRT support to use the innovations launched. The EMC2 competitiveness cluster is working with the IRT to develop these technological transfers.

Box 2. Example of four IRT innovations

Currently, 73 research projects are being undertaken, of which four are 'achieved', that is have reached a level of technological readiness and innovation created in the laboratory that is validated or demonstrated by a prototype (the next step would be application at the company level):

- The automatic welding cobot for the ship industry. This cobot designed by the IRT is capable of carrying out vertical support operations on the hull of boats that are difficult for technicians to access. It improves the quality of products, the working conditions of technicians and the productivity of factories.
- A mobile cobot for assembly operations in aeronautics. This cobot moves autonomously within the plane. It assists the technician in the assembly of parts with greater precision.
- The manufacture of composite turbine blades for marine energy: prototype marine turbine blades made of composites are designed to enable a consortium of regional SMEs to consider low-cost automated mass production.
- Multi-material assembly in the automotive industry: designing assembly processes between steel and composites to lighten the weight and improve the energy consumption of vehicles.

Another main objective pursued by the IRT – and hence a motivation for the selection of this case study – is the development of dual training or *alternance* in the French vocabulary (i.e. apprenticeship and professionalisation) in the industry of the future in connection with the research projects that have been carried out. Starting from the observation of a lack of supply of skills in the advanced production trades, as shown by a study of the regional office of industrial skills[7], the IRT plans to develop the supply of through the school dedicated to the dual training mentioned above (Jules Verne Manufacturing Academy or JVMA), which is still under development. The goal is to reach 1,000 students, half of them following dual training programmes. This school will train technicians and technology engineers for new industrial jobs likely to be developed in the coming years in companies in the region. Companies will thus have a high level workforce, operational and responsive to technological developments.

Before the opening of this school, the IRT has adapted its local training programs to these technologies. Twenty diplomas have been identified by the IRT in connection with its areas of research. The IRT then brought its technical expertise and knowledge of advanced technologies, and a dozen diplomas have been reviewed and revised. The future school already has its site (3000 m2) offering advanced technological equipment (prototypes of industrial robots, 3D metal printers, forming press, means of injection of composite materials with large capacity, a test bed of large structures, etc.).

The beneficiaries of the initiatives led by the IRT are, first and foremost, the partner companies that can build on the spinoffs of the research projects. Training institutions will also benefit from these developments to improve the training they offer.

These innovations are generating new skills needs in the companies that use them. In consultation with partner companies, the IRT has identified their needs and the qualifications that require revision in order to adapt to technological developments. The institutions that deliver these courses have been accompanied by the IRT to adapt their training, for example, qualifications in the field of boiler-making or welding, the creation of a post-graduate diploma in 2016 for International Technologists in welding, a diploma at the same level as the one in Non-destructive

[7] ORCI, an institute created by UIMM, the Region and the IRT.

Testing, another welding qualification and finally, the creation of a post-graduate diploma in composite plastics (EQF level 6).

The action of adaptation and creation of appropriate qualifications is of benefit to educational establishments (CFA, university and schools); students in apprenticeship, allowing them to have better training and more chances of finding a job; and finally, companies that can recruit from an operational workforce.

Another initiative that should be highlighted is the launching of regular large-scale meetings (like job matching activities) which aims at facilitating the link between apprentices and companies in the region. It has thus far allowed 1,000 young people to sign a work-study contract (apprenticeship or professionalisation) since 2013. This action has become an unmissable event for industrial companies and young people in the region and students. In 2017, it welcomed 450 young people and 85 recruiters from 37 industrial companies for 350 work-study positions on offer. There were also 30 vocational training colleges offering 75 industrial qualifications. 1,100 interviews were conducted that day. 68% of contracts signed were apprenticeship contracts and 32% professionalisation contracts. Around half of these contracts are for higher education (EQF level 6 and above).[8]

These meetings also make it possible to establish or develop relationships and networks. As regards young people, to quote a manager of the IRT, 'we give them the chance, especially for the least favoured, to benefit from this network of companies and training organisations to develop their professional future' (IRT Manager). It is also an opportunity for companies to create a source for future recruits: 'We can already select interesting profiles that we can draw as soon as we have a request from operators. In this way, we progress faster in hiring' (according to a recruiting manager interviewed on the site of the IRT).

Linkages to national programmes and initiatives

The qualifications that have been adapted or created on the initiative of the IRT are all state-recognized diplomas. For some qualifications, some adaptation has been made, by providing specific options. These options take the form of industrial specialisations designed to meet the needs of business. This is for instance the case of an industrial welding qualification adapted to a specific need in the aerospace industry (automated welding); or again, the development of post-graduate diplomas in the plastics industry towards composite materials used by the aeronautics, automobile, nautical and energy sectors.

The industrial assembly trades (welding, sheet metal work, machining) have been experiencing a labour shortage for two years because of a negative image, according to interviewees. The robotisation and automation of these trades now allows companies to suffer less this shortage. At the same time, innovative metal materials have being used more and more. These transformations reveal new skills needs - hence the adaptation of qualifications to meet the requirements of manufacturers and to improve the image of these professions for young people.

Scope of the programme/initiative

The qualifications concern a wide target group from ISCED level V to that of engineer. But for the most part, they concern secondary levels (*baccalauréat*) and higher-level graduates. The

[8] In detail: the level CAP to Vocational Baccalaureate (EQF level 4) represents 17% of the signed contracts, 41% in BTS-DUT (EQF level 5), 17% in license (EQF level 6) and 24% for the diploma of engineer (EQF level 7).

information acquired concerning qualifications in the CFA concerned shows that these are small groups of 10 to 15 places. The number of places is thus defined according to the needs of the companies. For example, the post-graduate diploma 'plastics and composites' (*brevet de technicien supérieur*, BTS) is designed for a group of 15 apprentices. The latter are essentially apprentices who have already undergone lower level training in the CFA. In this sense it is a gateway to higher learning. The qualification for the International Welding Engineer has an intake of 10 apprentice students, including students who have completed their engineering studies and who are pursuing this specialisation for one year (higher apprenticeship). The others are engineers with a job contract who wish to supplement their professional experience with this specialised type of training.

3 Project design, planning and implementation

Needs assessment and type of change implemented

The adaptations discussed above are implemented after an annual diagnosis of skill needs in the industrial trades at the local level. To this end, a regional observatory of industrial skills (ORCI) was created in 2012 to identify needs and guide the training policy of the region to adapt the training supply to the current technological challenges. This observatory was created and co-piloted by the professional organisation UIMM, the IRT Jules Verne and the Region. In its latest study (2017), its skills needs survey was conducted among 24,000 industrial enterprises and covers 200 industrial trades. It shows a 17% increase in recruitment projects in the industry in 2017 compared to 2016. This survey identified a shortage of manpower in several industrial trades. One of the main reasons is the imbalance between the needs of firms and the skills available in the local labour market. The mechanical and materials industry, which accounts for half of the hiring projects (i.e. 5,000 jobs), is the sector that had the most difficulties to hire. Four industrial activities are principally concerned: the automobile industry, engineering, aeronautics and shipbuilding industries, and finally the manufacture of machinery and equipment.

The main professions where skills are required are:

- Qualified mechanic maintenance workers
- Qualified workers in electronics and electricity
- Production Engineers
- Welders (skilled workers, technicians, and senior technicians)
- Boiler-makers (skilled workers, technicians, and senior technicians)
- Machinists (skilled workers, technicians, and senior technicians)
- Maintenance technicians
- Unskilled workers in engineering
- Unskilled workers in electronics and electricity

The IRT tries to complete this diagnosis by matching the needs of companies with existing training opportunities. The main adaptation initiatives put in place are of two types. First, the adaptation of diploma reference systems to the skills of the engineering and mechanical industry: welders, boiler-makers and manufacturers of precision metal parts. A second field of adaptation are improvements of local training with the introduction of new qualifications. This mainly involves setting up new qualifications that do not exist in the Loire-Atlantique administrative region. Five new qualifications have been created.

The project of the future school JVMA plans to set up a new pedagogy that consists of mixing apprentices of different levels of qualification in the same training group. This is a need expressed by the CFAs, with the aim of improving the level of the least qualified apprentices. For the better qualified, this allows them to discover the professional skills required for managers and for joint project coordination (source: interview with CFA). A more advanced perspective of this pedagogy consists of mixing students with different backgrounds (school training, apprenticeship,

continuing learning, etc.). This contributes to the 'decompartmentalisation'[9] of the French training system (National Council of Industry, 2017).

According to one of the CFA representatives interviewed in the context of this study, 'one of the conditions of our participation in this school will be the possibility of developing this pedagogy that we consider innovative. Moreover, we currently have a project with the University of Nantes to set up this pedagogy soon" (CFA Training Manager). Indeed, this CFA and the university collaborate together to improve the level of learning, including establishing a promising gateway to higher learning. The CFA welcomes IUT (technology university) students in its workshops for training in composite processes. In return, the university opens its training to apprentice students of the CFA to continue their studies towards higher qualifications.

Involvement of different actors

The main actors are the IRT Jules Verne, educational institutions (two CFAs and two universities in our case), the UIMM and other professional organisations, companies and industrialists.

A specific case that we have analysed in more detail illustrates the cooperation of different actors but also the issues and tensions that might have emerged. This is the creation of a post-secondary diploma (BTS) in plastics and composites in a CFA of the region, at the initiative of local actors. However the region and the rectorate concerned were reluctant to support its creation, for the simple reason that this qualification already exists in a nearby 'department' and is delivered by another CFA. The risk of competition between the two institutions and the financial cost were advanced as arguments. According to one of the actors interviewed, 'local political issues also played a negative role'. Here we find the inevitable political tensions between the territories around the evolution of the regional map of initial and vocational training.

It required the intervention of Airbus group and the IRT for the region to finally authorize the creation of this diploma in 2015. The argument put forward by the aircraft manufacturer and the IRT was the lack of regional training in this skill (plastics and composites) to meet the needs of the aerospace industry (interview, IRT). According to the CFA manager in question, 'there is room for two CFAs addressing these composite skills'. There is also some flexibility in the precise content of the curriculum leading to the same qualification awarded by two professional high schools or two CFA.

This flexibility is not always available, according to the head of the IRT, because it requires mobilisation of funds and the training of trainers. Designing new training that responds to the technological evolutions of companies requires, according to him, finding suitable equipment to train students and teachers. However, not all CFAs and local authorities have sufficient financial resources to invest in new training. The pooling of technological equipment (through a single industrial learning platform) would be a response to this problem. Moreover, this is the objective of the IRT with its JVMA project to make available its research equipment to local training institutions.

For the manager of the UIMM, adapting a diploma requires a good knowledge of local skill needs in business: 'Our role is to help educational institutions better understand the technological changes actually implemented in companies and the skills needs they imply' (UIMM). In collaboration with the IRT and the Region, the UIMM has created an observatory of industrial skills, which carries out an extensive study each year to identify skills shortages.

[9] Actually, the dual training system is very complex in France. One has to distinguish between public/private, apprenticeship/professionalisation, vocational education/alternating, etc. Hence the idea of a very 'compartmentalised' system.

Another example illustrates innovative cooperation between a vocational secondary school (*lycée professionnel*), local businesses and the Region in improving training. It is a factory-school created in 2017 by the professional secondary school La Joliverie (which hosts a CFA) in collaboration with manufacturers of industrial machinery (Haas, Schneider, Siemens, Rockwell and Fanuc). These companies and the Region co-financed the construction of this factory-school, and also its equipment needs, at a cost of 8 million euros. The technology park of this school contains 15 computer numerical controlled machines, 2 3D printers, 40 PLCs, 1 metrology laboratory and 2 Fanuc robots, according to the CFA website. The aim is twofold: to improve the attractiveness and level of training in industrial occupations on the one hand, and to enable companies participating in this project to train their employees and their customers in line with technological evolutions, on the other. 450 young people are enrolled in this school in initial training and alternating in industrial training from vocational secondary diploma (level V) to bachelor degree.

This school-factory looks like the model of the JVMA of the IRT Jules Verne, but with one particular difference. The JVMA supports the training of different CFAs of the region, sharing a common goal of pooling equipment and resources. By contrast the Joliverie factory-school is dedicated to the students of one particular CFA and employees of partner companies.

Financing

The financing of the initiatives mentioned here, whether it is the creation of the JVMA, the adaptation of the supply of training or the Joliverie factory-school, has mobilized public and private funding. The Region is the main funder of modernization initiatives in the apprenticeship sector. It has co-financed the creation of the JVMA, the La Joliverie factory-school, and the operating costs and equipment related to the creation of a new diploma.

The novelty to be found in this type of funding arrangement concerns the JVMA where the State participates via the IRT Jules Verne (the State being financially supporting the IRT). On a starting budget of 30 million euros, 10 million were provided by the State and 15 million by the region. The rest is brought by the city of Nantes for the construction of a student housing and by the UIMM and industrialists. But in October 2017 as mentioned above, the newly elected regional council finally decided to reduce by half its financial participation considering that the cost of this project was too high.

The other novelty is the participation of companies in the Joliverie factory-school project. For them, the expected return on investment is the use of the equipment of this factory school for the need of the internal training of employees and also customers of these companies.

Concerning salaries, the apprenticeship or professionalisation contract guarantees an income to students varying from 370 € per month to 1,185 €. The level of this progressive salary depends on several elements, principally the level of the qualification and the age of the apprentice (see Eurofound, 2018). The wages are paid by the companies but they benefit from exemptions from social security contributions and other forms of state aid.

In addition, local authorities provide various supports for the mobility and accommodation of apprentices. A new residence of 100 units was built in 2017 for JVMA apprentices. In addition, they receive financial aid for transport, food and accommodation.

Other forms of local, regional and/or national support and expertise

Other actors complete the ecosystem structured by the IRT Jules Verne. At the national level, the Alliance for Future Industry, which is a national platform for the promotion of the industries of the future (including different actors, mainly employers' associations, but also Chambers of Commerce or research institutes), brings in its expertise on advanced technologies, such as the

additive manufacturing research project to which the IRT is associated. The IRT is able to get closer to SMEs on the basis of support from the EMC2 competitiveness cluster. An initiative, called 'seed of innovation', was launched to enable engineers from three schools to immerse themselves in voluntary SMEs to work on their research and development issues. This offers effective experience for the students and brings value for SMEs, according to them; this experience might lead to future recruitments. The EMC2 cluster has also created a label named 'by EMC2' awarded to innovative projects in the industries of the future. This label can be awarded to diplomas or innovative training programs.

Implementing the programme/initiative

The manufacturing academy project (JVMA) was launched in 2015. This project is related to the technological innovations developed at the IRT with the idea that these technologies will be taught in this school. The aim is therefore to train technicians and engineers on advanced manufacturing processes so that they are operational as soon as they leave school. In France, companies are often obliged to complete the training of young people hired by additional internal training, because they are not fully operational. The ambition of the JVMA is therefore to change this and to make the young people directly operational. In other words, 'it is to make sure that the difference between the reality of the company and the training is as thin as possible' according to the UIMM partner of the IRT in this JVMA project.

The JVMA project, still ongoing, has so far been implemented in two stages. The first has been to establish advanced cooperation with current existing training organisations (mainly CFAs, vocational schools and higher education institutions) in order to adapt their training. The purpose of this cooperation is to help these institutions to improve the attractiveness of their training and to adapt certain qualifications or to create new ones to anticipate technological developments. The IRT has identified 20 qualifications awarded by 10 institutions. Of these qualifications, about ten have been adapted or created[10].

The second step, which is currently underway, is the regrouping of the 20 qualifications identified within the manufacturing academy, which will open in 2019-2020. This school aims to pool with ten partner institutions the technological equipment of the IRT currently used for its research. School workshops specialised in the implementation of composites and metal structures are already installed. According to an IRT official, 'we will be teaching the latest technologies in assembly, welding, collage, robotics and automation'. The partner institutions will thus be able to create new training courses, something they cannot do at the moment due to the lack of technological means. The teaching methodology is innovative. It consists in bringing together in training groups students of different levels (multi-level teaching). This was emphasised by several CFAs in the region to improve the level of apprentices. According to the head of the IRT, 'the idea is to create bridges and common modules, to associate the academic world and the engineering schools, but also to include technicians, operators and engineers in joint projects, to make sure that they learn to work together.' In addition to the objective of raising the level of apprentices in CFA (in general preparing qualifications from EQF level 3 to post-graduate diplomas), this mix with engineering students or specialists is intended to improve the attractiveness of training in apprenticeship. Such a mix is also deemed to encourage apprentices to continue their studies in higher education.

[10] Regarding the creation of new diplomas, there are two possibilities: either existing diplomas at the national level but not in the region are set up, or new specialties or options to supplement existing degrees are introduced.

In October 2017, three years after the start of the project, the JVMA was scaled down. Considered too expensive, the regional council decided to reduce its financial contribution to € 5 million instead of the € 10 million originally planned. The goal remains to create a work-study school which will now be managed by the UIMM professional organisation and no longer by the Region. Moreover, the internal CFA of the UIMM (called AFPI) will move next year to the site of this future school. The IRT will bring its technological equipment and expertise but will not be the main operator. The 10 CFAs will be able to benefit from the technological equipment of this future school but with a different approach. It is no longer about relocating their training within the school as originally planned but participating in shorter training sessions. Access to technological equipment will be reduced for these institutions and their apprentices. On the other hand, the AFPI and its students will be the big beneficiaries of this change after their move to the future school. The AFPI, which has experienced difficulties in recruiting apprentices in recent years, will thus be able to modernize its training and raise the level of the qualification offered, according to its training manager: 'This JVMA project is a great support, as the AFPI cannot afford the technologies of the future because of their cost. This relocation will improve the quality of training and offers new degrees in higher learning.'

The region decided to participate by financing the technological equipment of the future school. It contributes up to 40% of the budget. The State, through the IRT, completes the financing. The Nantes metropolitan area is also involved in the construction of the building, including the residence for future students. It must be remembered that the difficulty of mobility of young people, due to lack of housing supply in the Nantes metropolitan area, is one of the obstacles to participation in apprenticeships in the region and more generally to integration into employment.

Finally, the 10 training institutions - including three CFA, two universities and three engineering schools - will participate through the relocation of their training in the future school. An entry fee not yet established will be required to use the IRT technology equipment. According to one of the three CFA managers, “it is normal to pay a fee to at least participate in the maintenance of this equipment, but this rate should not be a deterrent, otherwise there is a risk of excluding some CFAs”.

Quality assurance mechanisms

The quality of the revised qualifications is controlled by academic inspectors under the authority of the Ministry of National Education). The inspection guarantees the conformity of the qualifications issued by the institutions to national standards.

This quality control is complemented by other evaluation measures. The first is the labelling by the competitiveness cluster EMC2 (label 'by EMC2') of innovative projects, including training projects. The second measure consists of an internal evaluation of the results of training. In accordance with the agreement with the Region and Ministry of National Education, schools must conduct a survey of apprentices who have completed their training to measure. This ex-post evaluation relates to non-completion rates, graduation rates and transition to work rates

Concerning the AFPI, the results of the last survey were as follows:

- Graduation rates: 86% at AFPI (in the agreement with the region a target of 85% was set)
- Non-completion rates: 5% at AFPI, in comparison with 12% on average in the region and 20% at national level
- Transition to work rates: 80 to 85% of AFPI students.

Skills of involved training and mentoring personnel

The representative of a CFA interviewed in the context of this study indicated that they have each year a training session for their trainers and for apprenticeship supervisors in companies (mentors). This is part of their contractual commitments. For teachers, the training programme is managed by the Human Resources Department of each institution following the recommendations of the region. According to a CFA representative, they propose every year two days of training for in-companies mentors: 'this is an objective fixed with the Region. But the results are mixed. The participation rate in these courses remains relatively low'. The lack of interest in this training can be due to their quality or to their lack of relevance. The aim of this training is to professionalize the tutors. They learn how to accompany apprentices, to make assessments and to transmit knowledge, etc.).

Difficulties and challenges during implementation

The problems encountered in adapting the training courses, as developed above, are primarily administrative. Adapting the vocational curriculum is a long and difficult process, requiring a procedure of about 2 years. The intention is for the IRT to bring its expertise to bear to rapidly meet the demand of training institutions.

The second difficulty is financial. The region has to manage the creation or evolution of qualifications in a context of declining budgets. Institutions must therefore convince the region when asking for creating or modifying qualifications which should not compete with other existing qualifications.

Regarding the creation of the JVMA, the main difficulty is financial. This problem did not exist at the start of the project in 2015 since an agreement was found on the sharing of the financial participation between the region, the State and the UIMM. With the political change at the regional level (after the 2015 elections), the Region decided in October 2017 to reduce its participation. This decision does not call into question the creation of the school but reduces its initial ambitions.

4 Outcomes, impact and lessons learned

Major outcomes and impacts on company and region

The expected impact of this initiative is to improve the supply of skills at the local level in order to improve the competitiveness of the local industry. The observation shared by the actors is that there is a shortage of qualified labour in certain industrial trades and that there is a lack of responsiveness of the training offer to technological developments in the local industry.

To cope with the shortage of skills, dual apprenticeship training appears to be the most relevant way, according to representatives of CFAs and UIMM. However, a problem is the lack of interest shown by young people for this type of training. Many students prefer general curricula at a university rather than dual training, particularly as industrial jobs are often associated with difficult working conditions. Hence a series of initiatives to change the image of these professions towards young people has been promoted by the UIMM, in collaboration with the Academy of Nantes, the IRT and the CFAs. The best way to improve attractiveness is to show young people that apprenticeship leads not only to better professional integration, but also to a better career outlook in the industry (according to the UIMM manager). The 'Gateway to Higher Learning' is an initiative that goes in that direction. This is a partnership between universities, engineering schools and vocational secondary schools to encourage young people to consider pursuing vocational studies towards a higher level. This is the case of the collaboration between a CFA (hence young apprentices) and the University of Nantes for training on composite processes that allows apprentices from both institutions to work together. Multi-level pedagogy (associating CFA apprentices, engineers and university students in the same training group) that the JVMA wants to set up also pursues this objective.

According to initial observations, the image of apprenticeship or *alternance* begins to evolve. As the head of the UIMM testifies, 'according to the feedback I have from the training institutions, more and more young people are spontaneously coming to vocational training courses. There is evidence that the image of industry is beginning to change.' According to her, 'the trend of *alternance* has reversed in the last two years. After a steady decline, the number of industrial apprentices is starting to increase. In our industrial trades, we have an increase by 2 or 3% in the number of apprentices. If we add the professionalisation contracts, the increase would be 5%'. This trend is confirmed by those CFA representatives interviewed in the context of this study.

There is also a promising result regarding higher apprenticeships. Figures from the Academy of Nantes show that the number of students in higher apprenticeships (level III and above) increased by 39% between 2010 and 2016 compared to 29% at the national level. The level of engineer and master (level 1) has increased by 71% in the region against 53% at the national level. We are also seeing an increase in recruitment to newly created or revised qualifications. For example, the rate is 100% in the diploma of plastics and composites since its creation. The engineering curriculum created at Polytech in Nantes (a technological university) in collaboration with the IRT also has an enrolment rate close to 100%. AFPI, which has adapted its educational tools for industrial training (digitization of training, etc.) has also benefited from an increase in apprenticeship numbers. These figures are to be compared with the enrolment rates for other diplomas, which is around 50 to 60% according to interviewees.

Another result to highlight is the innovations launched by the IRT and implemented in companies including SMEs. These innovations in industrial processes are likely to generate significant needs for industrial skills in the years to come. This could further improve industrial apprenticeships in both higher and the lower levels. As stated by various stakeholders, technological developments are affecting the skills of a large number of occupations, including low-skill occupations. The

example of welding is illustrative. This job requires more and more skills in connection with the new welding technologies. Hence the adaptation of 3 diplomas related to this profession.

Attractiveness and capability of apprenticeship

Concerning the evaluation of the project, several numerical indicators can be used. With respect to the attractiveness of apprenticeships, we mentioned above the enrolment rate of places in the CFA and the growth of the workforce. In general, the transition to work rate increases with the level of qualifications. This is the general case in France. But there is also a high transition to work rate for new qualifications created in the region. The growth in apprenticeship numbers is a good indicator of the attractiveness of apprenticeships. It can be coupled with other performance indicators, which are used by some regions (as financers), such as in the Pays de la Loire region. These indicators are: the non-completion rate of apprenticeships and the completion rate. The figures we have gathered show that the region performs rather well: the rate of non-completion is 12%, in comparison the 20% national average. The graduation rate is 83% compared to 80% nationally. In the advanced industrial trades, this rate reaches 93% on average in the region (ORES, 2017).

As noted by the representatives of two CFAs, these rates are also higher than the regional and national average. The AFPI CFA has a pass rate of 86% and a non-completion rate of 5%. The transition to work rate measured in the region is 70% but varies according to the level of diplomas and specialty. It is 90% or more in high technology industrial training (industrial control technologies, computer and data processing, etc.). In a CFA, this rate is between 80 and 85%. In another CFA, this rate is close to 100% in a newly created diploma on composite materials.

With regard to the characterization of apprentices, the usual indicators used are educational attainment, gender and age. The educational attainment level is one of the indicators that actors analyse to evaluate the learning system. The trend in the region is the rise in the level of apprenticeship degrees at a higher rate than the national average. In industry, the share of apprenticeships at EQF Level 6-8 in the region is 15% in 2016, up 7 points compared to 2010. The region is catching up with the French average: 17% in 2016 in France against 12% in 2010 (Academy of Nantes, 2016). According to representatives of CFAs, this trend towards raising the level of qualification of apprentices is accelerating over the past two years.

Key success factors and lessons learned

One of the main success factors of the initiatives identified is the quality of the partnership and the degree of involvement of the various stakeholders in the creation of the IRT Jules Verne and management project. This is particularly the case for local businesses and the region, which have taken a constructive approach from the start. The story began with the creation in 2005 of the EMC2 Competitiveness Cluster by large local companies with the aim of developing an ecosystem favourable to technological innovation. The involvement of large companies in the region such as Airbus, STX, Dassault Aviation, PSA, etc. but also a dozen of internationally highly dynamic SMEs has been crucial in the success of this partnership. Trade unions however are not involved in the process. The State has also facilitated this partnership by giving companies a large degree of autonomy in developing IRT projects. It should also be noted that in this area there is a long tradition of cooperation between industry, the academic world and the public authorities. This has facilitated the development of an industry-friendly learning ecosystem that was structured around the IRT.

The other factor of success is the strong economic dynamism of the region and more specifically the dynamism of local industry. The region is the second most industrialized region of France, with stronger production growth and the presence of a significant number of large companies.

Technological developments in these companies require adapting apprenticeship training, which provides an opportunity to modernize training on offer and attract more apprentices. According to representatives of IRT and CFA's, the Academy of Nantes, being aware of developments in industry, seems to facilitate the task of adapting training to the needs of companies.

5 Commentary and conclusions

This case study shows how cooperation between industry and public and private R&D has been able to create the conditions for the development of apprenticeships, particularly at the higher levels, in the industrial sector. The figures clearly show that there are more young apprentices in the Pays de la Loire region where the IRT Jules Verne is located, than in the rest of France, and specifically in the industrial sector. Another interesting figure is the progression of higher apprenticeship in the region. In the last three years, the number of apprentices preparing higher qualifications has increased twice as much in the region as in France overall.

These good results are linked to the innovation ecosystem developed over the last 10 years, which has been extended to the actors of dual training (*alternance* including apprenticeship). This was done with the creation of the IRT Jules Verne in 2012, one of whose missions is to develop the dual training on offer in connection with its research into industries of the future. This link between research and development and dual training within the same project seems to be a unique case in France.

So far, the action carried out by the IRT has consisted primarily of helping vocational training institutions to adapt their offer to technological developments. The IRT has also taken action to improve the attractiveness of industrial learning by organizing large-scale meetings between companies and young people. A school of dual training (JVMA or Jules Verne manufacturing academy) dedicated to the trades of the industry of the future, will open in 2019. This school will train 1,000 students of which half in apprenticeship and the other half in vocational training. Twenty industrial qualifications are already identified as part of the future training on offer. A site of 3,000 m2 is built, equipped with advanced technological infrastructures.

This school is an interesting model in that it pools high-level technological equipment with a dozen training providers, including CFAs (apprenticeship training centres), schools and universities. This pooling of technological equipment and knowledge allows these institutions to offer high level training that they cannot do at present. The multi-level pedagogy that will be deployed is also innovative, consisting of creating mixed training groups made up of different levels of qualification (from EQF Levels 3 to 7). This makes it possible to improve the level of apprenticeship and its attractiveness for younger people. Beyond this objective, this school model is a form of 'decompartmentalisation' of the different education streams between initial, vocational, apprenticeship and higher education, through innovative educational methods such as mixing apprentices of different levels of qualification in the same training group and mixing students with different backgrounds (school training, apprenticeship, continuous learning, etc.). In the French context which is very compartmentalized, this is innovative.

This school also aims to better match the skills acquired by apprentices with the needs of enterprises. The UIMM, the engineering professional organisation, which ensures the management of the school, will have the opportunity of revising towards areas with skills shortages. The objective will be to train technicians and operational engineers as soon as they leave school, whereas today it is often necessary to supplement their skills by in-company training.

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Annex

A.1 Glossary

Abbreviation	Original term	English translation/explanation
BTS	Brevet de technicien supérieur	Level 5 diploma delivered by vocational secondary schools
Licence	Licence	Level 6 diploma delivered by universities
CCI	Chambre de Commerce et d'Industrie	Company interest representation organisation providing them with support and advice
CFA	Centre de Formation d'Apprentis	Apprentice training centre (as a complement to training received in enterprises). Managed by the Ministry of National Education, or professional branches, or consular chambers
EMC2	Pôle de compétitivité EMC2	Cluster dedicated to advanced technologies. It includes enterprises, educational institutions, public and private research organisations. It is one of the founders of IRT Jules Verne
JVMA	Jules Verne Manufacturing Academy	Dual training school with the professions of the industries of the future
IRT	Institut de recherche technologique	Technological Research Institute. Eight institutes dedicated to advanced technologies were created in 2012 as part of the new French industrial strategy. Their specificity is a partnership between the State and the enterprises.
EQF	European Qualifications Framework	European framework for the comparison of national qualifications
UIMM	Union des industries et des métiers de la métallurgie	Main engineering professional organisation

A.2 List of interviewees

Type of organisation	Organisation	Interviewee
Company/Organisation	IRT Jules Verne	Head of training
Company/Organisation	IRT Jules Verne	Former HR manager
VET provider	AFPI – the CFA (apprenticeship training centre) of the engineering professional organisation UIMM	Head of apprenticeship training
VET provider	Vocational secondary school and CFA 'Les Savarières' (preparing apprenticeships)	Deputy Director
Employer organisation	UIMM (union des industriels des métiers de la métallurgie) engineering professional organisation	Deputy director, responsible for skills anticipation

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