Country report

France

Contents

Lifelong Learning Programme

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1. Introduction

Since over fifteen years, the training programs in the branch of mechatronics in France have been continually increasing. Thanks to the growing interest of enterprises for the field of mechatronics, many engineering schools and universities have created mechatronic courses, related mostly to the mechanical department.

The mechatronics curricula are usually very general and the training path includes a wide scale of subjects and a lot of materials that are taught – there are only few areas of engineering that are not directly or indirectly related to mechatronics. However, the curricula offered by different institutions are roughly homogenous from one institution and include different learning outcomes in general mechanics, sensors, actuators, signal processing, telecommunications, electronics, robotics and computer science course.

The mechatronics engineers are a highly regarded industry for their versatility and general knowledge and a global vision of systems. The major sectors of employment are: automotive, aerospace, medical, energy, defence, etc. From an economical point of view, all industries linked to mechatronics have benefited from strong growth in turnover in France in 2011 (20-28%)[1].

Many different qualifications exist that are linked to the field of mechatronics; however, the designation of "mechatronics" is still rarely used in the field of education. These qualifications exist primarily in EQF levels 4-7 as indicated below: In the analysis we also include the number of educational institutions that are allowed to award the given certification as well as a relative part of them that offer the qualification through apprenticeship. The yearly number of graduates in these fields is not available.

EQF 4 (baccalauréat, baccalauréat professionnel)

Existing qualifications: Maintenance of industrial equipment (450 institutions2, 32% through apprenticeship), Management of production lines (86 institutions, 73% through apprenticeship)

EQF 5 (Brevet de technicien supérieur – BTS, Diplome universitaire de technologie – DUT)

Existing qualifications: Design and implementation of automated systems (130 institutions, 20% through apprenticeship), Industrial control and automatic control (45 institutions, 55% through apprenticeship), Industrial Maintenance (185 institutions, 53% through apprenticeship), Electrical engineering and Industrial computing (53 institutions, 51% through apprenticeship), Industrial engineering and maintenance (25 institutions, 40%

[1] www.mecatronique.fr

[2] www.onisep.fr

through apprenticeship), Mechanical Engineering and Production (45 institutions, 35% through apprenticeship)

EQF 6 (licence professionnelle, licence)

Existing qualifications: Automation and electronics (6 institutions), Automation and computerisation, specialty industrial process automation (3 institutions), Industrial production, speciality industrialization of automated production systems (1 institution)

EQF 7 (ingénieur, master)

Many different qualifications exist on this EQF level; we have been able to identify at least 11 universities or engineering schools delivering different certifications that mainly or partly covered the field of mechatronics.

The apprenticeship is not very common in France for the EQF 6 and 7 qualifications – students usually gain experience during their internships. Their duration can vary from 3 to 12 months during the courses of study.

It can be concluded that the word "mechatronics" is not yet very well integrated in the French educational system nor in the context of the industry, as our interviews with experts have confirmed. However, the learning outcomes that are included in qualifications paths in the field of mechatronics in other European countries are to a very large extent embedded in the qualifications that are named using the terms "industrial maintenance", "micro technology", "mechanics", "industrialisation" and "automation" etc. These fields of study receive a growing interest from candidates, as the industrial sector creates approximately 100 000 vacancies every year despite the economic crisis and thus it is highly promoted by the national education authorities.

From the educational point of view, the curricula respond relatively well to the requirements of the employers, as the level of apprenticeship is high for the French context, namely on the EQF level 5 (37%) and 6 (41%). Training programs where the qualification is not acquired through apprenticeship always offer a significant placement period within a company. Many educational programs are also open through lifelong learning and all qualifications can be also acquired through the process of validation of experiential learning.

2. The learning outcomes approach

History and context of learning outcomes approach in France

From the historical point of view, three different initiatives have heavily impacted the learning outcomes approach through the development of the French VET system:

- *"Référentiels d'activités professionnelles"*, or repositories of professional activities. It had been introduced by the Ministry of Education in the process of development of the diplomas. The main objective was to make the purpose of the training visible and understandable to professional and make them a subject of a dialogue with the social partners. The construction of the training path starts from the knowledge, skills and competences that must be acquired because they are necessary in the real world. This approach is very close to the notion of "learning outcomes".
- *"Unités capitalisables"*, or accumulation units. This had been an initiative of the Ministry of National Education and the Ministry of Agriculture. The idea was to modularize training and allow for a validation of partial outcomes (units) and not only of the final qualification (and thus make it more accessible, especially to adults in lifelong learning). This system is very close to the notion of units developed in the ECVET.
- *"Validation des acquis d'expérience"*, or validation of experiential learning. This had been first introduced by the Ministry of Education with the VAP in 1992, and the Ministry of Labour in 2002 with the VAE. This was an opportunity to recognize the legitimacy of other ways of acquiring skills other than formal learning and make certifications more accessible to adults. From the point of view of the learning outcomes approach, the VAE has led to the elaboration of units of qualifications in terms of "blocs" of competences, without changing the repositories of professional activities.

Units of learning outcomes

French experience shows that the description of qualifications in terms of learning outcomes (listed in the repositories of activities and skills) promotes the better legibility of acquired knowledge, skills and competences during the qualification path. The same certification can be used in initial training, lifelong learning and validation of experiential learning.

Concerning the structure and the content of the units of learning outcomes and the historical context in France, three different approaches exist:

- an integrative professional approach that integrates different types of knowledge that aims the recognition and validation of experiential learning;
- an educational approach, more analytical, whose purpose is the progressive

development of learning, which leads to the establishment of units that are linked together, the acquisition of some of them necessarily before the acquisition of the following ones;

- a validation approach strictly speaking, where the units are strictly linked to the examination criteria.

In France, it is the first approach that is by far the most dominant in the field of mechatronics. Units of learning outcomes are structured as chunks of knowledge, skills and competences, formulated first in terms of activities carried out (see "repository of professional activities") and then in terms of observable actions realized in a given context and evaluated on the basis of predefined performance indicators (see "units of competence").

Examples of the presentation and the structure of the learning outcomes

Repository of professional activities

a. General descriptions

Activity	Associated tasks
1: corrective maintenance Implement and optimize corrective maintenance	1.1. Diagnose failures; 1.2. Prepare interventions; 1.3. Perform corrective actions related to different technologies: mechanical, electrical, pneumatic and hydraulic; 1.4. Update and enrich the resources involved in the intervention.

Table 1: General description of professional activities

b. Detailed descriptions

ACTIVITY 1 – TASK 1: Diagnose failures
Task description Identify risks and define preventive measures to be implemented throughout the intervention: ▪ Establish the finding of failure; ▪ Isolate the dysfunctional chain; ▪ Identify the components of this chain; ▪ Hypothesize the possible sources of failure, prioritize them according to the ratio of information/investigation time; ▪ Perform tests and inspections successively based on previous results; ▪ Identify the faulty component; ▪ Appraise the property (before or after repair) to identify the cause of the failure.
ACTIVITY 1 – TASK 1: Diagnose failures

Initial situation ▪ An equipment has a total or a partial dysfunction.
Conditions of realisation Means: ▪ The authorization of intervention; ▪ Investigative tools: measuring devices, console, diagnostic aids ...; ▪ Equipment of individual or collective protection. Connections: ▪ The operations department; ▪ The manufacturer of the property; ▪ Possible specialists. References and Resources: ▪ The technical file; ▪ Documents potential resources.
Expected results ▪ The location of the failed component is made; ▪ Identification of the cause of the failure is made; ▪ The time of diagnosis is optimal.

Table 2: Detailed description of professional activities

Units of competence derived from the activity

REALIZE		
CP1: Realize the maintenance interventions		
CP1.1: Diagnose failures		
Data	**Actions**	**Performance indicators**
▪Equipment in total or partial failure ▪Description of the events by the operator ▪Technical documentation of the equipment ▪History of the equipment ▪Possibly assistance for diagnosis ▪Measuring and control instruments ▪The means of investigation (programming console, computer and communication software,	Establish the finding of failure Identify the failing function: ▪basic operative function	The collection of information related to circumstances of the failure is performed correctly: ▪The production situation at the moment of the failure is defined ▪The configuration of the equipment is controlled (configuration obtained by failure, by security stop...) ▪The control of protection status, power supplies, LEDs signalisation is performed correctly

…) ▪Tools required ▪Documentation specific to the manufacturer ▪Protective equipment (individual and collective)	▪safety function ▪communication function ▪communication function ▪energy supply function ▪monitoring function	The failing function is identified
	Identify and list the components related to the non-realization of the function and likely to be faulty: ▪action string ▪acquisition system ▪safety chain ▪communication structure ▪dialogue chain ▪energy supply chain	The components of the chain are listed The hierarchy is logical
	Locate the problem: ▪prioritize assumptions ▪define and perform tests, measurements, controls to validate them	Test points are identified Measuring and control instruments are properly selected and used
	Appraise the equipment	The identification of the defective item is correct The sequence of tests, measurements and controls is appropriate and justified
	Identify the cause of failure	The cause of the failure is plausible The time of diagnosis is optimal
	Monitor and manage the risks all along the intervention	The risks of the intervention are identified and safety regulations are respected

Table 3: Units of competence (example)

Credit points

Credit points are not used in French VET system. Two main objections exist towards this approach:

- Credits should not be pushed forward at the expense of the coherence of the content of the certification and thus leading to the relative disintegration of certifications and paves the way for extreme segmentation of acquired learning outcomes;
- Credit system can possibly permit the acquisition of a certification through accumulation of complementary units in relation to which mandatory units would be in minority.

The system of credits is unfamiliar to French VET culture. However, the relative importance of different units of learning outcomes is expressed in the system of coefficients and notes, which can be considered somehow similar to the credit system (see chapter 3 for a more detailed description of the coefficient system).

Validation and recognition

Since 2002 France has been deeply involved in the process of validation of the experiential learning (VAE). The recurring question is whether the certification issued has the same value when it is a result of an initial formal learning (and as such it is more or less indicating a potential), or when it is a result of a validation of demonstrated knowledge, skills and competences. Moreover, one can wonder if the fact of recognizing the professional experience by submitting to formal recognition is not to give a reduced devalued vision of the experience.

Another question is the question of "competent authorities" for validation, who are given an enormous responsibility to ensure the credibility of a complex and problematic process and they are supposed to be the holders of trust. It is difficult, as there are many variables even within a single member state.

3. Examination procedures

Examination procedures for awarding a certification are described in the qualification criteria that are published by different French ministries that are charged for the education. There are different ways that are used for assessing the acquired knowledge, skills and competences. No credits are awarded when a student passes an exam – instead, his performance is evaluated by a note ranging from 0 to 20. Different subjects have different weights attributed (called coefficients) and according to their importance, they contribute differently to the final note, which is then calculated as a weighted average of selected notes. Coefficients are attributed by professionals from the field of mechatronics and industry in general, in order to reflect the relative importance of every subject. Coefficients can be very high, ranging sometimes from 1 to 9. In the field of mechatronics, high coefficients are attributed to professional and practical subjects (internship report and evaluation, practical evaluation), while general subjects (French, general knowledge) have lower coefficients.

Different evaluation methods that will be described below are used as formative (once or several times during the training) and summative (obtaining of the unit) evaluation.

Written examination

Specifically designed to evaluate the knowledge of the candidate, written exams are traditionally an important part of the examination procedures. The subjects of the examination as well as the proposed questions can be different, however, in the field of mechatronics the work is usually centred on technical subjects. In the following an example of the examination procedure specification is given:

Examination E4: functional and structural analysis (Coefficient 3)

1. content of the examination

The exam allows the candidate to demonstrate that he/she is able to mobilize the knowledge in order to validate all or part of the following skills:

CP22: Analyse the functional and mechanical organization and solutions of operational functions;

CP41 Search, argue and realise a dossier of mechanical solutions of operative functions.

Performance indicators are those defined in the repository certification.

2. conditions of realisation

Technical support is provided from industry automation and mechatronics. Some extracts from the technical specification (assembly drawing, technical instructions, excerpts from catalogues, maintenance data) are to be used to establish solutions of technical problems in a mechanical or mechatronics department of the company.

3. methods of evaluation

Written exam, duration 5h

A situation assessment, a maximum of 5 hours will be offered to the candidate during the second half of the training. The development of the assessment situation and the organization of the course are within the responsibility of the educational team.

Following this evaluation situation, the establishment of educational training team will constitute a file for each candidate containing:

- full text of proposed questions and problems;
- brief description of the equipment and available instruments;
- documents written by the candidate;
- evaluation sheet of the work done.

The evaluation sheet will be elaborated by an independent jury composed by teachers and professionals from the field of mechatronics.

Table 4: Examination E4

Oral examination

In its structure, the oral examination is very similar to the written one: it is also constructed to evaluate a specific area(s) of competences of the student and is based on technical specification (assembly drawing, technical instructions, excerpts from catalogues, maintenance data, technical and economic data) that are used to establish solutions of technical problems in a mechanical or mechatronics field. Usually, the student is given the question with the supporting material and has between one or two ours in order to prepare the solution to the presented problem. The presentation of the solution takes usually 20 minute and is done in front of a jury composed by teachers and professionals from the field of mechatronics.

As an example here are some fields of evaluation situations that can be used for this type of examination:

- Identify indicators of availability and/or reliability and/or maintainability;
- Identify the equipment and/or subassemblies or most penalizing components;
- Propose areas for improvement;
- Determine the costs of maintenance;
- Justify preventive operations;
- Define and justify a maintenance strategy;
- Plan and schedule maintenance operations;
- Define systematic operations preventive maintenance;
- Define conditional preventative maintenance operations;
- Exploit information from surveillance;
- Define requirements and constraints related to the installation of a new equipment;
- Determine maintenance time;
- Identify sensible points from the standpoint of maintenance support and propose areas for improvement;
- Define procedures for the start and for the monitoring of interventions;
- Define information to be collected for analysis;
- Define spare parts and maintenance supplies to keep in stock.

Activity report from a company

Activities of students in companies during internships and their activity report are subject to an assessment by the company tutor and teaching staff using the following type of

appreciation forms:

Competences		Evaluation + ... -
C18 Perform, test, integrate all or part of an automatic system	▪ Initiate procurement of components and subcontracted elements ▪ Receive and verify the compliance of internal or external realisations ▪ Conduct an assembly of elements ▪ Implement the components ▪ Perform wiring and connections ▪ Perform a partial wiring and connections ▪ Set a programmable automation controller, a network, an interaction interface, a supervisory system ▪ Configure a automation component providing a dedicated function ▪ Establish a program for a programmable ▪ automation controller ▪ Use the program in simulated mode ▪ Provide data in a specified format ▪ …	

Table 5: Appreciation form (excerpt)

The examination consists first of a 20-minute student's presentation on the knowledge of the company in terms of industrial technology, organization and management, and the description of the activities undertaken. For some activities, after a brief presentation of the attributed mission, the applicant describes the process that led to the expected results. This presentation will be followed by an interview of 10 minutes with the jury consisting of a representative of the profession and two teachers. This is to assess the candidate's ability to synthesize his observations about the company and to interpret the results of its own operations.

Management and execution of a project

This type of examination allows the evaluation of competences in the field of communication, project management, ability to work in a team, as well as in conception, implementation and testing of a mechatronic system. Very similar appreciation sheets are used for the evaluation of students' performance by the pedagogical staff.

The examination is an oral form of thesis defence followed by an interview with the polling commission that usually takes 50 minutes. The file delivered to the jury includes a detailed description of the project. The student, after describing the initial need of the company, performs a demonstration of the operation of the system to the jury. He/she then describes the entire process that was followed in order to ensure the compliance with the initial specification as well as the testing and validation phases. He justifies the approaches chosen, implemented solutions and techniques and procedures used. He/she must justify any adaptations needed to achieve the objectives set for the project.

Following the presentation, the jury, which thoroughly reviewed the candidate's file, discusses with the student in order to assess:

- Autonomy in the execution of activities;
- The ability to respond with appropriate arguments to questions relating to the implementation, improvement, testing and validation.

4. Conclusion

From the point of view of ECVET, France has accumulated experience that should easily allow the application of the requirements of the ECVET system: the design of diplomas on the basis of the job description, learning outcomes that can be achieved by various means, the practice of cutting of learning outcomes into units or blocks of skills as well as the emerging practice of defining equivalences between qualifications or parts of qualifications.

There is however a terminological tradition in defining and structuring units of learning outcomes, that is a little different from the ones proposed in EQF. In France, it is often distinguished between three basic components of competence:

- Knowledge *(savoir)* is based on a body of scientific and/or technological knowledge that can be acquired by teaching or by self-directed learning. Such a definition is, however, partly rejected by those in the occupational learning field, who stress the importance of knowledge-in-action, that is, the individual's ability to represent a situation or a problem in his or her occupational field in conceptual terms.
- Know-how *(savoir-faire)* is based on the implementation of knowledge and experience in a concrete situation (such as the manual dexterity, the ability to deal with breakdowns or malfunctions). These 'empirical' forms of savoir-faire may be acquired both through learning and through professional experience.
- Behaviour, attitudes *(savoir-être)* relate more to inter-personal relationships than to technical matters and may also relate to communication (for example with peers or clients), to problem-solving capacity (aptitudes, capacités) within a team, or to the level of autonomy.

In this regard, the French discussion on competences sometimes differs from other EU countries (e.g. UK), where 'competence' is often synonymous with performance and narrowly defined in the behavioural sense. Traditionally, the French initial and continuous VET system focuses on three aspects of *formation* - forming a human being, a citizen and an economic actor. This leads to a relatively 'holistic' concept of certification (*diplôme*). Qualification paths always include some 'general' education, including such topics as language, history or civic education, with the aim of maintaining a balance between these three aims. This holistic concept is also an attempt to prepare students for life in the broadest sense rather than preparing them for the immediate demands of the labour market at a given point. This question touches the lifetime perspective of a qualification and whether it prepares an individual in the short term for particular employment or also prepares the individual for future developments, including possible career development and/or moves into a new occupation. The broader perspective is advocated by the Ministry of Education and the training sector. The narrower perspective, by contrast, tends to be the one endorsed by employers' organisations. It is important to take these two perspectives into account in the construction of the ECVET system – ECVET mobilities are interesting not only from the point of view of acquiring new technical knowledge and skills, but also in developing soft skills and in some extent career management skills.

In French VET system, units of learning outcomes are usually designed to be inter-related and often the validation of one unit of learning outcome must be preceded by the acquisition of another unit of LO. Any certification forms a whole; while it is possible to gain the award in discrete units within France's national qualification register, it is impossible to disaggregate these units. There is a recent initiative called *Répertoire national des certifications professionnelles* (National repository of professional certifications, 2002) that actively contributes to the discussion on the readability of certifications and establishing equivalence, bridges between various certifications, but so far the system is rather rigid in terms of mobility.

In relation to the units of learning outcomes, it is important to understand the notion of competence in French VET system:

- The notion of 'competence' is conceptualised in terms of 'capacity' in relation to a broad occupational field rather than in terms of performance of particular skills.
- The description of competencies is often general and is rarely defined in terms of precise and discrete tasks.
- Competences are understood broadly, with a particular accent on explicit theoretical knowledge and a mastery of a broader set of skills and competences.
- Individual competencies are related to each other and are difficult to dissociate from the overall occupational or job profile; they are integrative rather than cumulative.
- Competences are built up and cannot be deduced from the employment context.

- Competences can sometimes be expressed as dynamic processes, which means that an individual is not just capable of doing something at a given point but is also capable of developing, learning and passing on knowledge.

In spite of the consistence and cohesion of the system of qualifications there is a gradual shift away from the notion of the *diplôme* in terms of its collective recognition and the more or less long-term correlation between a qualification and a job on the labour market. This development is resulting in the creation of a more specific, specialised and relatively short training paths and certifications (*Certificat de qualification professionnelle, titres, …*) that are more in line with the narrower perspective of a qualification. We can say that somehow this development can gradually lead to a better modularisation of qualifications in long term.

Another important specificity of the French VET system is the system of validation of experiential learning (*Validation des acquis de l'expérience).* Since 2002 every certification is accessible either through the means of formal learning (a scholar path) or through the way of validation of learning outcomes. This has had an important impact on the formulation and structure of the units of learning outcomes and has developed further pressure on connecting them to work-related tasks and activities. The units of learning outcomes were reorganized into logical chunks of interrelated competences, based on the professional activities in real-world professional settings. The VAE process is based on the validation through a dossier, in which the candidate describes his experience in a very detailed way (through specific examples) in order to prove that he has acquired the knowledge and skills required by the certification specification. There is a clear accent on explicit knowledge (contrary to the UK and tacit knowledge) and the ability to describe one's competences. Additionally, some behaviours and attitudes linked to the exercise of the activity are taken into account. It is a very demanding and time-consuming process; a network of VAE guidance centres is available for candidates. In this way, the accent is put on the pedagogical value of the process in terms of the development of career management skills. From the point of view of ECVET it is important to note that a partial validation is also possible and the candidate than has 3-5 years to acquire the lacking knowledge or skills, either through professional experience or through additional training. However, the permeability of the system in terms of the possibility to decompose a qualification into independent units of LO is rather weak.

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