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Using ECVET in progression in the mechatronic sector

"Quality by Units"
through quality standards and recommendations

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1. Guideline for the reader

Claudia Gaylor

This report consists of four sections: 1) Outline of demands of key industries and political context, 2) presentation of the research design, 3) description of the status quo of the implementation of ECVET in different VET systems, 4) presentation of the quality standards and illustration of the recommendations for their implementation, presentation of a tool to enhance usability of the standards and recommendations and contextualisation of the quality standards and recommendations in the current expert discussions on ECVET.

Chapter 1 provides an overview on the political context and its evolvement, in which the project integrates. Chapter 2 illustrates the gradual development of the standards and recommendations. A matrix is created (analysis tool, former title: taxonomy table), which should enable the systematic description and evaluation of the status quo of the implementation of ECVET in the four national VET systems. Chapter 3 aims at displaying the status quo of the implementation of ECVET in the four different educational systems illustrated along five European countries: Germany and Austria (dual system), UK/England (sub-degree higher education with a much stronger practical orientation), Poland (alternating) and France (school based). Chapter 4 explains in a cross-system view how quality standards for the description of learning outcomes respectively units of learning outcomes and its ascertainment and assessment can be designed. Recommendations, which are based on the principles of ECVET and should support the implementation of the quality standards, are also formulated in this report. A tool to enhance the usability of the standards for VET practitioners is presented. The Chapter furthermore reviews the projects' outcomes in in-depth European expert discussions and their innovative aspect and added value in relation to other European tools.

2. Demand of European key industries and answer of European VET policy

Furio Bednarz, Gabriele Fietz, Omar Trapletti

Mechatronic as an emerging field of work, in many key industrial sectors, plays a major role for competitiveness of European economy in a global market. As a multidisciplinary branch of metal construction, assembly and engineering its outcomes are relevant for success of many other European industries: "It is found across a wide variety of industries including manufacturing in general but especially the automotive, aerospace, defense and materials processing industries." (CEDEFOP 2012, p. 45). To a high extent, its power to compete relies on a skilled workforce – and this is no fixed status quo – skills demand in the mechatronic sector is on continuous move.

Due to accelerated technical progress in this sector, skills and competences in companies need to be adapted continuously; learning on the job plays a major role. Moreover, the need of permanent adaptability requires to a high extent personal and social skills and competences: self-organized learning, capability to work in teams, organizational skills, etc.

To a high degree competitiveness of this sector depends on the capacity to dispose the required set of skills and competences at any time, either by attracting suitably skilled workforce from national and international labor markets or by upgrading a companies' workforce in non-formal or informal training processes.

In this context the notion of learning outcomes became a matter of European VET policy: Whereas in some European countries (most prominent example is the UK) upcoming of outcome orientation can be traced back to the early 90s of the last century, it was put on the agenda of European training policy beginning of this millennium, together with the aim of promoting and recognizing lifelong learning (cf. CEDEFOP 2008). Initiated in Bruges in October 2001, the creation of a set of outcome oriented instruments in order to improve transparency and recognition and increase transnational mobility[1] was formally set out in the Copenhagen Declaration in June 2002[2]

Today, mid 2014, those outcome oriented European instruments have reached an advanced stage of development. Since adopting the recommendation on establishing the ECVET (European Credit System for Vocational Education and Training) in 2009 (cf. European Council and Parliament 2008) the European Commission has

[1] Among them the European Credit system for Vocational Education and Training (ECVET), to make learning outcomes transferable from on learning context to another, the European qualifications Framework (EQF) as a translation tool for European qualifications and the European Quality Assurance Reference Framework for Vocational Education and Training (EQARF), containing 10 quality indicators designed for improving quality of VET systems.

[2] ec.europa.eu/education/copenhagen/copenhagen_declaration_en.pdf.

started various initiatives that accompany gradual ECVET implementation. Member states were invited to undertake preparatory measures by 2012 and to provide necessary conditions for ECVET by 2014. At the same time, 2014 has been marked as a deadline for reporting and reviewing the ECVET instrument. A first contribution to the ECVET evaluation has already been published in a Cedefop Monitoring report (cf. CEDEFOP 2013). For a long time, outcome orientation has been seen predominantly useful in transnational mobility context, but also in the VET systems. In the meantime, the 32 European countries involved in the Copenhagen process have been establishing National Qualifications Frameworks (NQF) and about half of them have completed their referencing towards the EQF standards (cf. CEDEFOP 2013, p. 42)

According to the purpose of European VET policy to provide training systems that are suitable to meet skills demands of European industry learning outcomes are not only relevant for transparency and permeability, but also for quality and flexibility of training. Therefore development of outcome oriented curricula and training programmes comes in the focus of European discussions: "In particular, learning outcomes are a distinctive way of expressing what learners should gain from their learning programmes. (…) the use of learning outcomes to inform the writing and implementation of IVET curricula" (CEDEFOP 2012, p. 34) has been placed on the agenda in many European countries recently. This development demonstrates that the issue of European VET policy is not focused on "*whether*" outcome orientation is suitable for progress of European economy, but rather – in the sense of a "*fine tuning*" – how to shape and exploit it for additional value, not at least in the key sectors of European industries. This report confirms increasing importance of outcome orientation not only in mobility context but also within the VET systems: It shows how the use of ECVET principles (units of) learning outcomes as an organizational principle in vocational education and training can be applied in order to achieve a higher quality in VET.

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3. Developing VET-Quality by using ECVET: "Quality by Units" – an overview

Claudia Gaylor

3.1. What is ECVET?

The diversity of European vocational education (VET) systems obscures the comparability of educational pathways and its respective qualifications. The question of comparability is especially relevant when transferring learning outcomes from one VET system or from one learning context to another, for instance when transferring and recognising learning outcomes acquired abroad. In this context, a set of instruments had been developed in order to facilitate the transfer and recognition and increase transparency of qualifications – or part of these – between the Member States. Since 2009 the credit-point-system ECVET (European Credit System for Vocational Education and Training) is being tested in vocational training. ECVET is an instrument, which aims to increase the mobility of young people in initial vocational training by creating the formal framework for mobility: It suggests a methodical approach on how to describe and structure qualifications independent of the learning duration and the learning location. ECVET promotes a common language by the description and structure through (units of) learning outcomes. Learning outcomes are "statements of what a learner is expected to know, understand and/or be able to do or is able to demonstrate after the completion of any learning process" (Bundesministerium für Bildung und Forschung[3]). To promote the implementation of ECVET a set of additional documents and guidelines is provided for training institutions, learners and competent bodies are supports by, such as standardized document templates for a partnership agreement (Memorandum of Understanding), for learning agreements and instruments for the documentation of acquired competences, for instance by using the mobility-document "europass". Beyond the mobility context ECVET can also enhance the quality of national vocational education systems. Learning outcome orientation can support proposed reforms in the European countries, which target on increasing the permeability between educational pathways.

Therefore a fundamental basis for the transfer and recognition of qualifications and of parts of qualifications across learning contexts or VET systems is already created by the application of ECVET. The effect will be even more positive if the use of ECVET is based on common principles, such as quality standards. To define such standards, it is helpful to identify approaches and procedures that have been proven in the different education systems. They provide an inside view on which pathways are taken in the implementation of ECVET and how they can contribute to quality improvement. They can also show the difficulties that may occur and what strategies have been developed to overcome them in the education systems.

[3] www.ecvet-info.de/de/249.php, Internetsource without year

In this report standards for the utilization of ECVET and recommendations for its implementation are defined. In detail this report deals with the quality-assured description, ascertainment and assessment (of units) of learning outcomes, using the example of the mechatronics training. This report is addressed to the professional public, including stakeholders, who are responsible for:

- the description of learning outcomes respectively units of learning outcomes and for the conception of curricula and/or
- the ascertainment and assessment of learning outcomes respectively for the determination of appropriate assessment procedures.

This report and the brochure "Mechatronics on the move. Learning outcomes approaches in Europe: Framework conditions and selected practice" are based on results of the project "Quality by Units". This project has been funded with support from the European commission within the framework of the Leonardo da Vinci Programme between October 2012 and September 2014. The report was developed in a transnational partnership between experts in vocational education and training of five European partners led by the f-bb.

3.2. Research design: steps, analysis criteria, partnership

The project "Quality by Units" has been an innovation transfer project. Two innovative products had been adapted to the considered VET systems: The VQTS-Model (Vocational Qualification Transfer System) and products from the project "EDGE – Development of models to allow credit to be given for learning achievements between different training courses in the twin-track training system on the basis of ECVET" (part of the German DECVET initiative). The VQTS-Model conducted to relate the qualification "Mechatronics" to other comparable qualifications in the countries of the project partner and thus to make them better understood. In the project EDGE the qualification "Mechatronics" had been structured and described in eight units of learning outcomes and standards for competence ascertainment had been defined. A detailed description of the transfer products is enclosed in the appendix. Based on the analysis of good practice by implementing ECVET in the project EDGE the project "Quality by Units" had adapted these approaches of good practice to the needs in further educational systems. Therefore in a first step the status of implementation in the different VET systems had been described and compared. In order to build a common foundation for the description criteria of analysis had been developed. The following sections provide details about the process of developing and validating the quality standards and recommendations:

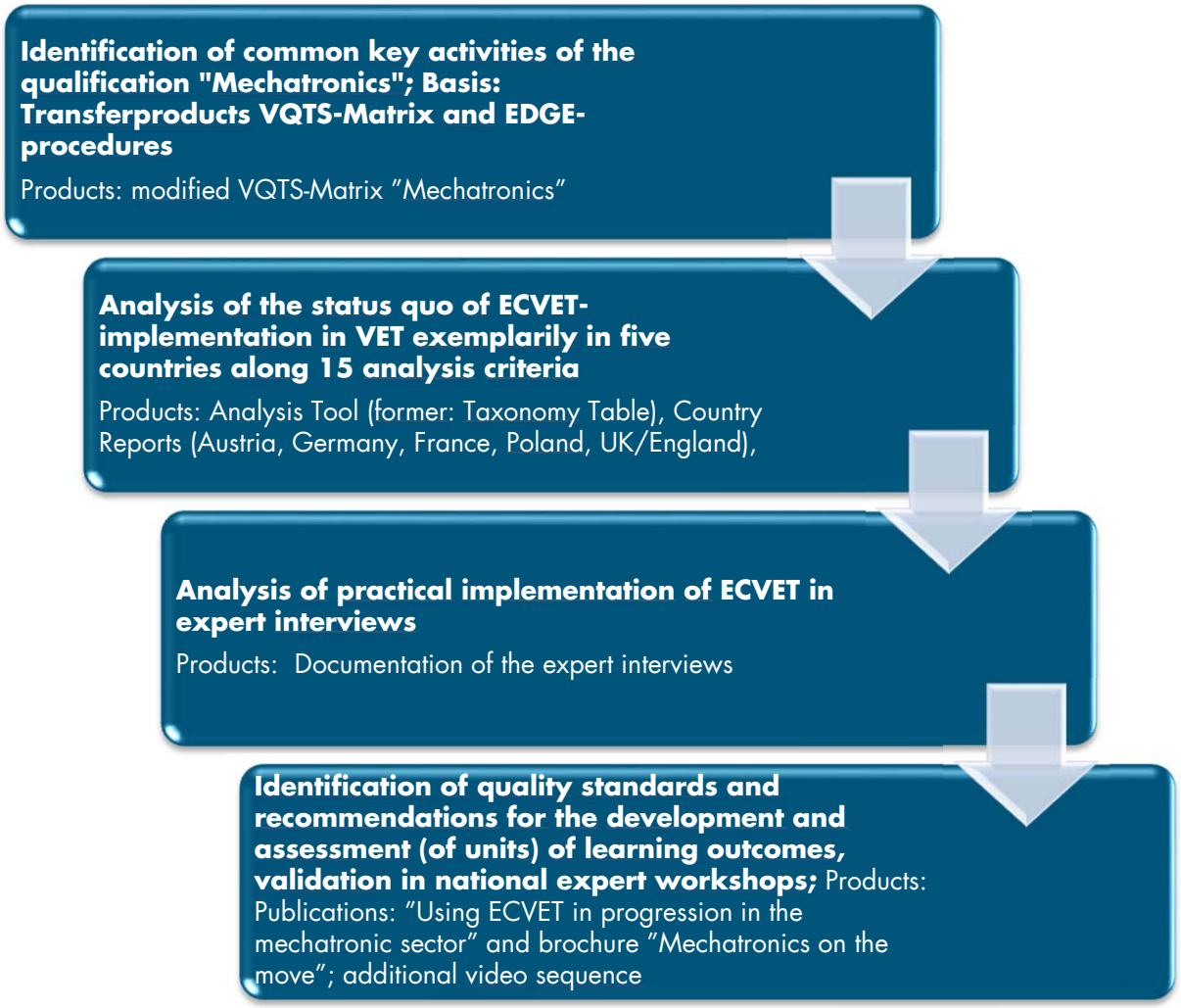

Table 1: Steps of development of standards and recommendations

The continuous high dynamics by implementing ECVET in vocational education, which for instance is indicated by the development of curricula that are compliant to ECVET in some European countries, but also the diverse levels of implementation of ECVET demanded a research design that is in step with actual practice. National experts from the field had been involved in the project, particularly from bodies implementing assessment (e. g. chambers), research institutes, vocational schools, VET providers (companies, schools, training providers), VET and ECVET experts and state representatives during two phases of the project: 1) Their task was to clarify and underline the current status of implementation of the learning outcomes approach which was compiled mainly on desktop research by five countries in advance and to identify challenges that may arise by implementing the results in the practical phase. 2) Furthermore in five national expert workshops by the participating countries they analyzed the comparability of the standards and recommendations with the respective national regulations and their added value.

15 analytical criteria, which can be ranged in four levels of analysis, had been singled out by experts from diverse vocational education systems. They determined the core points and the core questions for the description of the status of implemen-

tation of ECVET in the country reports. Furthermore they assisted by guiding the comparison of the status of implementation. On the basis of this comparison quality standards and recommendations had been derived in a further step. They comprise the following 15 analytical criteria and core questions:

Levels of analysis	Criteria	Leading questions
Competence understanding	1. *Countries definitions/concepts*	What is the definition/concept in education policy? Which traditions should be considered?
Conception of learning outcomes approaches	2. *Description of learning outcomes in units/ modules*	In which way are learning outcomes described? What role do units/modules play? How do they look like? What is indicated?
	3. *Role of employers and other stakeholders*	In which way are employers' needs considered? Are other stakeholders involved? If yes, who and in which way?
	4. *Kind of approach*	Is there a holistic or rather specialised approach in describing learning outcomes?
Conception of assessment	5. *Curricula*	What is defined in the curricula?
	6. *Structure*	Is there a theoretical and/or a practical part?
	7. *Determination time of assessment*	Are there partial/final assessment procedures? Is there continued recording of learning outcomes? Is assessment unit-related?
	8. *Role of employers and other stakeholders*	In which way are employers' needs considered? Are other stakeholders involved? If yes, who and in which way?
	9. *Task creation process*	Who is responsible for the task creation? Are they standardized?
	10. *Examiners' Qualification*	Who are the examiners? In which way are they qualified?

Levels of analysis	Criteria	Leading questions
Assessment implementation	*11. Tasks*	What kinds of tasks are applied (multiple choice etc.)?
	12. Choice of Methods/instruments	What impact does the learning outcomes approach have on assessment methods?
	13. Assessment execution	In which contexts are exams executed (in a school, at the chamber of commerce/of craft, at workplace etc.)?
	14. Judgement/evaluation	How are learning outcomes valued? (Are there marks?)
	15. Role of employers and other stakeholders	In which way are employers' needs considered? Are other stakeholders involved? If yes, who and in which way?

Table 2: Analysis tool with criteria (formerly: taxonomy table)

In the Project "Quality by Units" six European partners from Germany, Austria, France, Poland, UK/England and Switzerland had been involved in a partnership led by the Forschungsinstitut Betriebliche Bildung (f-bb).

Forschungsinstitut Betriebliche Bildung (f-bb) (Germany):

The Forschungsinstitut Betriebliche Bildung (f-bb)/Research Institute for Vocational Education and Training in Nuremberg supports the modernization of systems of occupational training with practically-orientated research. Working closely with public and private sector clients, it develops occupational training strategies that are fit for the future, and also conducts research into the suitability of these measures for specific work settings. The f-bb led the project EDGE, in which products had been tested and further developed for new scope of applications, i.e. for additional educational systems.

3s research laboratory (Austria):

3s research laboratory is one of the leading VET-research organizations in Austria. They are experienced in the design of projects in the fields of knowledge, learning and work and in the development of methods, tools and instruments for anticipating and assessing qualifications and competences. 3s research laboratory is a member of the Austrian Reference Network CEDEFOP and collaborates with the Austrian Ministry in the field of EQF/NQF, ECVET as well as the certification procedure in continuous training and quality certification.

CIBC (Centres Interinstitutionnels de Bilan de Compétences) Bourgogne Sud (France):

The CIBC Bourgogne Sud has been created within the frame of experimentation of the "Bilan de Compétences" methodology in France in 1986. It is a founding member of the "Fédération Nationale des CIBC" and of the "European Federation of Guidance and Career Counselling Centres (FECBOP)". It has a yearly reception of 1600 people requiring career counselling guidance, competences validation and competence evaluation. Since 1995, the CIBC Bourgogne Sud has been directly involved in transferring methodologies and/or creating centres of Bilan de Compétences either for EU or non-EU partners. The CIBC Bourgogne Sud starts the national path of quality of French CIBC as well as of the European path of quality "Labellisation Qualité Europe Bilan de Compétences".

Towarzystwo Naukowe Organizacji i Kierownictwa Oddzia w Gda sku (Poland):

TNOiK - The Scientific Society for Organization and Management is a non-governmental, non-profit organization established in 1925. Its mission is the development and promotion of the professional management and integration of scientists and practitioners (companies) for the development of Polish economy and Polish state. The Gdansk Branch of TNOiK supports the development of knowledge-based society. It is a partner in European research and educational projects of Leonardo da Vinci Programme and European Social Fund (including the EU Initiative EQUAL). Its task is the implementation of projects' results, both in SMSs and in VET system. TNOiK Gdansk promotes the idea of social and citizen dialogue to support the regional socio-economic coherency and it offers public consultation processes. The Society provides training courses for individuals, companies, institutions and organizations, as well as workshops, seminars, conferences, etc. It's the Examination Centre of ECDL (European Computer Driving Licence).

Institute for Employment Research (IER), University of Warwick (United Kingdom/England):

The Institute for Employment Research (IER) at the University of Warwick is a multidisciplinary research institute. It is one of Europe's leading centres for research in the labour market field. Its work includes comparative European research on employment and training as well as that focusing on the UK at national, regional and local level. Research spans academic and theoretical contributions and policy-related projects. One distinct strand of the work of IER has been research and development to improve understanding and communication of changes in assessment and qualifications in relation to VET, both nationally and in collaboration with other countries.

ECAP Foundation (Switzerland):

ECAP R&D, Research and Development Unit of ECAP Foundation is one of the most important Swiss Institutions in the lifelong learning sector with altogether 9 training centres and 750 collaborators. It is located in Lugano (Lamone) and manages a Competence Centre for Language Learning also in Biel (Bern).ECAP R&D is mainly active in EU networks, within European and international research projects, dealing with:

- research on the need for education and on the social effects of education
- research on Active Labor Market Policies and practices (ECAP Foundation operates in that field on behalf of local employment services)
- monitoring and evaluation of training pathways and transnational projects
- comparative study of VET systems and best practices for integrating informal, non-formal and formal learning outcomes
- planning, implementation and evaluation of new educational models
- participation in and promotion of trans-national observatories and educational activities
- organization of conferences and seminars, publication of researches, essays and didactic materials

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4. Learning outcomes approaches and assessment procedures in Europe

4.1. Mechatronics in different VET systems: a typology

Furio Bednarz, Gabriele Fietz, Claudia Gaylor, Omar Trapletti

The following reports describe comprehensively the status quo of the usage of ECVET in different educational systems. Differentiating aspect is the role of the learning venues company and vocational school in the training. Depending on the degree of responsibility four types[4] can be distinguished:

Type I: Dual system – DE, AT	Type III: School-based training – FR
Type II: Alternating training – PL	Type IV: sub-degree higher education – UK/England

Table 3: Classification of VET systems related to place of learning

Type I – Dual system (Germany and Austria):

Training takes place in a company (three or four days per week) and part-time in vocational schools (one or two days a week). Company-based training is particularly practice-oriented i.e. it provides apprentices with job-specific skills and competences. The apprentice is contractually linked to the employer and receives remuneration (wage or allowance). The employer assumes responsibility for providing the trainee with training leading to a specific occupation (cf. CEDEFOP 2004, p. 25).

Type II – Alternating training (Poland):

Education or training can take place in alternating periods in a school or training centre and in the workplace. Learning in the mechatronics sector is mainly school-based, however, the Polish system of education is currently under re-construction and there are planned efforts to re-enter a dual system with practice-oriented learning in companies.

Type III – School-based training (France):

Learning is mainly school-based, however the level of practical training provided in a company is in occupations in the mechatronics field relatively high for the French context. Learners usually gain practical experience during internships. Their duration can vary from 3 to 12 months during the courses of study.

[4] Fietz/Le Mouillour/Reglin distinguish three types: Dual system, alternating system and school-based system (cf. Fietz/Le Mouillour/Reglin 2008, p. 147). Higher education is a special case in VET in mechatronics.

Type IV – Sub-degree higher education with a much stronger practical orientation than most undergraduate degree programmes (United Kingdom/England):

Entry to mechatronics fields in the UK is just starting to be delivered through higher level technician apprenticeships (EQF level 4), but until now the more usual route was through sub-degree higher education provision (EQF level 5), which was intended to develop practical engineering skills through projects and enrichment activities, as well as the requisite underpinning knowledge in order to operate as an advanced practitioner.

A recent classification focuses on the degree or the traditions of implementation of the learning outcomes approach. Accordingly, "Quality by Units" partnership can be classified into two groups (cf. Brown/de Hoyos-Guajardo 2014, p. 67 and CEDEFOP 2012): Whereas the holistic structured countries of Austria and Germany belong to the "recent developers", France, Poland and the United Kingdom are seen as "early developers" whose orientation towards the learning outcomes approach started in 1990 or even before. According to this report, each system of the "early developers" has already provided units of learning outcomes in its own way. Whereas for UK and France this status of "early developers" is out of doubt, Polish experts estimate the emerging of the notion of learning outcomes in their country in parallel with the development of European instruments – above all the EQF – in the first decade of this century. The reform impulse coming from European VET policy caused fast progress of development of outcome orientation in Poland, an early creation of a National Qualifications Framework and outcome oriented curriculum design. "Today all qualifications in general education and the VET school system have been defined using the learning outcomes approach" (CEDEFOP 2013, p. 89).

As regards qualification in the mechatronic sector major differences showed up during workshop discussions and in the country reports: Of course, it was clear from the beginning, that there is no unique qualification "mechatronics" in the countries involved. Related to many aspects "mechatronics" is not easily to define:

- As a kind of multidisciplinary sector, mechatronics involves a variety of occupations or of parts of occupations in the field of engineering, which is not identical across the systems. E.g. Austria: "According to the classification of economic branches of the Austrian Public Employment services (AMS), mechatronics is a subfield of electro mechanics and electrical machines in engineering, electronics and telecommunications. It covers in practice a wide range of occupations" (Dzhengozova 2014, p. 24). This variety of occupations (and also of applications) leads to a phenomenon that in some countries experts in interviews are not very familiar with the topic "mechatronic", as the French example shows: "It can be concluded that the word 'mechatronics' is not very well integrated in the French educational system" (Rochet/Sprlak 2014, p. 51).
- Mechatronics covers several qualifications pathways, ranging from initial education and training (IVET) to higher education (HE) that leads to differ-

ent levels of qualifications. Countries' qualifications systems offer mechatronics qualifications at several levels, e.g. Austria, Germany, France and Poland offer IVET and HE qualifications, whereas in the UK, Mechatronic qualification is offered exclusively as a Higher Education master or bachelor degree starting with level 5 – there exists no mechatronic qualification at level 4/3. In context of "Quality by Units" the UK partners focused on "Foundation degrees", even if there are fewer options to study. With level 5 they fall in the area of HE, but different to the HE pathways Foundation degrees "allow flexibility in relation of how they can be studied" and are designed in partnership with employers and include employer-based training" (Brown/de Hoyos-Guajardo 2014, p. 66).

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4.2. Dual system: Country study Germany

Claudia Gaylor

4.2.1. Introduction

The report provides an overview of the sector mechatronics with its different qualifications. With a focus on the apprenticeship "mechatronics" in the dual system it describes the status quo of learning outcomes orientation and competence assessment procedures.

Mechatronics in Germany

Relating to the Classification of Occupations 2010[5] of the Federal Institute for Vocational Education and Research (BIBB) mechatronics covers a range of occupations such as mechatronic fitter, mechatronics for refrigeration technology and motor vehicle mechatronics technician. According to the classification it is also a subcategory of electrical engineering occupations, such as industrial electrician, micro technology, information system technician etc.

The profession of a mechatronic fitter covers a broad range of occupational fields. It can be found in the electrical industry, in machine and plant construction, the automotive industry, the steel industry as well as crafts. Mechatronic fitters are dealing with the assembly and maintenance of mechatronic components and systems from manufacturers in plant and machinery, with the operators of the systems and in service areas and service providers in different industries and sectors. In Germany, there are several qualifications in the field of mechatronics linked to several VET-pathways:

- In Germany, the access path most people choose to the occupational field mechatronics is achieved through dual vocational education. The training occupations "mechatronics fitter (crafts)" and "mechatronics fitter (industry)" are *recognized training occupations* according to the Vocational Training Act. Its duration is 3 1/2-years. Due to the relevance of the qualification in the dual system the report will focus on this training occupation. Current data issued by the Federal Institute for Vocational Education and Research[6] shows that – despite a decrease from 2012 to 2013 – the number of new training contracts is still on a high level. It is still a male dominated training occupation (table 4).
- *Further training qualifications* such as "Meister (master craftsman)" and "Techniker (technician)" are offered for people in employment. Entry requirement is usually the final examination and professional experience in a

[5] www.bibb.de/de/66262.htm.
[6] www.bibb.de/de/65907.htm.

recognized training occupation relevant for the objective of the field of continuous training. The qualifications are regulated under federal law.

- In *undergraduate courses* both training integrated courses and practice integrating courses are possible. A study of mechatronics can be combined for example with training in recognized training occupation mechatronics/mechatronics or electronics/electronics technician for automation technology (industry). The undergraduate course ends with the degree Bachelor of Engineering.

Training occupation	New training contracts			
	2012		2013	
	male	female	male	female
Mechatronik Fitter (Crafts)	195	9	177	3
Mechatronik Fitter (Industry)	7263	531	6891	498

Table 4: Number of new training contracts (source: own illustration, data from BIBB, www.bibb.de/de/65907.htm)

4.2.2. The learning outcomes approach

In the German vocational education and training system the outcome orientation of curricula and training regulations is still ongoing. There are several initiatives to further develop this approach and its implementation in regulatory instruments. The following principles serve as a conceptional framework for the development:

- *Orientation to competences:* The training regulations determine the competences, which apprentices need to acquire. This competence-oriented description includes the professional, methodical, social and personal dimension.
- *Learning-outcome oriented description of competences:* The competences are described in terms of learning outcomes. These terms lay down what trainees know, understand and are able to do after finishing a learning process.
- *Orientation to working and business processes:* The competences which must be acquired by the trainees are oriented on the working and business process.

Dual training "mechatronics fitter": Training in a recognized training occupation – such as mechatronic fitter – is to impart "Berufliche Handlungsfähigkeit", which is the professional ability to act responsible in private, social and vocational situations and provide the necessary professional experience. This is mainly achieved by company-based training (three or four days per week) and part-time teaching in vocational schools (one or two days a week). Training in the company is based on training regulations the Federal Government issues for recognized training occupa-

tions. This ensures a comparable level of training throughout a specific occupation. It is within the sphere of the Standing Conference of the Ministers of Education and Cultural Affairs (KMK) to issue framework curricula in accordance to each training regulation, structured along learning fields. Training regulations and curricula are the basis for training in the dual system.

The training regulation contains the duration of apprenticeship and guidance times, examination requirements and skills, knowledge and competences to be acquired by the trainee. The latter are summarized in a training profile and – in more detail – in the general training plan (table 5):

No. and Part of the training occupation profile	Skills, knowledge and competences to be imparted	Guidance times in weeks in the training year		
		1	2	3
20: Maintain mechatronic systems (§ 3 Paragraph 2 No. 20)	a) Inspect mechatronic systems, check function of safety systems and protocol checks b) Maintain mechatronic systems in accordance with maintenance and repair plans, exchange parts subject to wear and tear as part of preventative maintenance c) Dismantle devices and sub-assemblies noting their function and label parts with regard to position and functional alignment d) Rectify malfunctions by conducting remedial procedures and exchanging parts and sub-assemblies e) Rectify software errors f) Compare system parameters with stipulated values and adjust g) Repair mechatronic systems according due consideration to company processes h) Adapt mechatronic systems to altered operational conditions i)Use diagnostic and maintenance systems			13

Table 5: Part of the general training plan for mechatronic fitters (source: www2.bibb.de/tools/aab/ao/mechatroniker_ao_rlp_engl.pdf)

The school-based element of dual training focuses on theoretical and practical knowledge related to the occupation, general subjects such as economic and social studies and foreign languages. Since 1996 curricula for vocational schools are defined in units of learning outcomes (so-called fields of learning). Fields of

learning are formulated in a competence-oriented manner. At the level of the KMK framework curricula the competences are defined in largely general terms in order to take into account regional and sectoral developments. They must be concretized in so-called educational program conferences at the respective individual school.

In the Committee on Innovation in Vocational Education and Training (IKBB) representatives and experts from Federal Government and the Länder, companies, schools and industry associations agreed upon the "the reorientation of the training regulations towards competence descriptions" (Bundesministerium für Bildung und Forschung 2007, p. 18). Currently the "concept to design competence-based training regulations" is developed and tested in two occupations (mechatronics is not among them). A working group of the Federal Institute for Vocational Education and Training will discuss requirements for future training regulations on the basis of the results of this project. Other initiatives aim at the unification of training regulations: The project "EDGE" (Development of models to allow credit to be given for learning achievements between different training courses in the twin-track training system on the basis of ECVET) identified learning units for the mechatronic training, specifying the corresponding competences and training duration. However, the unification and modularization of training regulations is still discussed controversially in Germany.

4.2.3. Examination Procedures

The examination system is regulated consistently in the Vocational Training Act ("Berufsbildungsgesetz", Bundesministerium für Bildung und Forschung 2012, p. 30). With the revision of the training regulation of the apprenticeship mechatronic fitter in 2011 a new examination structure was introduced. The so-called extended final examination ("*Gestreckte Abschlussprüfung*") consists of two parts at two different times and replaces the traditional form that consisted of an interim and a final examination. Whereas the former interim examination was used to assess a trainee's progress only and did not play a role in the grade issued for the final examination, the new structure foresees that the results of both parts count into the final grade. Both parts consist of a practical part, expert discussions ("Fachgespräch") and written assignments.

Final examination: Part 1

The final examination Part 1 takes place 18 months into training and has a weighting of 40 percent onto the final result. The trainee is given a *work task* in the field *work on a mechatronic subsystem*. The task also includes situational *expert discussions* and written assignments[7]. The time given for this task is 8 hours, including expert discussions and written assignments.

[7] berufenet.arbeitsagentur.de/berufe/berufId.do?_pgnt_act=goToAnyPage&_pgnt_pn=0&_pgnt_id=resultShort&status=A08

Final examination: Part 2

The final examination Part 2 takes place at the end of training and has a weighting of 60 percent onto the final result. It consists of 4 areas of assessment related to a work assignment, organization of work, functional analysis and economic and social studies. The *work assignment* covers the section "assembly or maintenance and commissioning of a mechatronic system". It proves whether the candidate is able to analyze and plan work tasks, obtain, evaluate alternative solutions taking into account operational procedures and responsibilities on site etc. Within the area the company has the option to choose between a company assignment (option 1) or a work task (option 2): Option 1 requires the candidate to conduct of a company assignment in 20 hours and document the results. The expert discussion builds on the documentation and lasts no more than 30 minutes. Option 2 covers the preparation, conduction, postprocessing and documentation of a work task in 14 hours (6 hours for conduction the task) and ends with a situational expert discussion of no more than 20 minutes.

The areas *organization of work, functional analysis* and *economic and social studies* are assessed in written assignments. The test time in the areas of organization of work and functional analysis is 105 minutes each, in the field of economic and social Studies 60 minutes. The written part can be complemented in certain assessment areas by an oral examination, if this is crucial to passing the exam. It proves whether the candidate can demonstrate that she/he is in a position to plan a work task, choose the necessary mechanic and electric components, software, tools and devices, plan measures for maintenance or commissioning taking into account operational processes and whether she/he can demonstrate knowledge of general economic and social context.

The final examination is taken by examination boards of the competent authorities (chambers), consisting of at least three members (representatives of employers, employees and part-time vocational schools). The members must be knowledgeable about the examination areas and suitable to participate in the examination system (cf. Bundesministerium für Bildung und Forschung 2012, p. 31).

The fact that examination methods and tasks are as close as possible to the real working and business processes is an indicator that examinations are largely competence oriented. However, little research has been done on the implementation of this approach. Currently, there are several initiatives to further develop competence based assessment and its implementation in examination procedures (cf. Lorig et al. 2012).

4.2.4. Conclusion

In Germany, the learning outcomes approach is closely connected to the concept of the professional ability to act. Its implementation (regarding the reorganization of trainings regulations and curricula, competence oriented assessment) is still an ongoing process. There are several initiatives to further develop this approach and

its implementation in regulatory instruments and assessment procedures, including qualifications in the field of mechatronics. One result of these initiatives is the recently published recommendation of the Board of the Federal Institute for Vocational Education and Training (BIBB). This recommendation states that training regulations, beginning with the application process in 2015, should be described in a competence-oriented manner and according to typical work and business processes in fields of action[8].

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Lorig et al.: Kompetenzbasierte Prüfungen im dualen System – Bestandsaufnahme und Gestaltungsperspektiven. Bonn 2012. Internet: www.bibb.de/de/wlk54485.htm (accessed 28.08.2014)

[8] www.bibb.de/de/11703.php

4.3. Dual system: Country study Austria

Mariya Dzhengozova

4.3.1. Introduction

The aim of the current report is to provide a short description of the sector of mechatronics in Austria, including an overview of related qualifications. Another aim is to describe the application of learning outcomes approach in different education sectors as well as assessment procedures focusing on the field of mechatronics.

This report, together with the reports from the other partner countries (France, Germany, Poland and United Kingdom) will provide the basis for the development of a common analysis tool (formerly taxonomy table) including countries' definitions/concepts related to competence understanding, conception of learning outcomes approaches as well as conception and implementation of assessment.

The Mechatronics sector in Austria

According to the classification of economic branches of the Austrian Public Employment Service (AMS), mechatronics is a subfield of electromechanics and electrical machines in electrical engineering, electronics and telecommunications. It covers a broad range of occupations dealing with manufacturing, assembly, repair and servicing in mechatronic systems in the mechanical engineering, plant construction and equipment manufacturing industries.

In Austria, there are several qualifications in the field of mechatronics acquired in different VET pathways. For example, graduates of apprenticeship training who successfully complete the apprenticeship-leave exam, acquire a 'Certificate of Apprenticeship Mechatronics' (ISCED 3b)[9]. The duration of the training is three and a half years. Current data, provided by the Austrian Economic Chambers (WKÖ), shows that in the period between 2004 and 2013 the total number of apprentices in mechatronics increased from 826 to 1,929. Since 2004 the number of women has more than quadrupled, from 32 apprentices in 2004 to 156 apprentices in 2013. Nevertheless, mechatronics is still a male-dominated occupation – this is reflected in the over-representation of male apprentices (table 6).

[9] zeugnisinfo.at.penguin-cloud.at/file_upload/9_tmpphpefLFkz.pdf

	male	female	sum
2004	794	32	826
2005	916	43	959
2006	1027	53	1080
2007	1143	74	1217
2008	1343	93	1436
2009	1463	114	1577
2010	1514	136	1650
2011	1643	147	1790
2012	175	152	1877
2013	1773	156	1929

Table 6: Number of apprentices from 2004 to 2013 (source: Austrian Economic Chambers - WKÖ10)

In addition, the Austrian Economic Chambers provided current data on the apprenticeship-leave exam (table 7).

	No. of applicants		Successful exams	Unsuccessful exams
	Total	Repeaters	Total	Total
mechatronics	693	60	574	119
male	604	51	504	100
female	89	9	70	19

Table 7: Apprenticeship-leave exam in mechatronics in Austria, 2013 (source: Austrian Economic Chambers - WKÖ)

Graduates of specialised VET colleges who successfully complete the final exam (Reife- and Diplomprüfung) acquire a qualification in a specific area of mechatronics such as automation[11] or precision engineering[12] (ISCED 4A). This qualification is a double one as it entitles to practice of a profession and gives an access to higher education. The duration of the study comprises five years.

In relation to continuous vocational education, for people in employment for example, there are foreperson courses in mechatronics. The successful completion of the course including a final exam leads to the acquisition of a certificate 'Abschlussprüfungszeugnis der Werkmeisterschule für Berufstätige für Mechatronik'

[10] WKÖ, Lehrlingszahlen, www.bic.at/berufsinformation.php?beruf=mechatronik-lehrberuf&brfid=88
[11] zeugnisinfo.at.penguin-cloud.at/file_upload/9_datak0003wwwsrv4vhost1phptmpphpsBvkZp.pdf
[12] zeugnisinfo.at.penguin-cloud.at/file_upload/9_datak0003wwwsrv4vhost1phptmpphpoIEKIs.pdf

(ISCED 5A)[13]. The duration of the course is up to four semesters.

Due to reasons of comparability related to qualifications available in the other partner countries (i.e. Germany, Poland and United Kingdom), the country report will focus on the apprenticeship training in mechatronics.

4.3.2. The learning outcomes approach

In the Austrian education and training system, the implementation of the learning outcomes approach has been going on for some years and is still not fully implemented. There are several initiatives to strengthen and further develop this approach, many of which closely relate to the development of the National Qualifications Framework (NQF).

School-based VET

In 2004, the Federal Ministry of Education and Women's Affairs (bmbf, formerly known as Ministry of Education, Arts and Culture/bmukk) introduced educational standards in the VET school sector in order to ensure the comparability and quality of training. These standards form a part of the so-called framework curricula, which define the objectives and content of education and training at VET colleges and are regulated by the Ministry of Education. The standards are formulated in terms of learning outcomes; however they do not follow the knowledge/skills/competence model (KSC). They focus on holistic qualifications integrating the following core competences, i.e. a) general-education core competences; b) occupation-related core competences and c) social and personal core competences (cf. BMUKK/BMWF 2011, p. 107).

Since 2007, VET standards have been undergoing comprehensive testing in so-called pilot phases. In June 2010, the Ministry of Education published a "Guide for the design of competence-based and learning outcome-oriented curricula for VET colleges and secondary training colleges" (cf. BMUKK 2010). As a result, some new curricula were developed including also curriculum of VET colleges for Mechatronics. Compared to the old curriculum[14] in the new one occupation-related learning outcomes are clearly specified and social and personal competences are integrated. However, descriptions of learning outcomes do not relate to assessment standards[15].

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[13] Abschlussprüfungszeugnis der Werkmeisterschule für Berufstätige für Mechatronik. Internet: zeugnis-info.at.penguin-cloud.at/file_upload/9_datak0003wwwsrv4vhost1phptmpphp8FR2IK.pdf (accessed 25.04.2014).

[14] BGBl. I Nr. 382/1998. Lehrplan der Höheren Lehranstalt der Mechatronik. Internet: www.htl.at/fileadmin/content/Lehrplan/HTL/HL_MECHATRONIK_Anlage_1.1.6_BGBl._382-98.pdf (accessed 25.04.2014).

[15] Lehrplan der Höheren Lehranstalt der Mechatronik (2012). Internet: www.htl.at/fileadmin/content/Lehrplan/HTL_SV_2011_2012_2013/SV_Lehrplan_HL_Mechatronik_modul_2012.pdf (accessed 25.04.2014).

Apprenticeship training

In general, apprenticeship training in Austria, known also as dual system, consists of a company-based training (which comprises 4/5 of the entire training duration) and a part-time instruction (1/5 of the training) at a vocational school. Company-based training is particularly practice-oriented, i.e. it provides apprentices with job-specific skills and competences. It is within the sphere of competence of the Federal Ministry of Science, Research and Economy (bmwfw), formerly known as the Ministry of Economy, Family and /bmwfj), which elaborates the Vocational Training Act (BAG) and adopts the training regulations for the individual apprenticeship occupations. Of note is that social partners are in charge of decisions about the content of training regulations.[16]

The training regulation consists of an occupational competence profile ("Berufsprofil") with related activities and work descriptions, and a job profile ("Berufsbild") with knowledge and skills to be acquired by apprentices. "Berufsprofil" and "Berufsbild" are both formulated in a largely learning outcomes-oriented manner (table 8).

- ability to read and apply technical documents
- specification of steps, work equipment and working methods
- planning and control of workflows; assessment of final results/the results of work; application of quality management systems
- manufacture, processing and treatment of mechatronic parts; assembly and adjustment of mechatronic subassemblies and components
- assembly, fitting and installation of mechanical, electrical and electronic elements, subassemblies and components
- measurement and testing of parameters related to mechanical engineering as well as of electric variables
- fitting, installation and testing of mechatronic hardware and software components
- establishment and testing of electrical, pneumatic and hydraulic controls
- programming and testing of mechatronic systems
- assembly, fitting, examination, and testing of machinery, plants and installations
- installation, fitting, testing, adjustment, operation and commissioning of enterpris-especific systems in equipment, machinery, and installations
- maintenance and servicing of mechatronic systems
- localisation, diagnosis and clearing of faults, defects and failures of mechatronic systems
- establishment, examination and documentation of protective measures to prevent damage to persons and damage to property
- performance of the work taking into consideration relevant safety regulations,

[16] In comparison, the role of social partners in the design of framework curricula for VET colleges is more limited. In so-called curriculum committees, teachers, experts from the Ministry of Education and the economy develop draft curricula for the respective subjects. The social partners receive the drafts and issue statements on them.

standards and relevant environmental standards ▪ collection and documentation of technical data on workflow and work results ▪ advisory services for customers on the use, application and servicing of mechatronic systems ▪ appropriate written and oral command of language and mode of expression as well as use of job-related foreign language

Table 8: Occupational competence profile in mechatronics (source: ibw: Lehrberufsbeschreibungen Deutsch-Englisch. December 2013)

By way of contrast, the school-based element of apprenticeship training focuses on the provision of basic theoretical knowledge and general education. The Ministry of Education is responsible for this part of the training (i.e. elaboration of draft legislation and framework curricula). Up until now curricula of VET schools for apprentices have been predominantly in-put oriented. However, curricula are in the process of being revised, which is an initiative that started in 2011.

The Amendment to the Vocational Training Act (BAG) in 2006 created the possibility for modularising apprenticeships. Since 2010, several apprenticeship occupations (mechatronics is not among them) have been modularised. Modularisation refers to a modular structure of apprenticeship training with several combination and specialisation options. It comprises three "modules": The basic module as a rule lasts for two years and includes the knowledge and skills, which correspond to the basic activities of one or several apprenticeships in a specific occupational area. A main module lasts for at least one year. It comprises the knowledge and skills, which exceed the fundamentals and make up the typical qualifications of an apprenticeship or several apprenticeships in a specific occupational area. There can be several main modules that build on a basic module. And a special module lasts for half a year or a full year and aims to provide additional knowledge and skills that correspond to specific modes of production and services. (cf. Tritscher-Archan 2012, p. 8).

Foreperson courses of mechatronics for employed persons

Curricula of foreperson courses are structured in a similar way as curricula of school-based VET.[17] The profile of skills and competences include technical skills and competences as well as personal and social ones.[18]

Technical skills and competences refer to:

- Planning and design of mechatronic systems
- Selection of material as well as preparation for production
- Coordination of production and quality assurance

[17] The curricula is available in German at: www.bmukk.gv.at

[18] The translation of the technical and social and personal skills and competences is done by 3s. The original version is available in German at: zeugnisinfo.at.penguin-cloud.at/file_upload/9_datak0003wwwsrv4vhost1phptmpphp8FR2IK.pdf

- Use of relevant software and CAD systems
- Knowledge of the relevant rules and procedures

Personal and social competences refer to:

- Accurate and systematic performance of tasks according to technical specifications, standards and legal requirements
- Completion of work orders both independently and in a team with other professionals
- Further training in areas relevant to mechatronics
- Communication with customers and suppliers, drafting of relevant documentation, understanding of technical descriptions and literature.

No further information has been identified regarding the implementation of the learning outcomes or competence orientation in relation to foreperson courses.

Higher education

In higher education the integration of learning outcomes has started together with the implementation of Bachelor-, Master-, and PhD- degree programmes and relates to modularisation of the curricula. According to the Austrian report regarding the Bologna Process implementation 2009-2012, learning outcomes are defined in national steering documents only in connection with the Dublin descriptors, and as prescribed in terms of knowledge, skills and competences in the individual curricula, established under university autonomy. Of note is that, the use of learning outcomes in curricula development and student assessment is a precondition for the accreditation of all study programmes at universities of applied sciences.[19]

4.3.3. Examination procedures

School-based VET

From the 2015/16 school year, the standardised, competence-oriented upper secondary school-leaving exam, the "Reife- und Diplomprüfung", will be introduced at VET colleges, and common quality standards will be established. This exam will apply to all candidates and be comprised of diploma projects (subject-specific piece of work including presentation and discussion) and standardised forms of written exams in German, modern foreign languages, and applied mathematics[20].

Apprenticeship training

The apprenticeship-leave exam (LAP) in mechatronics consists of a practical and a theoretical part. The theoretical part of the exam precedes the practical and is in a written form. It consists of three components related to technology, organisation of

[19] National Report regarding the Bologna Process implementation 2009-2012 Austria, pp. 1-2, section 4
[20] www.bmukk.gv.at

work and functional analysis. The *technological component* includes test questions from several areas (i.e. mechatronic systems, basics in electrical engineering, testing and measuring techniques, etc.). The time for answering is 90 minutes. *Organisation of work* covers the preparation of a work plan for the installation and assembly of a mechatronic system following specific guidelines. The time given for this task is 150 minutes. The *functional analysis* comprises the description of procedures for preventive maintenance and for minimising errors in a mechatronic system. The time given is 150 minutes[21]. "The theory exam can be waived if the exam candidate can prove successful completion of the final grade of a part-time vocational school" (Tritscher-Archan 2012, p. 20).

The practical part includes a performance check ("Prüfarbeit") on practical know-how and job-related skills of the candidate. It is followed by an expert discussion ("Fachgespräch") between the candidate and a board of examiners (examination committee). The examination committee is made up of a chairperson, who has to be an authorised apprenticeship trainer and legally established stakeholders i.e. employers and employee representatives, who have to be professional experts in mechatronics. The *performance check* relates to the elaboration of a mechatronic sample according to guidelines, formulated in the form of a company contract. Specific tasks include construction, modification or maintenance of a mechatronic system, installation of a control programme, work planning and documentation of work steps. The candidate has 14 hours to complete the task. The *expert discussion* builds on the performance check and proves whether the candidate can demonstrate knowledge of technical terms, whether he/she can offer professional solutions to subject-related problems and establish procedures for their execution. The time given for the discussion is up to 30 minutes.

4.3.4. Conclusion

In Austria, vocational education and training includes diversity of pathways, which provides several possibilities for acquiring a qualification in the field of mechatronics. The implementation of the learning-outcomes approach (in relation to curricula design, setting of assessment standards) in VET as well as in the other education sectors is still work in progress and at different stages even within the same education sector. This is illustrated by the apprenticeship training. While the occupational competence profile and the job profile (specified in the training regulations by the Ministry of Economy) are largely formulated in learning-outcomes oriented manner, the curricula for the school-based element of training (regulated by the Ministry of Education) have been predominantly in-put oriented up until now. This poses a challenge for the implementation of the learning outcomes approach as learning contents are described in separate documents, and separate bodies are responsible for these.

[21] BGBl. I Nr.374/2003. Verordnung des Bundesministers für Wirtschaft und Arbeit über die Berufsausbildung im Lehrberuf Mechatronik (Mechatronik-Ausbildungsordnung)

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4.4. Alternating training: Country study Poland

Tomasz Giesko, Lech Kunc, Maksym Pimenow, Wojciech Szczepański

4.4.1. Introduction: A short description of the sector of mechatronics – areas of employment in Poland where the occupation is practiced

Jobs in the professions directly or indirectly related to mechatronic engineering can be found in a majority of sectors of the national economy: the industry, transport and scientific research in the first place. The most prominent of the sectors is industry, in which the following lines of business, where professional mechatronic technicians (engineers, technicians, assemblers and operators) are employed, can be named:

- electromechanical engineering (machine-building industry, metal processing industry, precise engineering, production of means of transport, electrical and electronic industry);
- high-tech industries;
- power industry;
- food industry,
- light industry,
- printing industry.

Besides typical manufacturing industries, a significant and ever broadening area of mechatronic engineers employment is the sector of services (the assembling and repair of machinery and equipment in particular). As regards transport, it is mostly the jobs related to the use and maintenance of means of land/air/maritime transport that are concerned. In the fifth sector of the economy an ever broader area where mechatronic engineers are employed is, besides scientific research, the military and police, where the specialists are required to operate the modern specialist equipment.

Which mechatronic jobs are covered by the Polish (formal and non-formal) system of education and professional improvement

The Polish system of vocational education and improvement includes a wide number of jobs directly and indirectly related to the area of mechatronic technologies. As per the current classification of jobs and specialties[22], jobs related to the sector of mechatronics can be found in the following groups: specialists, technicians and other medium-level staff, machinery and equipment operators and assemblers. A complete and unmistakable identification of jobs related to the sector of mechatron-

[22] Ordinance of the Minister of Labour and Social Policy of 27 April, 2010 on Classification of Occupations and Specialties for the Needs of the Labour Market and the Range of Its use (Journal of Laws No. 82 of 17 May, 2010, item 537).

ics is rather complicated owing to the differences existing between the classification of occupations and specialties (Polish abbr. KZiS) developed for the needs of the labour market and the classification of occupations under the system of vocational education and improvement (Polish abr. KZSZ)[23]. Table 9 includes the jobs identified under the system of vocational education and improvement, which – considering the qualifications required – are related to the sector of mechatronics:

Job code as per KZSZ 2007	Job code as per KZiS 2010	Job name	Level of qualifications as per ISCO-08	Level of qualifications as per PRK (Polish Qualification Framework)
	214404	Mechanical engineer – industrial machinery and equipment	Level 4	Levels 6-7
	214405	Mechanical engineer – precise engineering		
	214408	Air mechanical engineer		
	214903	Automation and robotics engineer		
	214904	Avionic engineer		
	214905	Biocybernetics and biomedical engineer		
	215103	Electrical engineer		
	215104	Electrical/automation engineer		
	215201	Electronic engineer		
	215202	Mechatronic engineer		
311[07]	311408	Electronic technician	Level 3	Level 4
311[08]	311303	Electrical technician		
311[20]	311504	Mechanical technician		
311[50]	311410	Mechatronic technician		
311[52]	311513	Automotive vehicle technician		
314[05]	315317	Air mechanical technician		
314[06]	315316	Avionic technician		

[23] Ordinance of the Minister of National Education of 23 December, 2011 on Vocational Education System Classification of Occupations (Journal of Laws of 3 January, 2012, item 7).

Job code as per KZSZ 2007	Job code as per KZiS 2010	Job name	Level of qualifications as per ISCO-08	Level of qualifications as per PRK (Polish Qualification Framework)
723[02]	723310	Machinery and equipment mechanician/assembler		
723[04]	723103	Automotive vehicle mechanician		
724[01]	741103	Electrician		Level 3
724[02]	741203	Automotive vehicle electromechanician		
724[05]	741201	Electromechanician		
725[01]	742102	Electronic assembler		
725[03]	742114	Mechatronic assembler	Level 2	
731[01]	731102	Industrial automation and precise engineering mechanician		

Table 9: Jobs under the system of vocational education and improvement (KSZS), related to the sector of mechatronics

What qualifications are required for doing the jobs

The level and scope of detailed qualification requirements for the jobs indicated in table 10 is adjusted to the specific area of engineering and particular features of the job. The selected main qualification requirements for the jobs have been developed using the current core curricula. In case of engineers, no standards of vocational qualifications have been developed. For some of the jobs from the area no job descriptions are available either. The table does not include the requirements concerning technical education and the targeted knowledge for the job (as the general requirement and key precondition for the attainment of the indicated vocational skills).

Job	Description of basic vocational qualifications
Level 4 ISCO-08 (6-7 level PRK) – specialists	
Engineers (as per the list in Table 9)	Indicated based on the analysis of training curricula at domestic technical higher education institutes dealing with mechatronic engineering ▪ formulating and solving mechatronic design tasks; ▪ designing and structuring mechatronic devices and systems; ▪ programming and use of mechatronic devices and systems; ▪ assembling and dismantling mechatronic devices and systems; ▪ diagnosis of technical condition of mechatronic devices and systems; ▪ programming and managing processes of mechatronic device and system repair
Level 3 ISCO-08 (4 level PRK – technicians)	
Electronic technician	▪ installation and maintenance of electronic devices ▪ use of electronic devices ▪ repair of electronic devices
Electric technician	▪ assembling electric machinery and devices and putting them into operation ▪ laying down electric wiring and putting it into operation ▪ assessment of technical condition, identification and repair of electric machinery/devices/installations damages
Mechanical technician	▪ development of parts of machinery and devices ▪ assembling of machinery and devices ▪ - installation of machinery and devices and putting them into operation
Mechatronic technician	▪ designing and construction of mechatronic devices and systems ▪ assembling and dismantling mechatronic devices and systems ▪ programming and use of mechatronic devices and systems ▪ diagnosis and repair of mechatronic devices and systems

Job	Description of basic vocational qualifications
Automotive vehicle technician	▪ diagnosis of technical condition of automotive vehicles ▪ service and maintenance of automotive vehicles ▪ service of automotive vehicles arrangement and supervision thereof
Air mechanical technician Avionic technician	▪ providing technical assessment of aircraft ▪ service of aircraft ▪ repair of units and equipment of aircraft
Level 2 ISCO-08 (3 level PRK) – assemblers and mechanicians	
Machinery and equipment mechanician/assembler	▪ assembling, installation of machinery and devices and putting them into operation ▪ operation and maintenance of machinery and devices
Automotive vehicle mechanician	▪ diagnostics of automotive vehicles ▪ repairing automotive vehicles
Electrician	▪ assembling electric machinery and devices and putting them into operation ▪ laying down electric wiring and putting it into operation ▪ assessment of technical condition of electric machinery/devices/installations after assembling, based on measurements
Automotive vehicle electromechanician	▪ assessment of technical condition and repairs of electric/electronic systems of automotive vehicles
Electromechanician	▪ assembling of electric machinery and devices using technical documentation and putting them into operation ▪ assessment of technical condition of electric machinery/devices/installations after assembling, based on measurements ▪ assembling control/regulatory/protection systems of electric machinery and devices, using technical documentation
Electronic assembler	▪ assembling electronic elements/sub-assemblies/systems ▪ installation and maintenance of electronic devices

Job	Description of basic vocational qualifications
Mechatronic assembler	▪ assembling and dismantling mechanical elements/sub-assemblies/systems in mechatronic devices and systems ▪ putting mechatronic devices into operation and providing the required adjustments ▪ repair and maintenance of mechatronic devices and systems
Industrial automation and precise engineering mechanician	▪ assembling of industrial automation and precise engineering systems, putting into operation and servicing them

Table 10: Statement of essential qualification requirements for the jobs related to the sector of mechatronics

Under the now pursued policy of vocational education an obvious assumption is that the vocational qualifications, as set by the core curricula to be achieved by the students, reflect systematically monitored expectations of the employers. There remains, however, certain inertia as regards the updating of the training curricula; the latter should be better adapted to the results of the research done on the development of the economy and labour market needs. A precondition for the creation of an efficient system of vocational education and training should lie in systematically taken measures aimed at flexible reactions to the changes in business life and a significant shortening of the time for the adjustment of training curricula to the current needs.

Given modern trends of the development of Poland's economy and demands of the country's business people the following primordial qualification requirements can be named for mechatronics-related jobs.

Level 4 of ISCO-08 – specialists (level 6-7 of PRK)

- computer literacy and use of tool software;
- knowledge of English, technological vocabulary in particular;
- comprehensive knowledge in the field of mechatronics and the ability to quickly broaden it in a specific area as required by the company;
- use of, development and dissemination of technological information;
- managing the work of subordinated specialists and technicians;
- keeping the documentation related to the work done;
- designing mechatronic devices and systems, the customer's requirements being taken into account;
- making use of the latest technological and organizational developments;
- assembling mechatronic devices and systems and putting them into operation;
- diagnosis of technical condition and repair of mechatronic devices and systems;
- organization and management of a quality maintenance system;
- managing the processes of machinery and device utilization.

Level 3 of ISCO-08 – technicians (level 4 of PRK)

- computer literacy and knowledge of basic English technological vocabulary;
- identification and analysis of the structure and rules of operation of machinery and devices using technological documentation;
- assembling machinery and devices and putting them into operation;
- supervision of the operation of machinery and devices;
- diagnosis of technical condition and repair of machinery and devices;
- use of, development and dissemination of technological information;
- designing devices (at the basic level), the customer's requirements being taken into account.

Level of 2 ISCO-08 – assemblers and mechanicians (level 3 of PRK)

- identification and analysis of the structure and rules of operation of machinery and devices using technological documentation;
- assembling machinery and devices and putting them into operation;
- supervision of the operation of machinery and devices;
- diagnosis of technical condition and repair of machinery and devices;
- use of technological information.

It should be stressed that under the conditions of quickly developing technologies and the dynamic changes of market environment, the approach dominating in the companies assumes:

- high specialization (flexibility and adaptation), quickly attained at various jobs where mostly technicians are employed;
- the ability to quickly broaden general knowledge in the mechatronic sphere of company operation and reach specialization in the desired direction.

The above mentioned skills are important for efficient operation of the company, as they contribute to the attainment of the required flexibility of the staff.

4.4.2. The learning outcomes approach

The influence of EQF on vocational educational and training systems in Poland, in particular their connection with the labour market in the field of mechatronics (the way in which EQF is implemented in Poland in formal and non-formal education – rules, legal regulations, contemplated time framework for implementation)

For the purposes of training, in accordance with the classification of occupations as used under the system of vocational education, areas of education were indicated, with occupations assigned to them. Within the areas of education occupations are grouped taking into account common or similar qualifications needed to perform the tasks within a single occupation. Taking into account the Polish Classification of Activities (equal to NACE Classification), 8 areas of education have been singled out:

- administration and service (A)
- construction (B)
- electrics/electronic (E)
- mechanics and mining/metallurgy (M)
- agriculture and forestry along with environmental protection (R)
- tourism/catering (T)
- medicine/social services (Z)
- art (S).

Within each vocational area occupations have been classified by thetype of school: vocational school below secondary level, vocational secondary school, post-secondary school.

The training contents, as specified in the ordinance (the Ordinance of the Minister of Education on the Core Curriculum for Vocational Education of 7 February, 2012) are described as the expected learning outcomes regarding: knowledge, skills and personal/social competences required for the occupations or qualifica-

tions specified within the occupation include:

- learning outcomes which are common for all the occupations, including personal and social competences;
- learning outcomes common for the occupations within the educational area, being the foundation for training in an occupation or a group of those;
- learning outcomes specific of the qualifications singled out within the occupations.

The set of the expected learning outcomes, specific of a given qualification, is divided into parts that can be accomplished at the vocational skill courses mentioned in the regulations on continuing education in out-of-school forms.

The ordinance is accompanied by an appendix composed of three parts:

1. Part I outlines the general purposes and tasks of vocational education;
2. Part II determines the learning outcomes that are common for all occupations, learning outcomes common for the occupations within the educational area and learning outcomes singled out within specific occupations;
3. Part III includes a description of education in specific occupations and thus contains: names and symbols of occupations as per the classification of occupations used in the vocational education, names of qualifications distinguished within the occupations, terms of education in specific occupations, minimum number of hours of vocational education and the options for the acquisition of additional qualifications in the occupations forming an educational area within the classification of occupations applied for the purposes of vocational education.

The individual components of the core curriculum have been marked using codes allowing for their identification. The qualifications distinguished within separate occupations are labeled by capital letters indicating the occupational area to which they are assigned and sequential number. The learning outcomes common for all occupations, including personal and social competences, have been denoted using codes made up of three capital letters:

BHP – occupational safety and health;

PDG – starting and running a business of one's own;

JOZ – occupation-oriented knowledge of a foreign language;

KPS – personal and social competences;

OMZ – work organization at small teams (only for the occupations taught at the technician's level – required at the secondary and post-secondary schools).

The learning outcomes common for the occupations within an educational area, being the foundation for training in the occupation or a group of occupations have been marked using a three-letter PKZ code and, additionally (in brackets): a capital letter indicating assignment to an occupational area and a small sequential letter of the alphabet pointing out to the learning outcomes common for the occupation/group of occupations within the educational area.

The connection between areas of vocational education and specific occupations within occupational groups allows for greater training flexibility, thus making it possible to adapt the education to the dynamic changes of the labour market needs. It is also possible to avoid repeating the same contents in the training process, a factor most important when it comes to retraining or gaining additional qualifications in the occupations falling into a common area. An approach like gives added value to the education of adults, the life-long learning (LLL).

A model description of the learning unit (training module)

Dividing occupations into qualifications makes the education flexible and allows the student to supplement his/her qualifications so as to meet the market demand or his/her own needs and to satisfy the student's ambitions. Common qualifications can be found in the occupations trained at the vocational schools below/at the secondary school level. For instance, as regards the *mechatronic assembler* the following qualifications have been identified:

E.3. Assembling mechatronic devices and systems

E.4. Operation of mechatronic devices and systems.

The E.3. qualification is one of the two qualifications distinguished within the mechatronic assembler occupation and provides the foundation for the training in the profession of a mechatronic technician. The mechatronic technician has the qualifications relevant for the occupation, being the superstructure over the E3 basis qualification (these being the qualifications E.18 – Exploitation of mechatronic devices and systems and E.19 - Designing and programming mechatronic devices and systems). Yet another group of common outcomes of an occupational area are the outcomes that provide the foundation for the occupational training, marked using the PKZ.(E.a), PKZ(M.a) and PKZ(M.b) codes.

Qualification		Symbol of occupation	Occupation	Common elements
E.3.	Assembling mechatronic devices and systems	742114	Mechatronic assembler	PKZ(E.a) PKZ(M.a) PKZ(M.b)
		311410	Mechatronic technician	
E4	Operation of mechatronic devices and systems	742114	Mechatronic assembler	PKZ(E.a) PKZ(M.a) PKZ(M.b)
E.18.	Exploitation of mechatronic devices and systems	311410	Mechatronic technician	OMZ PKZ(E.a) PKZ(E.c) PKZ(M.a) PKZ(M.b)
E.19.	Designing and programming of mechatronic devices and systems	311410	Mechatronic technician	OMZ PKZ(E.a) PKZ(E.c) PKZ(M.a) PKZ(M.b)

Table 11: Learning outcomes common for the occupations within an educational area, being the foundation for the training in a group of occupations

Training curriculum for the mechatronic technician occupation

As the relevant ordinance of the Minister of National Education on framework curricula at initial vocational schools provides, the minimum number of vocational education hours shall be 1,600. Out of that general number, 630 hours are assigned, as a minimum, to the theoretical education and 970 hours to practical training.

Within the core curriculum for the education of a mechatronic assembler a minimum number of hours for the vocational education has been specified for the learning outcomes. The number now is:

1. Learning outcomes common for all the occupations and learning outcomes common for the occupations within the area of electricity/electronics being the foundation for the education in the occupation/group of occupations and the area of mechanics/mining &steel industries being the foundation for training in the occupation/group of occupations – 600 hours;
2. E.3. Assembling of mechatronic devices and systems – 330 hours
3. E.4. Operation of mechatronic devices and systems – 150 hours

Modular vocational training **									
Vocational training module		Total number of hours							
		Year 1		Year 2		Year 3		Average weekly number of hours	Total number of learning hours
1	742114.M1 Performance of measurements in electric/electronic systems	5	5	10				10	320
2	742114.M2 Examination of mechanical structures	9	9	8				13	416
3	742114.M3 Assembling mechatronic elements, devices and systems				16	15		15,5	496
4	742114.M4 Exploitation of devices and carrying out activities in the line of mechatronics					4	19	11,5	368
Total number of vocational training hours per week		14	14	18	16	19	19	19	1600

Table 12: Modular structure training curriculum for the Mechatronic Assembler occupation

The exam whereby the first E.3. qualification *Assembling of mechatronic devices and systems* is confirmed takes place at the end of the initial term of the third grade.

The exam whereby the second E.4. qualification *Operation of mechatronic devices and systems* is corroborated takes place towards the end of the third grade.

No.	Module name	Modular units	Tentative number of hours
1	**742114.M1 Performance of measurements in electric/electronic systems**	742114.M1.J1 Observance of BHP regulations	16
		742114.M1.J2 Use of a foreign language in mechatronics	32
		742114.M1.J3 Examination of electric/electronic systems	272
2	**742114.M2 Examination of mechanical structures**	742114.M2.J1 Examination of mechanical structure properties	304
		742114.M2.J2 Use of technical drawing	112
3	**742114.M3 Assembling mechatronic elements, devices and systems**	742114.M3.J1 Assembling mechanical elements, sub-assemblies and units	188
		742114.M3.J2 Assembling pneumatic and hydraulic elements, sub-assemblies and units	144
		742114.M3. J3 Assembling electric and electronic elements and sub-assemblies	164
4	**742114.M4 Exploitation of devices and carrying out activities in the line of mechatronics**	742114.M4.J1 Linking up mechatronic devices and systems	208
		742114.M4.J2 Maintenance of mechatronic devices and systems	112
		742114.M4.J3 Legal environment of business activity	24
		742114.M4.J4 Running a mechatronic firm	24

Table 13: List of module/modular units for the mechatronic assembler occupations

4.4.3. Examination procedures

Examination to confirm vocational qualifications – basic information

The following examination committees are established by a relevant legal act to carry out the Examinations to Confirm Vocational Qualifications:

- District Examination Committees (Polish abbr. OKE): Act of 7 September, 1991 on the System of Education (unified text: Journal of Laws of 1996,

No. 67, item 329, with further amendments, the amendment of 28 July, 2011 in particular). Ordinance of the Minister of National Education of 18 February, 1999 on the Establishment of District Examination Committees and Their Territorial Competence (Journal of Laws of 1999, No. 14, item 134, with further amendments)

Regulation of the Minister of National Education of 31 March, 1999 on Granting Charters to the District Examination Committees (Official Gazette No. 12 of 1999, item 169, with further amendments).

- Examination Committees of the Chambers of Crafts: Act on Crafts of 22 March, 1989 – unified text: Journal of Laws of 2002, No. 112, item 979, amended in 2003, Journal of Laws No. 137, item 1304, provides, inter alia, that:
  - master and apprentice examination committees shall be appointed by the competent body of the chamber of crafts; the registered office of the chamber shall become the registered office of the committee;
  - standards being the basis for the master and apprentice exams in the occupations corresponding to a specific craft shall be set forth by the Alliance of Polish Crafts; for the school-taught occupations the standards shall be established by the Minister of National Education;
  - the operation of the examination committees shall be supervised by the Alliance of Polish Crafts;
  - mandatory training of members of the examination committees shall be provided by the chambers of crafts, based the curriculum established by the Alliance of Polish Crafts;
  - examination tasks and questions as well as detailed evaluation criteria shall be approved by the chambers of crafts;
  - the chambers of crafts shall also keep the documentation of the examination committees and the register of the exams;
  - examination fees for the apprentice/master/verifying exam shall be fixed by the chambers of crafts;
  - persons having passed the exams shall be awarded apprenticeship certificates and master diplomas by the chambers of crafts; the documents shall be supplied with round seals with the national emblem of the Republic of Poland.

The exam confirming vocational qualifications can take place at schools, education centres (Practical Education Centres, Continuing Education Centres) or at the employer's, provided that the exam standards are met, at the place indicated by the

- District Examination Committee - OKE (as regards the student/trainee) or
- relevant Examination Committee of the Chamber of Crafts (regarding the young employee),

which are competent for the place where the learning outcomes are to be confirmed.

The exams shall be held by Examination Committees, established to that end by the District Examination Committee (OKE) under the legal regulations on conditions and ways of evaluation, classification and promotion of students and trainees at public schools and the Examination Committees of Chambers of Crafts under the regulations concerning the apprentice and master title exam. The document confirming the vocational qualifications is issued by the OKE or Chamber of Crafts. The practical vocational training of adults ends with the exams confirming vocational qualifications, held by OKE in accordance with the regulations concerning the conditions and ways of evaluation, classification and promotion of students and trainees at public schools as well as holding tests and exams at public schools or with the apprenticeship exam held by the examination committees of craft chambers, in accordance with the regulations concerning the apprentice and master title exams.

The exam confirming occupational qualifications (as of 1 September, 2012)
The exam is held for: ▪ young employees ▪ vocational school students ▪ vocational school graduates ▪ graduates of vocational qualification training courses ▪ persons eligible to take the exam as external students
The exam is held based on the core curriculum and concerns every qualification embraced by the occupation
The exam may be held at any time during the school year
The exam includes a written part (from 45 to 90 minutes) and a practical one (from 120 to 240 minutes)
The written part can be held electronically (on-line)
The form of the practical part is independent of the type of the school
The practical task is evaluated by the examiner immediately after completion of the practical part
Evaluated by the examiner are: ▪ quality of the final result: the product, service or documentation, for meeting the requirements specified in the examination task as contained in the examination chart, ▪ quality of the intermediate result, where the evaluation of the latter has direct impact on the evaluation of the final result and is not possible to carry it out upon completion of the examination task contained in the examination chart; ▪ performance of the examination task contained in the examination chart for: o observance of the rules of occupational safety and health, o compliance with methods or technologies relevant for completion of the examination task as contained in the examination chart.

Table 14: The exam confirming occupational qualifications (overview)

Description of a typical examination procedure: Procedure of the exam confirming a qualification singled out from the occupation:

1. A declaration to take the exam is filed by a school student with the headmaster.
2. A declaration to take the exam is filed by a school graduate with the director of OKE (District Examination Committee).
3. Besides the data identifying the candidate the declaration shall also contain: the number, occupation name and name of the qualification from the classification of occupations and the number from the core curriculum; the declaration shall be filed not later than 4 months prior to the date of the occupational exam.
4. The written part is held online or by using a hard copy document. The supervising team includes:
    - at school or an education centre – a minimum of three teachers, at least one of them being a teacher employed with another school or centre;
    - at the employer's – at least three employees authorised by the employer in question or by other employers;
    - Where there are more than 30 exam-taking persons in the examination room, the number of the supervising team shall be increased by one person per every additional 20 exam-takers;
    - The supervising team shall not include teachers involved in training activities concerning the subject matter of the exam nor class tutors of the exam-takers.
5. The practical part of the exam shall be held at an OKE-accredited centre: a school, education centre, work establishment. Responsible for the organization and performance of the exam is the Head of the Examination Centre (Polish abbr. KOE) (who, *inter alia*, provides a technical assistant for the exam). KOE appoints Practical Part Supervising Teams (Polish abbr. ZNPC) and heads of the teams.
6. A ZNCP is composed of:
    - at school/education centre: two teachers employed with the school/centre,
    - at the employer's/craftsman's: two employees authorised by the employer.
7. A ZNCP must not include teachers and trainers practically teaching the occupation, who run classes with the exam-takers.
8. The practical part is supervised and evaluated by an examiner (one per six exam-takers).

9. In addition, a technical assistant (nominated by KOE) is present at the exam.

Quality standards of the exams

a) Technical facilities for the examinations

- Providing a register of the operating examination centres
- Development of standards specifying the equipment of the examination centres for all the occupations/qualifications mentioned in the classification of occupations, as used in the vocational education system under conditions of occupational training

b) Examination standards

- Each qualification confirmed separately.
- Vocational exams are made uniform regardless of the type of training (school/out-of-school type).
- A bank of examination tasks is established.
- The practical part of the exam is standardized.
- The written test is solved using a computer.
- Exams held throughout the year.

c) Exam structure

- Written part: a test composed of 40 multiple-choice tasks, time: 60 minutes
- Practical part: a practical test including a single practical task, time: 120-240 minutes (specified in the guidebook)

d) Examination dates

- A vocational exam can be held throughout the year on a date fixed by the head of OKE, in agreement with the head of the Central Examination Committee (CKE).
- The date of the vocational exam shall be announced by the head of OKE not later than 5 months before the vocational exam is held.
- The time-table of the practical part of the vocational exam shall be fixed by the head of OKE and shall be passed to heads of the examination centres (KOE).

e) Scope of exams

The exam confirming occupational qualifications is a form of evaluation of the level in which the exam-taker has mastered the knowledge, skills and competences re-

garding a specific qualification distinguished within the occupation, as determined in the core curriculum for training in the occupations.

f) Organisation of the exam

- Responsible for the organisation and performance is the head of the examination centre (Polish abbr. KOE) (who, inter alia, provides the participation of a technical assistant for the exam).
- KOE appoints the teams supervising the practical part in individual room (ZNCP) and heads of the teams.
- A ZNCP is composed of:
    - at school/education centre: two teachers employed with the school/centre,
    - at the employer's: two employees authorised by the employer.
- A ZNCP must not include teachers and trainers practically teaching the occupation who run classes with the exam-takers.

g) Requirements concerning the examiners

- The examiner shall be entered in the register of examiners conducting the exams confirming occupational qualifications.
- The examiner shall be appointed by the KOE from among the examiners included in the list passed by the Director of OKE.
- The examiner must not be a teacher employed with the school or education centre where the practical part of the vocational exam is held

4.4.4. Conclusion

The Polish system of vocational education and training has undergone transformation. The now developed and implemented Polish Qualifications Framework (Polish abbr. PRK) is aimed to improve the quality of the existing subsystem of education to adapt them to the needs of the labour market and become coherent with what the employers expect. The said PRK is Poland's basic instrument serving the purpose of reformation of the education subsystems (the general elementary education, elementary vocational education, vocational education of the adults, education at the supra-elementary level, higher education) and validation of the learning outcomes for meeting the requirements of qualification transparency at the European level, as specified by the European Qualifications Framework (Polish abbr. ERK).

Originally 7-leveled (2009), the PRK has finally taken the shape of an 8-level scheme – its 5th level being regarded as an intermediate one between the post-secondary (level 4) and higher education (level 6). The level is "void" for the time

being, but it can soon be "filled up" by new qualifications, both those academic (resulting from a shortened training cycle) and the technologically advanced vocational qualifications. The said is a good example to illustrate the shift from the input-oriented system of determining the levels of qualifications by taking into account the country's institutional structures to the output-oriented concept basing on learning outcomes. And thus PRK makes it possible to use the qualification levels as a point of reference not only for the existing qualifications (subscribed to the domestic institutional structures), but also for the qualifications that are being under development or have been recently created.

For many years employers have been complaining about the employees-to-be being insufficiently prepared to doing work in specific occupations. Despite heavy attempts done on the national level, such as National Qualification Framework, National Standards of Competences, new occupational core curricula (based on the learning outcomes approach) being implemented, efficiency and flexibility in that respect is still unsatisfactory. One of the solutions allowing to overcome the barrier is the modularization of occupational education curricula. The employers suggest gradual diverting from the occupations, to be replaced by the notion of a "professional profile" containing learning outcomes resulting from the context of company operation. Such an approach, combined with the modular training technology, will make it possible to flexibly adapt the learning units (within the educational modules) to the needs of the companies. Since the beginning of the year 2014 the government decided to implement the new inter-ministerial taxonomy of qualifications. That means that it is going to follow the direction mentioned above, i.e. adjusting of learning offer to qualifications (and not occupations as it is now) using the modular technology in vocational education and training in Poland, where each module respond to certain units of learning outcomes forming a qualification.

Considering the said, the newly created training curricula (the mechatronic sector being no exclusion) should not only have modular nature, but should also be supported by appropriate stakeholders and decision-makers in preparing the appropriate set of instruments allowing to bridge two worlds (the world of education and the world of work) to allow a proper use of the knowledge and skills acquired, as required by the working environment.

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4.5. School based system: Country study France

Serge Rochet, Tomas Sprlak

4.5.1. 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%)[24].

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 institutions[25], 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

[24] www.mecatronique.fr
[25] www.onisep.fr

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% 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.

4.5.2. 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 15: 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 16: 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, …) ▪Tools required ▪Documentation specific	Establish the finding of failure Identify the failing function: ▪basic operative function ▪safety 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

to the manufacturer ▪Protective equipment (individual and collective)	▪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 17: 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.

4.5.3. 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 18: Examination E4

Oral examination

In its structure, the oral examination is very similar to the written one: it is also con-

structed 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 19: 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.

4.5.4. 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 interrelated 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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4.6. Sub-degree higher education: Country study UK/England

Alan Brown, Maria de-Hoyos-Guajardo

4.6.1. Introduction

Previously, the *Engineered Systems* pathway[26] qualification was mapped to the Competence Matrix "Mechatronics" provided by 3s. This UK National Vocational Qualification (NVQ) contains elements of Mechatronics but is not labelled in this way and the focus is different to Mechatronics qualifications in other countries. In other words, a Mechatronics VET qualification is not offered in the UK in the NVQ System at Levels 4 or below.[27]

The aim of the previous report was to map the learning outcomes of the UK qualification to the matrix provided to identify common areas of competence development and suggest new ones. In the process of this comparison it was noted that since the Engineered Systems pathway qualification is a Level 3/4 vocational qualification, some areas of competence development that were contained in the matrix provided by 3s were not covered. For example, the 'Mechatronics' matrix goes beyond *using* engineering drawing and documents and involves designing, adapting and building mechatronic systems and putting them in operation; these areas are not included in the UK qualification.

The UK Level 3/4 qualification mentioned above was chosen because being a National Vocational qualification (NVQ) means it is competence-based and aims to reflect what individuals are able to do in the work environment. Moreover, its learning units are based on National Occupations Standards (NOS) which are "statements of effective performance which have been agreed by a representative sample of employers and other key stakeholders and approved by the UK NOS Panel" (NOS, 2012). Consequently, the learning units that constitute NVQs such as the Engineered Systems Pathway are defined based on what workers must know, be able to do and understand to perform a given job role or function within the work environment.

The present report turns its attention to Mechatronics qualifications in the UK which are offered as such at Level 5 and above in the form of Foundation Degrees. Alt-

[26] From the Engineering Maintenance Suite 3 NVQ qualification structure.

[27] It is interesting to note, however, that Siemens have introduced from August 2013 a 'European apprenticeship' based in England whereby recruits can take part in an apprenticeship in either Mechatronics or Electrical/Electronic Engineering. The European Apprenticeship Scheme runs for 3.5 years, includes an extended placement in Berlin, and German lessons. However, the special European orientation of this programme is emphasised in that UK recruits to the programme can also spend 11-29 weeks per annu, in plants in Berlin and just 4 weeks in the UK. In this case the students work towards an IHK (Chamber of commerce) exam in German. Assignment after education will be follow-on employment in the UK. The ideal applicant will have a basic knowledge of German, but could be a school leaver (18 years +), a university student or a college graduates. Hence everything about this scheme shows it has a German genesis and is exceptional rather than representative of the UK system.

hough Mechatronics is also offered in the UK as a Higher Education (HE) degree, this report will focus on Foundation Degrees since they fall within the VET system. UCAS, the organisation responsible for providing information about higher education courses in the UK and of managing applications to HE, provides the following description of Foundation degrees:

- Foundation degrees are designed and delivered in partnership with employers to equip people with the relevant knowledge and skills for business.
- They are offered by universities in partnership with higher education colleges and further education colleges. The study methods can be very flexible, which means that they are available to people already in work, those wishing to embark on a career change and to those who have recently completed level 3 qualifications (e.g. A levels, Advanced Apprenticeships or NVQ3).[28]
- A foundation degree is the equivalent of the first two years of an Honours degree, may be studied full- or part-time, and consist of academic study integrated with relevant work-based learning undertaken with an employer. It may be studied as a stand-alone qualification or upon completion you may progress to the final year of an Honours degree.[29]

As this description suggests, Foundation Degrees allow flexibility in relation to how they can be studied and in terms of progression routes. They also designed in partnership with employers and include employer-based training. Nonetheless, there seem to be fewer options for studying a Foundation degree in Mechatronics than for studying Mechatronics as a Bachelor's or Master's degree. A UCAS home/EU search for Foundation degrees in Mechatronics yielded two results[30], whereas a search for 'Mechatronics on its own as a single subject' yielded nine courses at six different universities[31].

Other courses can be found in colleges or universities web pages, but on a closer inspection or after contacting these institutions, it became clear that the degrees are no longer available. It seems that dynamic nature of Foundation Degrees helps to make them relevant to students and employees but at the same time this makes them difficult to sustain over time. The two courses currently available through UCAS are:

- FdSc, Engineering (Mechatronics), City of Bristol College, 3 years part-time (validated by Plymouth University)

[28] www.ucas.ac.uk/students/choosingcourses/choosingcourse/foundationdegree

[29] ucas.faq-help.com/?search=Type%20your%20question%20here...#, See www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/FHEQ08.pdf for a description of The framework for higher education qualifications in England, Wales and Northern Ireland.

[30] fd.ucas.com/CourseSearch/Default.aspx#results_new (accessed 27.05.2013)

[31] search.ucas.com/cgi-bin/hsrun/search/search/StateId/EHAsQ7t9A1UGM7Kma7e-5Ou7DpRq_-VBOn/HAHTpage/search.HsKeywordSuggestion.whereNext?query=425&word=MECHATRONICS&single=Y (accessed 27.05.2013)

- FdA, Mechatronic Engineering, Coleg Morgannwg, 2 years part-time (validated by the University of South Wales and the University of Wales)

The next section looks at the learning outcomes approach in the UK VET system. It then explores learning outcomes in Mechatronics by focusing on the courses listed above as exemplars.

4.6.2. The learning outcomes approach

Learning outcomes have been used throughout the UK since the early 1990s in relation to higher education (cf. Adams, 2004). It may be said that, in relation to VET, their adoption can be traced back to the 1980s, as NVQ qualifications in the UK VET system are based on what experts in setting occupational standards consider individuals need to know to perform a given job in the labour market, i.e., on the desired learning outcomes defined by employers and relevant organisations. In order to be recognised as NVQs the standard setting process had to follow tightly prescribed procedures.

Back in the early stages of the implementation of this approach in the UK, Jack et al. (1993, p. 1) defined "learning outcomes" as "what learners are able to do as a result of learning". The authors stressed the importance of making learning outcomes explicit as well as the importance of linking them to the requirements of employment and/or progression in terms of education. From this approach stemmed a concern for ensuring that assessment concentrated on evaluating the extent to which individuals' capabilities matched the specified learning outcomes.

Learning outcomes are currently used in the UK education system at all levels but their adoption and impact on teachers and leaners is not without critique. Some suggest that establishing learning outcomes can narrow rather than extend the teaching and learning process to those aspects that can be measured and assessed (cf. Furedi 2012). They suggest that developing learning outcomes is, at best, an activity that is accepted as a task of the profession with little or no impact on practice. In spite of this criticism, it is recognised that learning outcomes provide a tool for planning how to help students progress and for measuring where students should be at a given level of development.

However, recent reforms to strengthen vocational education provide evidence of an imminent drift away from an over-reliance on competence-based units towards valuing more holistic qualifications, suggesting that learning outcomes will occupy a less central role in the proposed 'high value vocational qualifications". The next section discusses the critique of the leaning outcomes approach in the UK as well as some of the proposed changes for Level 3 Vocational Qualifications for 16-19 Year Olds. It then looks at some exemplary descriptions of Mechatronics courses and learning outcomes in this area.

Critique of the learning outcomes approach in the UK VET system

CEDEFOP (2012) classifies the UK as an early developer of learning outcomes in Europe together Belgium (Flanders), Finland, France, Hungary, Ireland, Lithuania, the Netherlands, Norway, Poland, Romania, Slovenia and Sweden. These countries started to develop their outcome-oriented curriculum before the 1990s. In contrast to these, central and eastern European countries as well as Mediterranean countries are classified as more recent developers as the introduction of learning outcomes dates from 2005 onwards. Recent adopters include: Austria, Belgium (Walloon), Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Germany, Greece, Iceland, Latvia, Liechtenstein, Malta, Portugal, Slovakia, Spain and Turkey.

In spite of this classification which shows widespread adoption of a learning outcomes approach across Europe, CEDEFOP (2012) reports difficulties in establishing to what extent it has been implemented, particularly in relation to VET. Among the difficulties, the report highlights that the learning outcomes approach can be a meaningful exercise that ultimately supports the teaching and learning process but it can also be seen as a 'paper exercise' with limited implications on the curriculum.

In addition to this, the adoption and implementation of the learning outcomes approach and associated implications vary from one country to another and more detailed comparisons reveal differences even among systems that may seem comparable. For this reason, classifying VET systems is a challenging task and different classifications necessarily focus on specific dimensions but obscure others.

In her literature review on divergences in VET in Europe, Michaela Brockmann (2007) adopts a typology which classifies VET systems according to their focus as learning outcomes developed. This typology suggests that VET systems may fall into two groups: those which "focus on education of the person for an occupation" on the one hand, and "those aimed at employability of individuals" (p. 2) on the other. This approach allows her to compare the VET systems of Germany, the Netherlands, France and England.

According to the author, VET in Germany, the Netherlands and France is moving toward putting more emphasis on employability, whilst retaining defining principles such as providing a holistic education embracing the notion of citizenship. This is reflected in VET systems that focus increasingly on occupational mobility and less delineated (rather than more specialised) occupations "in line with requirements of the knowledge economy" (p. 3). On the other hand, the author suggests that England is moving in the opposite direction by narrowing learning outcomes to specific skills as a result of a strong emphasis on fostering the skills demanded by employers. It is argued that these skills, nonetheless, do not provide the general education and culture essential for future education and training (cf. Green, 1998) or for lifelong personal development.

Of main relevance here is the conclusion that Brockmann (2007) draws in relation to how learning outcomes are negotiated in the countries being compared. Whereas in France, Germany and the Netherlands a range of institutions (the state, employers, unions, teaching institutions) are involved in the process of defining learning outcomes, in England employers' skills needs take centre stage. This leads to a VET system based on a holistic concept of education for the former group of countries, and a system based on the development of those skills required by employers in the case of England.

Brockmann (2007) concludes by saying that the English VET system presents a major challenge in relation to upgrading the UK skills base in order to achieve economic competitiveness. The role that the author portrays for learning outcomes is of restricting the development of a broader set of skills as well as aspirations. Although there is a debate regarding the role of learning outcomes in education in the UK, there is also the view that learning outcomes represent a useful tool for planning teaching and learning. As the following quote suggests, there is a place for learning outcomes in supporting teaching, although the question of who develops learning outcomes and who should be involved remains.

We expect every single learner to be completely engaged and participating; they're enjoying their lessons, they're excited about it and that their learning is rigorously assessed. In very simple terms, that's what we want to see but for every learner to travel some distance in a lesson there needs to be very clear learning outcomes set for them. The teacher really needs to know very well where those learners are at and in order to really contextualise the learning, make it relevant and interesting for them, know what they're interested in, what their aspirations are, and develop aspirations in them. Where do they want to work in the future? What are their strengths, how do they prefer to learn? So all of that background information is really important in order to plan learning (quoted in Faraday et al., 2011).

While it is difficult to argue against a process of planning pupils learning pathways and expectations and making these explicit through outlining learning outcomes, the limitation of the role of written specifications has also been recognised. As it was mentioned in The Wolf Report[32] "written specification plays only a small part in determining what is actually taught, let alone the standard and quality of the assessment" (Wolf 2011, p. 176).

Furthermore, The Wolf Report audited current provision and concluded that a requirement to comply with National Occupational Standards (NOS) creates a number of problems for VET for young people. NOS reflect practice at a particular

[32] The Review of Vocational Education, also known as The Wolf Report) was published in 2011. It was commissioned by the UK government to review the state of vocational education for 14-19 year olds in England and to provide recommendations as to how it could be improved.

point in time in a specific occupation.[33] Although this may be a suitable approach to specific qualifications for adults who are already in employment, "it is entirely inappropriate for young people who are likely to change jobs, and who are entering decades of employment in a rapidly changing economy" (Wolf 2011, p. 75). The report also suggests that for apprenticeship frameworks, England presents an 'unusual' case for the amount of responsibility for design of awards given to employer organisations.

As a result of the recommendations of The Wolf Report, the government carried out a public "Consultation on the Reform of Level 3 Vocational Qualifications for 16-19 years old" which led to a Government Response (Department for Education, 2013a) and a Technical Guidance for Awarding Organisations (Department for Education, 2013b). The latter document highlights the following characteristics that Level 3 vocational qualifications must demonstrate, namely: declared purpose, size, recognition, synoptic assessment, external assessment, grading, employer involvement, progression and proven track record.

The declared purpose states that qualifications "must declare the purpose of a qualification in terms that will be meaningful and relevant to students, parents, employers, post-16 providers and higher education institutions" (Department for Education, 2013b, p. 10). The size specifies the number of expected Guided Learning Hours and it is stated that relevant qualifications "should be publicly recognised by employers, recognised professional or trade bodies and/or higher education institutions (HEIs) as fit for purpose" (idem, p. 12). The document continues specifying each of the seven characteristics but there is no mention of learning outcomes. In all, there seems to be a move in the short term future from small learning units to more meaningful and holistic qualifications.

Exemplary description: 'FdEng Foundation Degree in Mechatronics'

After a discussion of learning outcomes in the UK VET system, this section considers learning outcomes in Mechatronics. Mechatronics degrees are available in the UK as Foundation Degrees as well as at Bachelor's and Master's degree level. The focus here will be in the former given that Foundation Degrees are considered as part of the VET system, although they are offered by higher education institutions and colleges offering higher education degrees. Above all, these degrees can be seen as offering permeability between VET and higher education.

The table below shows the structure of the courses currently being offered as Foun-

[33] Overall, the challenge in supporting the development of personal capabilities of those taking substantive work-based qualifications is reconciling the development of particular sets of skills, knowledge, understanding and ways of thinking, being and doing, with developing dispositions which go beyond these particular developments in responding to new challenges: curiosity, resourcefulness (including learning from others), resilience, ability to support the learning of others, taking responsibility for self-development and refexiveness. Vocational Qualifications above all need to support expansive forms of learning and development – it is important to move people to more challenging forms of work – higher skill utilisation etc. as the percentage of learning intensive skilled jobs in the UK is much lower than in other countries in Northern Europe.

dation Degrees and accessible through UCAS (see Section1). Both courses are offered as 2-year full-time degrees, or 3 years part-time. However, further descriptions of these courses are not available online. In the case of the FdA in Mechatronic Engineering at Coleg Morgannwg, the information provided states that assessment methods include: "written assignments, laboratory experiential learning, an examination and research reports related to industrial workplace"[34]. In the light of the lack of information available other courses delivered in the recent past, but not currently available, will be considered.

FdSc, Engineering (Mechatronics), City of Bristol College*		**FdA, Mechatronic Engineering, Coleg Morgannwg****	
Stage 1	**Stage 2**	**Year 1**	**Year 2**
Engineering Design Mathematics for Engineers 1 Materials Engineering Engineering Science 1 Business Management for Engineers Mechatronic System Principles	Industrial Project Design for Manufacture Engineering Science 2 Control Systems Programmable Logic Controllers Instrumentation and Control Principles	Engineering Mathematics Electrical Technology Programmable Logic Controllers Introduction to C Programming & Embedded Systems	Introduction to quality Electrical Principles Method & Simulation Mechatronic Systems an Individual Project Design of Electrical Installations Work Based Learning

*Offered in partnership with the University of Plymouth
**Validated by the University of South Wales and the University of Wales

Table 20: Foundation Degrees in Mechatronics currently accessible in the UK

The following description belongs to the FdEng Foundation Degree in Mechatronics offered by Farnborough College of Technology. The course is not available through UCAS and it was not possible to confirm with the College whether the course was on offer the next academic year or not. However, the description of the course provides further information about Mechatronics Foundation Degrees. As can be noted from the description, the course seeks to help students develop both practical and academic knowledge. The second paragraph places emphasis on vocational and practical skills required in the Mechatronic sector.

- The course structure is designed to offer students a well-balanced, broad range of subjects relevant to today's engineers. The programme of study will develop the student's practical engineering skills through projects and enrichment activities, as well as the academic knowledge required within a degree programme.

[34] www.morgannwg.ac.uk (accessed 24.10.2013)

- The combination of academic and vocational skills is designed to provide a holistic approach to engineering and to ensure that students are "work-ready" at the end of their programme. It is intended to produce high quality graduates, who are industrially focussed with vocational and practical skills, related to the Mechatronic sector of Engineering at an advanced practitioner level. Thus, success on this programme will place graduates in an ideal position to compete for positions within this flourishing area of the sector. [35]

The above descriptions do not provide a description of the learning outcomes involved in relation to these courses. This information is not available online although this does not mean that leaning outcomes have not been documented. In contrast to this, however, undergraduate and postgraduate degree courses seem to make their learning outcomes more readily available. For instance, the University of Ulster provides a list of the learning outcomes associated to the following Mechatronic engineering degrees:

- MEng Mechatronic Engineering with DPP (6691)
- MEng Mechatronic Engineering + German Master's Degree with DPP (6692)
- BEng(Hons) Mechatronic Engineering with DPP (Exit Award)
- AB Mechatronic Engineering with or without DPP (Exit Award)
- CertHE (Exit Award)'s part-time degree in Mechatronic Engineering

Table 21 provides the learning outcomes for the above Mechatronic engineering degrees. These are divided into i) knowledge and understanding; ii) intellectual qualities; iii) professional/practical skills; and iv) transferable skills. (Teaching, learning and assessing methods are also specified for each of these categories in the next section). As can be seen, the language used in the description of the learning outcomes are clear statements of what candidates should be able to do to be awarded the relevant qualification. They are statements of what can be achieved and/or assessed in a specific timeframe and are written in a language accessible to students as well.

[35] www.farn-ct.ac.uk/subjects/engineering/fdeng-foundation-degree-in-mechatronics%20-%20H (accessed 24.10.2013)

	Learning outcomes
Knowledge and understanding	K1 Demonstrate a comprehensive understanding of the scientific principles of mechatronic engineering and the related disciplines of electronic, mechanical and software engineering. K2 Demonstrate a comprehensive knowledge and understanding of mathematical principles necessary to underpin their education in mechatronic engineering and to enable them to apply mathematical methods, tools and notations proficiently in the analysis and solution of engineering problems. K3 Demonstrate a comprehensive understanding of concepts from electronic mechanical and software engineering, as well as business and management studies and apply them effectively in engineering projects. K4 Demonstrate extensive knowledge and understanding of management and business practices, and their limitations, and how these may be applied appropriately. K5 Demonstrate an awareness of developing technologies related to mechatronic engineering. K6 Demonstrate a comprehensive knowledge and understanding of mathematical and computer models relevant to mechatronic engineering, and an appreciation of their limitations.
Intellectual qualities	Demonstrate understanding of engineering principles and apply them to analyse key mechatronic engineering processes. I2 Identify, classify and describe the performance of mechatronic systems and components through the use of analytical methods and modelling techniques. I3 Apply mathematical and computer-based models for solving problems in mechatronic engineering, and the ability to assess the limitations of particular cases I4 Demonstrate understanding of and ability to apply a systems approach to solving mechatronic engineering problems. I5 Demonstrate a wide knowledge and comprehensive understanding of engineering design processes and methodologies and the ability to apply and adapt them in unfamiliar situations. School of Engineering 4 I6 Generate innovative designs for mechatronic products, systems, components or processes to fulfil new needs, and, where appropriate, make general evaluations of commercial risks through some understanding of the basis of such risks. I7 Use fundamental knowledge to investigate new and emerging technologies

	Learning outcomes
Professional practical skills	Demonstrate extensive knowledge and understanding of a wide range of engineering materials and components. P2 Plan and conduct laboratory and workshop tasks using a variety of equipment. P3 Demonstrate understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology development, etc.). P4 Source, integrate and use effectively technical literature and other engineering information and data. P5 Demonstrate an awareness of the nature of intellectual property and contractual issues, appropriate codes of practice and industry standards, and quality issues. P6 Work with technical uncertainty. P7 Demonstrate a thorough understanding of current practice and its limitations, and some appreciation of likely new developments.
Transferable/key skills	Make effective and appropriate use of Information and Communications Technology (ICT) skills. T2 Communicate effectively, both orally and in written form. T3 Able to function effectively as a member of a team and use management skills to plan, organise and provide leadership in work groups and projects. T4 Exercise planning, organisational, problem-solving, and time-management skills and effectively use available resources.

*Table 21: Learning outcomes and examination procedures of exemplary course**

*Mechatronic engineering courses at the University of Ulster (source: seng.ulster.ac.uk/uploads/documents/mengmechatronicengineeringprogrammespec.pdf)

The next section looks closer at the examination procedure and assessment in relation to learning outcomes in the UK.

4.6.3. Examination procedures

According to Jack et al. (1993), the outcome-based assessment model implies that that the specified learning outcomes provide a basis against which candidates 'competencies' are directly compared and evaluated. To do this, evidence can be gathered from a wider range of sources than is the case for the 'traditional' model of assessment. Given that in the outcome-based approach individuals' capabilities are at the heart of the evaluation, evidence of performance or development can include prior experience, observations, and portfolio evidence as well as evidence from more traditional forms of assessment such as oral or written examinations.

As the authors suggest, it is likely that the assessment process will require evidence from more than one source depending on the type of competencies being evaluated. In the case of assessment of knowledge, for example, performance evidence although useful may not be sufficient to establish that the candidate's performance is at the required level and that it can be maintained consistently. Therefore, this evidence will need to be complemented with evidence from other sources such as written tests or oral questioning (Jack et al., 1993). This is more so at higher levels where "'correct actions' are less easily prescribed and new unforeseen contingencies are more likely to arise" (p. 2).

Table 22 presents the examination procedures for the Mechatronic engineering courses at the University of Ulster discussed in the previous section. By comparing these with the learning outcomes listed in Table 21, it is possible to observe a relationship. However, the descriptions below are general and these differences cannot be observed in detail. All categories include coursework assignments and other sources of assessment methods that allow students to accumulate evidence of their progress. Professional and practical skills are also assessed through visits, reports and an oral presentation but these methods are also included in other areas.

	Examination procedure
Knowledge and understanding	Teaching and Learning Methods Subject related qualities are acquired mainly through lectures, seminars, directed reading, videos, IT based resources, case studies and experiential learning. Exposure to the engineering environment is an important aspect of the teaching and learning methods, as are projects. Assessment Methods Testing of the knowledge base is principally through examinations, coursework assignments, laboratory reports, project dissertation and oral presentations.
Intellectual qualities	Teaching and Learning Methods Intellectual qualities are developed mainly through coursework assignments, experimental work and projects. Assessment Methods Assessment focuses on the coursework assignments, experimental write-ups and project reports. Some of these skills are also assessed in the formal examinations.

	Examination procedure
Professional practical skills	Teaching and Learning Methods The teaching and learning methods place emphasis on engineering workshop practice, visits to local engineering companies and the supervised industrial placement year. Experimental work, team projects and design assignments also contribute. Assessment Methods The supervised work experience is assessed with visits, reports and an oral presentation. Coursework assignments, workshop exercises, laboratory reports, project dissertations and student peer assessment also contribute to the assessment methods.
Transferable/key skills	Teaching and Learning Methods Transferable and key skills are delivered throughout the programme, i.e. lectures, coursework assignments, laboratory work, industrial placement year and project dissertations. The IT skills are taught within the programme structure. Assessment Methods Assessment is principally through coursework assignments, laboratory reports and project dissertations. Assessment of teamwork is through submission of teamwork tasks, student peer and self-assessment, and oral presentations.

*Table 22: Examination procedures of exemplary course**

*Mechatronic engineering courses at the University of Ulster (source: seng.ulster.ac.uk/uploads/documents/mengmechatronicengineeringprogrammespec.pdf)

4.6.4. Conclusion

The UK is among the early adopters of the outcome-based approach in Europe. Like in all counties adopting this approach, its implementation and operationalization depend on each country's historical context. In the UK, the NVQ system introduced in the 1980s provided the basis for a system based on outputs (what candidates should be able to do) rather than inputs (the training that candidates should be offered). In this case, employer-defined National Occupational Standards (NOS) provide statements of outputs which are then translated into learning outcomes. The UK system differs to those of for example Germany, France and the Netherlands in the predominant role that employers are offered. Supporters of this view suggest that this leads to a "strongly demand-led system" which "ensures the production of a narrow set of skills suited to a low-skilled labour market" (Brockmann 2007, p. 3).

In spite of this critique, the learning outcomes approach is a tool which supports the integration of different actors in the education and training system, including

employers, students, teachers and qualification awarding institutions. The defining of learning outcomes is a process which can potentially integrate the interests of these groups. Moreover, it provides a map of the progress that candidates are expected to have made to be awarded a specific qualification. This provides useful information for those concerned. For example, to employers it details what individuals holding a specific qualification should be able to do and know. For teachers and learners it provides a description of what the latter should be able to demonstrate during examination procedures to be awarded the qualification.

Foundation degrees in Mechatronics are effectively the only VET courses offered in Mechatronics. As said above, however, they can also be seen as being on the frontier between VET and higher education, facilitating permeability between the two systems. One of the difficulties of running foundation degrees courses is ensuring continuity in terms of resources, students and partnerships with employers. Although foundation degrees are a model that is in principle efficient and effective from a learning development perspective, in practice the administration side of these programmes becomes a barrier to their sustainability. This is likely to impinge on the development of learning outcomes and on ensuring that these become relevant for all involved, including employers, education institutions and learners.

The most important aspect to recognise about the English VET system is the rediscovery of the importance of teaching and learning processes and the recognition that adoption of a 'hard' learning outcomes approach resulted in a significant narrowing of what was learned in VET. Now attention is focused upon both learning outcomes and processes in an attempt to deliver broader and more balanced curricula. Given that the development of National Qualifications Frameworks based on learning outcomes is still popular it is perhaps instructive to look at the reasons for the policy failure of an NQF based exclusively on learning outcomes in England. The major lesson to be learned is that a focus on competence, mapping qualifications, levels, and outcomes can become a distraction from the much more challenging goal of improving the quality of teaching and learning. Shifting attention to a developmental approach to the development of expertise may prove to be more effective by highlighting the importance of the processes of learning and the need to support the development of expansive learning environments in education, training, and employment (cf. Brown 2011). Recognising that the development of an NQF has a limited part to play in this process, and that a "rough guide" to equivalence will often be sufficient in mapping potential progression pathways, may be a useful starting point for this shift.

Brief exposition of reasons for the policy failure of an NQF based exclusively on learning outcomes in England

The starting point for any analysis of English policy in the area of vocational qualifications was the almost complete failure of the attempted reformation of VET through the introduction of outcomes-based National Vocational Qualifications (NVQs) in the decade following 1986 (Williams 1999). The standards of occupational competence upon which the NVQs were based were too narrow; employers

were reluctant to use the new qualifications; and the introduction of NVQs exacerbated, rather than mitigated, the "jungle" of vocational qualifications. In the mid-1990s unsuccessful attempts were made to restructure NVQs following a series of highly critical reports (cf. Beaumont 1996; Dearing 1996; Hyland 1998), but the National Council for Vocational Qualifications (NCVQ) and associated agencies continued to market the system overseas, without acknowledging the failings of NVQs and the competence-based education and training outcomes-driven system. Hyland (1998) highlighted how this was a strange case of exporting policy failure. The model was held up as promising reform even though it had not worked in practice in England.

Since then NVQs have been further reformed, a wider range of vocational qualifications have been encouraged and NCVQ was abolished and replaced by the Qualifications and Curriculum Development Authority (QCDA), which had responsibility for the development of a National Qualifications Framework. However, the whole area of qualifications reform remained a policy failure and the decision was taken to replace the NQF as the driver of reform with a Qualifications and Credit Framework (QCF) and to close the QCDA.

The reason for the move away from an exclusive focus on NQF outcomes, levels and qualifications was that these were too prescriptive – they excluded too many valuable qualifications, the system was too inflexible, did not support progression very well and 'level' was not a very good discriminator of the value of a qualification. The QCF now uses volume as well as level so that the system of credits can operate across units as well as whole qualifications. The credit based system recognises qualification size and represents a pragmatic and modest attempt at qualifications reform, and that the NQF development was the culmination of a major policy failure is now universally acknowledged.

The most obvious lesson is not to treat particular qualification design features as in some way inherently better than others and seek to apply them universally. The 'pure' English outcomes-based NQF was inflexible and unhelpful in practice, and although the new QCF system aligns less well with the recommendations for qualification framework development associated with the EQF, it was still possible to reference the QCF against the EQF. The key point about the QCF is that it is a pragmatic attempt to improve learner mobility, transferability and progression. The introduction of the QCF has been low key, recognising that earlier grand schemes based around a major reformation of vocational qualifications through NVQs and the NQF have been failures. Underpinning this change is the belated recognition that it is the quality of teaching, learning and skill development associated with qualifications that is key to whether they help individuals in processes of upskilling, reskilling and progression, not the imagined benefits of having qualifications of a particular type.

There is now recognition that qualifications are an inadequate proxy for skill development and that qualifications reform plays a much smaller role in improving the quality of VET than more direct measures to improve the quality of teaching,

learning and skill development and that for much of the past 25 years qualifications reform has actually been drawing resources away from improving the quality of the teaching, learning and the inter-relationship between the two (Nash et al. 2008). There is also an implicit recognition that the pragmatic evolution of the Scottish VET system over the last twenty five years, whereby each development built incrementally on a previous reform, has been much more successful in practice than the more radical attempts at reform of processes of qualifications design that have failed in England (cf. Raffe 2011). As a consequence the Scottish Credit and Qualifications Framework, a national credit transfer system for all levels of qualifications in Scotland, has gained widespread acceptance in practice.

In the QCF qualifications consist of a number of designated units, each of which has an approved credit value. These credit values represent the number of credits a learner will be awarded for successfully completing the unit. *One credit is awarded for those learning outcomes notionally achievable in 10 hours of learning time.* These changes were introduced to overcome the problems of having very different types of qualifications appear at the same level within a qualifications framework. An alternative approach may be just to exclude certain small qualifications from a NQF and keep the NQF just as a means of mapping the most important qualifications of a country in a way which could encourage progression within or across different pathways.

Developing an NQF which maps the broad pathways and major qualifications in a country, however they are described, and offers a 'loose coupling' to the EQF is probably sufficient to support the role of the EQF as a translation device to make relationships between qualifications and different national systems clearer. In that respect the lesson from the demise of a pure outcomes-based NQF in England is unequivocal: the drive for comprehensiveness and standardization in a qualifications framework consumed vast amounts of resources, was unworkable in practice and produced a whole array of qualifications which were not fit for purpose and were inferior to the qualifications they replaced when judged against the criterion of whether they supported continuing learning and development. In the field of NQFs less is more! It is a common trap to think that a more highly qualified workforce equates to a more highly skilled and more knowledgeable workforce. Indeed the focus on levels, qualifications and learning outcomes can be comforting because it gives the illusion of progress, but a much more sophisticated model of skill development and expertise is required to underpin a more meaningful movement towards a knowledge society (cf. Brown 2011).

4.6.5. Post-Script

Partly because of the weaknesses outlined in this report there is yet another review of direction of vocational qualifications and it is likely that vocational qualifications will now be expected to describe the abilities to be developed and the pathways where they might lead. This is in part because the national occupational standards on which many vocational qualifications are based tend to be too long and detailed, having been developed to be used directly in assessment.

While national occupational standards are usually restated in terms of the QCF units that make up most regulated vocational qualifications, the formats of the standards and the units are often similar, with the units also including detailed criteria to be used directly by assessors. Neither the national occupational standards nor the QCF units provide a summary of the qualification's content.

The Richard Review of Apprenticeships made a similar point:

"We have overly detailed specifications for each qualification, extraordinarily detailed occupational standards … We must turn the system on its head and set a few clear standards: preferably one per occupation, which delineates to employers what it means to be fully competent in that occupation" (Richard 2012, p. 40).

There is a need for a summary statement of the abilities that the qualification will represent. The statement needs to be expressed with sufficient detail to inform curriculum and assessment design, but it should not be made longer by the inclusion of additional detail such as the criteria for assessors. It should be more akin to a subject benchmark statement for a vocational degree than to a combination of national occupational standards or of QCF units.

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5. Results

5.1. Quality standards and recommendations for the ECVET implementation in vocational training "Mechatronics"

Furio Bednarz, Gabriele Fietz, Claudia Gaylor, Omar Trapletti

Development of (common) units of learning outcomes for the mechatronic sector has been subject of many European pilot projects, Leonardo da Vinci Transfer of Innovation or national initiatives: Up to now a long list of examples can be looked up[36] and different kinds of units are ready to be chosen by VET providers – either by taking them as they are or by adapting them to specific needs. Instead of supplementing this list of units of learning outcomes partners of the "Quality by Units" consortium took the decision for an alternative way: The consortium developed "Quality Standards"[37] targeted to two ECVET components:

- *units of learning outcomes* and
- *outcome oriented assessment* procedures.

Standard1: Refer learning outcomes to typical working and business processes.	Standard 1 – 3 related to the ECVET component "units of learning outcomes"
Standard 2: Define learning outcomes involving all relevant stakeholders.	
Standard 3: Ensure learning outcomes are user-friendly for different target groups – also in the matter of importance of teaching and learning.	
Standard 4: Assessment and assessment results are comparable, independent from place of learning and assessment.	Standard 4 – 6 related to the ECVET component "assessment"
Standard 5: Assess learning outcomes through multiple assessment methods.	
Standard 6: Ensure the qualification of experts in charge of assessing learning outcomes.	

Table 23: Quality by Units "Quality standards" – the normative base[38]

[36] See Table of Units of Learning Outcomes of the German ECVET contact point www.ecvet-info.de
[37] The glossary attached to the "guidance tool" provides the QBU consortium's definition of "standards"
[38] Each of these standards contains 2 to 4 concretizations.

The quality standards listed here serve as a normative base for the design of units of learning outcomes and adequate assessment methods. From this perspective, they address a wide span of target groups – ranging from competent bodies at system level to VET practitioners in schools or companies and numerous stakeholders in between. Given the diversity of the VET systems in terms of degree of unitization and assessment practices agreeing on common quality standards – valid for any of the VET systems involved in "Quality by Units" – was one of the major challenges the consortium had to face. To a high extent, this process required readiness to confront and compare relevant features and practices in vocational training. The quality standards are a result of this analysis and of an in-depth expert discourse organized in the five countries on site (see chapter 5.3.).

This section lists quality standards and recommendations that are considered essential from the perspectives of experts of different national VET-systems when designing and assessing (units of) learning outcomes. They can contribute to a more coherent approach in Europe, to the development of national approaches and thus help to further improvement of the ECVET application.

- Quality standards are norms, specifications or expectations that provide the basis for the quality assurance and development. Here they describe aspects that have been identified to enhance the quality in the implementation of ECVET. They are often already part of the national regulations in at least one educational system.
- Recommendations provide technical requirements for the application of the standards.

Table 24: Definition of the terms standards and recommendations

5.1.1. Standards and recommendations for the development (of units) of learning outcomes

Standard 1: Refer learning outcomes to typical occupational working and business processes.

A. Learning outcomes refer to a comprehensive professional action in relation to the standards expected of a professional worker (i.e. the ability to plan, execute and evaluate a work task independently).
B. Learning outcomes cover the professional action that will be assessed and may be mapped against agreed (national) occupational standards.

Standard 2: To ensure that the requirements of the labour market and civil society in general are met, learning outcomes are defined by all relevant stakeholders.

A. All relevant stakeholders ought to be involved in designing or revising learning outcomes, which especially means that organisations providing training (depending on national contexts companies, vocational schools, universities or colleges), bodies representing the interests of employers and employees (e. g. social partners), bodies implementing assessment (e. g. chambers), state authorities on different levels and research institutes are engaged.
B. The process is a continuous one, in which regularly evaluated recent and future labour market needs are the basis for continuous improvement of curricula. This can be arranged in focus groups or educational boards that consist of the stakeholders above.

Standard 3: Ensure learning outcomes are user-friendly for different target groups – also in the matter of the importance given to teaching and learning.

A. Learning outcomes are formulated in a comprehensible way and ensure the practical feasibility for students, teachers, trainers, schools and companies. That includes, that the language used should be clear and easy to understand. They should be published in a way that enables broad access, for instance on the internet or via social networks.
B. Surveys or focus groups are implemented among the above stakeholders and learners to gain a detailed understanding of perceptions of learning outcomes from multiple points of view. The results should be taken into account when revising curricula.
C. Material and guidance is provided to support learning and teaching (how to learn/teach and what to learn/teach), e. g. in form of indicators to support learners, teachers and trainers to identify obstacles in the learning processes. Teaching materials should be clear and understandable for students and teachers in form of videos, multimedia presentations or video conferencing.

5.1.2. Standards and recommendations for assessment of (units of) learning outcomes

Standard 4: Assessment and assessment results are comparable, independent from place of learning and assessment.

A. Evaluation criteria and evaluation principles are defined and assessment results are documented systematically, e. g. in standardized evaluation sheets.

B. Assessment also includes documents and papers of the everyday work procedures, for instance a study diary, a portfolio created by the learner or short reports about the overall educational progress of the learner.

Standard 5: Assess learning outcomes through multiple assessment methods.

A. Personal and social outcomes are part of the assessment.

B. Assessment takes place during a learning process (formative) and after learning has been completed (summative).

C. Different assessment methods – in oral and written form – (e.g. discussion, declarative methods, interview, observation, portfolio, presentation, simulation) are combined. Especially interactive assessment methods can be used to gather evidence for observable as well as indications on non-observable outcomes.

D. Real work assignments in the work context (or contexts designed close to the real work situation) are the core of assessment procedures. The ability to plan, execute and evaluate independently as well as the ability to perform in unexpected situations is part of the assessment. This includes those cross-occupational/interdisciplinary questions about security, ecological and safe behaviours which should be part of the assessment.

Standard 6: Ensure the qualification of experts in charge of assessing learning outcomes.

A. Assessors – whether they are involved in actual training or not – have the necessary knowledge, skills and competence in order to assess learners for their competences. That includes methodological and pedagogical skills.

B. Assessors are given the opportunity to acquire these competences, e. g. in certified training courses, e-Learning modules or Peer Review. Requirements for the appointment of assessors are defined.

5.2. Ensuring cross-border usability: The brochure "Mechatronics on the move"

Furio Bednarz, Gabriele Fietz, Omar Trapletti

Core outcome of "Quality by Units" and subject of this analysis is the brochure "Mechatronics on the move" for VET practitioners acting in transnational context, above all for those in charge of preparing geographical mobility of learners. This brochure integrates two fundamental products:

- "quality standards", for supporting the design of units of learning outcomes and the organization of outcome oriented assessment and
- an "analysis tool" (formerly taxonomy table" for creating awareness about differences between VET systems and promoting common understanding and mutual trust.

Both of these basics can serve for distinguished purposes. Bringing them together – as it is realized in the "Mechatronics on the move" brochure – offers the chance to enhance quality of geographical mobility of learners in the mechatronic sector and to promote mutual trust between VET practitioners from different learning cultures.

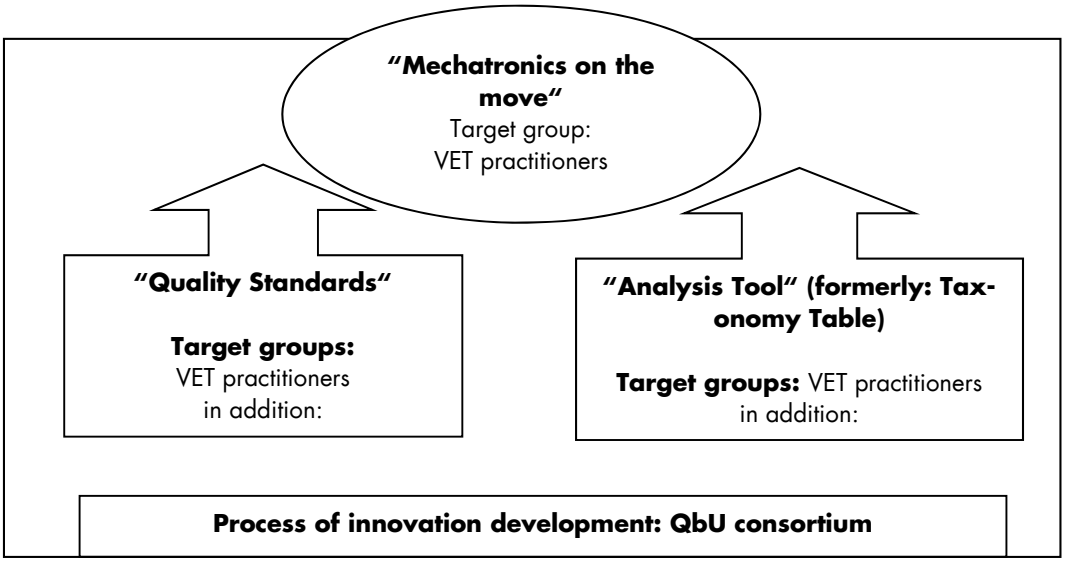

Table 25: "Quality by Units"- outcomes – results of a coherent development process

The methodology applied in "Mechatronics on the move" assumes that the common quality standards are indispensable for VET practitioners in schools and companies in charge of preparing transnational mobility programs and outcome oriented training and assessment processes in the mechatronic sector. Instead of presenting the end users the list of normative quality standards, the brochure goes the other way round: It puts open questions of VET practitioners in the center and provides answers by illustrating possible applications of the quality standards "in action". Specific attention is drawn to the transnational context: The "analysis tool"

developed during the transnational cooperation process, is used to explain differences of analog characteristics of the four types of VET systems. Those short explanations reveal framework conditions relevant for planning geographical mobility of learners. Moreover, the brochure provides examples of selected practice related to the use of the quality standards in VET systems involved. In this sense, this methodology is suitable for "bridging the gap" between normative standards and their practical application in cross border context and to support VET practitioners to establish a climate of "mutual trust" where confusions and bypasses could be minimized.

Summing up it can be stated that content and methodology of the brochure "Mechatronics on the move" ensures usability of the quality standards in cross border VET practice. Short and precise introductory chapters provide overview on the role of ECVET for quality assurance in transnational context; framework conditions of the different VET systems involved in "Quality by Units" are specified. A short guide provides practical hints where and how to use the brochure as a reference tool for specific questions. Remains to point out, that this brochure – as well as the quality standards and the analysis tool – is the outcome of intense transnational cooperation of partners from diverse qualifications systems; they put together their specific experiences and competences to provide outcomes of specific value for future transnational cooperation of VET practitioners in geographical mobility context.

In this regard, the outcomes of the "Quality by Units" project are specifically relevant in Erasmus+ (2014 – 2020) context where transnational cooperation is of major importance. Key Action 1 foresees "Learning Mobility of individuals"; Key Action 2 promotes "Cooperation for innovation and the exchange of good practices" e.g. in "Strategic partnerships", "Knowledge or sector skills alliances" (European Commission 2014). The methodology applied in the "Mechatronics on the move" brochure is for supporting those activities and contributes to the objective of strengthening and improving transnational cooperation in VET in Europe.

References:

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5.3. Contextualization of the results: European expert discourse

Furio Bednarz, Gabriele Fietz, Omar Trapletti

A draft of the "quality standards and recommendations" had been subject of an in-depth review in experts' circles organized in the five countries Austria, Germany, France, Poland and the United Kingdom/England. Discussions were focused on issues of usability of the quality standards for VET practitioners, the necessity of methods for creation mutual trust between actors from different VET systems or the innovative character of the standards compared to existing tools. This expert discourse has influenced the final shaping of the quality standards as well as content and methodology of the "Mechatronics on the move" brochure. This chapter provides insight into these controversial discussions and illustrates their impact on the fine-tuning of the project's outcomes.

"Target group(s) of the quality standards": In some national expert workshops multiple addressees had been identified, ranging from competent bodies at VET system level to VET practitioners, teachers, trainers, assessors and even trainees and other stakeholders in between. The project provides a clear answer – the quality standards address more than one target group:

- Definitively, the practice oriented brochure "Mechatronics on the move" addresses VET practitioners: "teachers, trainers in schools or companies, pedagogical staff in charge of preparing geographical mobility of learners in the mechatronic sector." The specific methodology applied in this brochure answers their questions concerning outcome orientation and supports units design and assessment according to the quality standards.
- A broader audience of various stakeholders at national, regional or sector level is addressed by the list of quality standards as attached to the brochure. This list had already been disseminated towards these target groups during various activities: in five national expert workshops in the countries on site, and during the fifth transnational workshop in Gdansk where about 35 regional stakeholders and practitioners had been involved. A final transnational expert workshop in Nuremberg, addresses experts from all countries involved in "Quality by Units".

Targeted sector: Other discussions tackled the question of how far the quality standards focus specifically on the mechatronic industry. In the view of an expert in England, "(…) the relationship to mechatronic is relatively weak, in that much of the content is generic." (Summary of responses from consultation in England). Keeping chapter 1 of this report in mind it can be stated, the standards are applicable for a broader span of industries – as fast changing skills demand due to globalization and continuous pressure to innovate is not exclusively reserved to mechatronics. Yet, the "Mechatronics on the move" brochure has been tailored to be appealing and useful for practitioners in the mechatronics industry, as it provides an insight into "framework conditions and selected practice" in this sector.

Concrete support for practitioners: Evidencing social and personal skills and competences is of major importance for any sector with high pressure to innovate, where "(…) an experienced skilled worker should also be able to cope with unplanned contingencies" (National experts' consultation in England). Assessment has to take into account those personal skills largely acquired in informal settings: at the workplace, but also in leisure time and family context. Quality Standard 5 advices: "Assess learning outcomes through multiple assessment methods". In the view of some experts standard 5 is lacking concrete hints and examples of various assessment methods and therefore – this standard (and related recommendations) was not estimated helpful for practice. The final version of the standards answer this objection by integrating recommendation D dealing with assessment procedures designed close to real work situations; moreover, the example of selected practice provides an evaluation sheet (p. 17 of the "Mechatronics on the move" brochure) that is specifically dedicated to personal and social competences of learners.

Learning outcomes for supporting teaching and training: It belongs to the basics of the learning outcomes definition that they are independent from the learning *process*. In the EQF, 'learning outcomes' are defined as "statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined as knowledge, skills and competences." (European Parliament and Council 2008). Referring to this definition experts in the German national workshop were critical about the formulation in draft standard 3, "relevance for teaching and training processes is assured". In their view, this would thwart the EQF definition. Given this objection, a glance to the example of one of the "early developing countries" might be useful for clarification: In the UK, for a long time, the training process played a subordinate role compared to assessment issues. In recent years, more and more the training process came into the field of consideration and learning outcomes got an additional role as they were accepted as means for supporting teaching and training. "However, although there is a debate regarding the role of learning outcomes in education in the UK (…) there is also the view that learning outcomes represent a useful tool for planning teaching and learning." (Brown, A./De Hoyos-Guajardo, M. 2014, p. 68) Understanding this role of learning outcomes for the teaching and learning process, the contradiction – *outcome* orientation vs. learning *process* – can be set aside.

For Polish experts "relevance of learning outcomes to learning and teaching processes" (draft standard 3) was out of doubt as it "fits the existing practice" (National experts' workshop in Gdansk, June 18, 2014). Two years after the introduction of the new outcome oriented core curriculum in Poland, support for teachers and trainers is required because "standards relating to the concept of learning outcomes for the majority of teachers are new, and people are naturally afraid of what is new and unknown." (l.c.) Given this background, Polish experts welcome any support for this target group, as is shown by their proposals for reformulating this quality standard 3: "Ensure learning outcomes are user-friendly for different target groups – also in the matter of importance of teaching and learning."

Sensitizing about VET systems' specifications

Clarifications of theoretical concepts has been a continuous process during transnational workshops and experts discussions. Whereas some open questions could be satisfied by reminding the appropriate definition, the majority of those misleading topics require a deeper understanding of the VET system's specifications and differences: E.g., "the terms competence, compétence and Kompetenz each have rather different connotations in their respective language and cultural traditions" (CEDEFOP 2009). In this and similar cases a look inside the VET systems' specifications is indispensable[39] in order to come to a better understanding.

This is also true for discussions about use of the topic "standards" during the UK experts' consultation: Different to other countries, in England "the use of 'standards' creates some confusion (…) since reference is also made to *occupational standards* (OS)." Creating awareness about the important role the "Occupational Standards (OSs)" have in England for assessment and quality of training can serve for a better understanding of this objection: Almost all sectors have those OSs; once defined by the Sector Skills Councils they are continuously updated according to the sector's need. This reveals the crucial point: In England, standards are automatically identified with the OSs. For pragmatic reasons partners decided on a compromise: The topic "standard" should be kept, but in the brochure "Mechatronics on the move" this topic plays a subordinated role, due the specific methodology applied. In addition, the glossary (as it has been attached to the brochure) contains a definition of "standards" as it had been agreed between Quality by Units partners.

The innovative aspect – relation to other European tools: Whereas the relation to ECVET and EQF was evident for all experts some statements claimed for better evidencing the specific value of "Quality by Units" compared to the "European Quality Assurance Reference Framework for VET (EQARF)". The analysis shows that each of them – "Quality by Units" and the "EQARF"– has specific value, moreover linking them might provide additional value for VET innovation:

The aim of EQARF is "to promote better vocational education and training (VET) by providing authorities and VET providers with common tools for the management of quality in VET". (EQARF leaflet, see www.equavet.eu). This framework has established 10 "quality indicators" and a "Quality Cycle" with four interlinked phases relevant to ensure quality in VET practice. (www.ecvet-toolkit.eu)

The quality standards provided by "Quality by Units" refer specifically to "indicator 6" of the EQARF „Utilization of acquired skills in the workplace". Compared to this indicator Quality by Units standards provide guidance that is far more specific: they support the application of this general maxim by means of the outcome oriented ECVET components (units of Learning outcomes and assessment). Linking EQUARF indicator 6 and the "Quality by Units" standards would result in a clear

[39] The analysis tool of Quality by Units supports this process.

added value, as this supports adequacy of VET practice related to the demands of European key industries.

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Appendix: Products of transfer: The VQTS-Model and project EDGE

Mariya Dzhengozova, Claudia Gaylor

"Quality by Units" drew on previous experiences and the transfer of the VQTS-Model and of the project EDGE (part of the German DECVET initiative) into different educational contexts. Both, the VQTS-Model and the EDGE products are examples for the description of learning outcomes according to ECVET.

The project EDGE

The flexibility, mobility and continuous development of vocational skills are, today, for many employees, essential to their working lives. With ECVET, a tool is being developed which aims to increase the mobility of young people during their first vocational training. ECVET can, however, also be of use beyond the context of mobility by helping to develop flexible means of documenting learning outcomes. It can help to make visible the results of lifelong learning and, by promoting a pan-European culture of assessment of learning outcomes, in the long-term achieve informative certification in the field of vocational training.

If ECVET is used in this way to increase the transparency of learning outcomes of vocational training, this can significantly increase the porosity of national education systems. Within the field of vocational training this means that learning outcomes can be accredited between different training courses. This contributes to making vocational training more attractive and reducing the number of isolated training pathways.

The project EDGE, which was conducted by f-bb, was part of the German DECVET initiative – a pilot initiative to develop a credit system in vocational education and training. The programme of the Ministry of Education and Research (BMBF) aimed at using and accrediting learning outcomes in order to increase flexibility and progression between education sectors in Germany. In the EDGE project, ECVET is used as a basis to develop models for allowing credit to be transferred between 8 two-track training courses in the metal and electronics industries. The project uses the ECVET points system to show possible ways of moving between related training courses and offer a sound basis for accreditation of achieved learning outcomes, e.g. in the case of a trainee seeking a new direction or to move on to a further qualification in a complex area.

The VQTS-Model

Comparing training programmes and understanding qualifications from other countries' systems is one of the main challenges of ECVET implementation. This is because of the various approaches, concepts and traditions for designing and describing qualifications. The VQTS (Vocational Qualification Transfer System) approach seeks to transcend the incomparability of qualifications and training contents by focusing on work processes. Of course, differences exist between national ways of offering and organising training but one can identify many similarities in the tasks of modern work processes. Different countries tend to apply similar material, technologies and processes. Therefore, the occupational requirements or the core work tasks – and the necessary vocational or professional competences – in an occupational field can be better compared than the training programmes in different countries for these competences.

The VQTS Matrix is a core element of the VQTS model, which provides a 'common language' to describe competences and their acquisition and also offers a way to relate these competence descriptions to the competences acquired in training programmes. The Matrix focuses on competences related to the work process and identifies the core work tasks within the context of a particular occupational field. The description of competences in relation to core work tasks can be seen as an attempt to bridge the terminological and ideological gap between the world of education and the world of work[40].

[40] Luomi-Messerer, K. (2009): Using the VQTS model for mobility and permeability, 3s.co.at/download/VQTS%20model_VQTS%20II%20results.pdf (10-07-2014), S. 10f.

Competence area	Steps of competence development			
1 Maintaining Providing "preventive maintenance" and assuring the reliability of mechatronic systems	He/She can perform the basic scheduled maintenance on mechatronic machines and systems and adhere to the equipment maintenance plans. He/she can complete relevant maintenance records accurately and pass them on to the appropriate person. He/she can dispose of waste materials in accordance with safe working practices and approved procedures.	He/She can master the maintenance procedures for mechatronic systems such as the use of service documents and maintenance plans.	He/She can use preventive maintenance to assure the trouble-free operation of mechatronic systems.	He/She can develop the necessary procedures for maintenance of mechatronic devices and systems, and can schedule the maintenance and quality-assurance procedures.
2 Installing and dismantling mechatronic systems and facilities	He/She can use written instructions to install and dismantle individual components (sensors, actuators, drives, motors, transport systems, bus systems, racks) that form a functional group of mechatronic systems. He/she can assist in the completion of installation documentation and is able to dispose of waste items in a safe and environmentally acceptable manner.	He/She can master the installation and dismantling of mechatronic systems that use several technologies (mechanics, hydraulics, pneumatics, electrical-mechanics, electronics, optics, optoelectronics), set up the connexion technology, and check the efficiency of the overall system.	He/She can provide independent mechatronic solutions for the construction of production lines, assure their overall ability to function, and, in addition, can use both existing and modified standard components.	
3 Installing and adjusting mechatronic components in systems and production lines	He/She is able to install and adjust standardized mechatronic components, e.g. individual electro-pneumatic valves, sensor and actuator units. He/she can work safely at all times complying with health and safety regulations and can deal promptly and effectively with problems within one's control and report those that cannot be solved.	He/She can install and adjust components of mechatronic subsystems (e.g., linear drives, measuring systems, transport systems).	He/She can install and adjust complex mechatronic facilities that include diverse technologies and instrumentation and control (I&C) equipment, adjust the associated parameters, test the facilities overall functions, and assure their reliability	

4 **Designing, adapting, and building mechatronic systems and facilities on the basis of client needs and site plans**	He/She can use machine tools controlled either manually or via computer-program to fabricate (according to production designs and customer requirements) the individual components for mechatronic systems. He/she can provide simple designs and descriptions of mechatronic subsystems and can use basic CAD applications. He/she can deal promptly and effectively with problems within one's control and report those that cannot be solved.	He/She can build simple mechatronic subsystems by using engineering drawing and can install the devices according to specific production needs. He/She can act on extensive knowledge of standards and regulations (e.g. on surface treatments) and is able to use CAD's more advanced functions (e.g. interference check).	He/She can build mechatronic systems by using both original construction techniques and previously designed parts. He/She fully understands CAD functions and can document system developments (parts lists, descriptions of function, operating instructions).	He/She can design and build autonomous mechatronic subsystems and, with suitable measuring and testing facilities, can assess the necessary production accuracy. He/She can document the results with quality-control systems.	He/She can make independent adaptations to the various devices (including selection of drives, sensors, PLC) and can use CNC programs for building the system. He/She can, through a digital mock up, assemble and simulate the functioning system and use computer-aided computations (e.g. FEM). He/She can perform cost-benefit analyses (e.g. as a basis for deciding whether components should be bought or individually constructed.)	He/She can independently develop complex mechatronic systems taking into account ecological and sustainable development considerations. He/she can calculate the economic usefulness of the system. He/She can optimise CNC programs for the manufacturing of complex mechatronic devices and systems and monitor the automated quantity of an open loop control system.
5 **Putting mechatronic systems into operation and providing clients with technical and economic support**	He/She can, according to specifications and blueprints, put mechatronic devices into operation and provide support to the client in the hand-over phase. He/she is able to ensure health and safety and other parameters are achieved, be able to deal with eventualities and to handle the equipment to the relevant user.	He/She, after considering the enterprise's needs and basic conditions, can put the mechatronic systems into operation, create the necessary documentation.	He/She, after considering all basic conditions, can master the start-up of interconnected mechatronic systems and machines, and can provide the necessary documentation including a manual.			

6 **Monitoring and /or supervising and evaluating both the process sequences of mechatronic systems and facilities and the operational sequence (including quality assurance)**	He/She can monitor and /or supervise process sequences according to specifications as well as implement any requested quality-control measures. He/she can work safely at all times complying with health and safety regulations and can deal promptly and effectively with problems within one's control.	He/She can independently supervise the process sequences, evaluate the results, operate an accompanying statistic process control (SPC) for the quality control plan, and prepare simple work schedules, including production schedule and time management.	He/She can operate and supervise mechatronic facilities, choose testing and monitoring plans, set up the accompanying SPC, seek the optimal results of the production line according to material-flow, and provide work schedules including standard production times.	He/She can master the monitoring of complex mechatronic systems using virtual instruments and PPS systems as well as open loop control for the optimisation of machinery arrangement, material flow analysis, and scheduling.	He/She can optimise the process cycles of mechatronic production lines, provide instructions on modifying the PPS systems (e.g. adjustment to SAP systems) and introduce quality systems for continuous improvement processes (CIP/KVP).
7 **Installing, configuring, programming and testing hardware and software components for control and regulation of mechatronic systems and facilities**	He/She is able to install and configure programs for hardware and software components as well as set up simple programmable logic control programs (PLC).	He/She can master the selection of basic hardware and software for mechatronic systems (sensors, actuators, interfaces, communication procedures) and can provide and test simple programmable logic control programs (PLC) according to production process requirements.		He/She can integrate and configure program-, control-, and regulation-mechanisms in mechatronic systems, program simple devices (in co-operation with developers), and simulate the program sequence before start-up.	He/She can develop, test, and configure hardware and software solutions for networked mechatronic systems; and can monitor system conditions with suitable measuring and visualisation tools.

8 **Providing "curative maintenance": diagnosing and repairing malfunctions with mechatronic systems and facilities, advising clients on avoiding malfunctions, and modifying and expanding mechatronic systems**	He/She can diagnose and/or repair errors and malfunctions on the simple components and devices in the mechatronic systems. He/She can use the necessary checking, measuring, and diagnostic tools. He/she can work safely at all times complying with health and safety regulations.	He/She can independently correct problems in mechatronic production equipment with the help of (computer-aided) diagnostic systems and the use of expert systems, databases, and error documentations.	He/She can diagnose and repair errors and disturbances in complex mechatronic equipment, estimate the time needed for reparations and is able to advise clients on how to avoid sources of malfunctions through changes or upgrades in the equipment and system.	He/She can develop, through analyses of malfunctions in the mechatronic equipment, a monitoring and diagnostic system and can calculate "impact on business"

Table 26: Modified VQTS Competence Matrix "Mechatronics"

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