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Education and Culture DG

COMPETENCE MATRIX

What is a Competence Matrix?

Competence Matrix is a table which displays work-related competence descriptions and the progress of competence development ('steps of competence development'):

- the left column of the table contains competence areas, based on the various core work tasks;
- in the right column each competence area is divided to steps of competence development so that the acquisition of competences by a person in training with reference to core work tasks is understandably described for each competence area.

The main aim of a Competence Matrix is to enhance transparency of competences and qualifications and thus mutual understanding between different countries and different contexts (for example, between the world of education and the world of work or between VET and HE) and to compare qualifications with one another.

A Competence Matrix can be used for those purposes where the transparency of competence profiles is very important, such as:

- transferring vocational competences acquired abroad (mobility in VET);
- transferring and recognising competences acquired within the official VET system as well as competences achieved through non-formal or informal learning;
- developing qualifications;
- composing job profiles as well as personnel (human resources) planning;
- referencing qualifications to qualifications frameworks;
- enhancing permeability between VET and HE.

How to create a Competence Matrix?

General approach

- *Level of application.* A Competence Matrix can be developed for the national level, or in cooperation between two or more partner countries, or by an international sectoral association.

- *Based on empirically derived core work tasks.* These must be identified in the professional context and should not be derived primarily from the educational system, which is marked by country-specific characteristics. Qualifications need to be described in a learning outcomes approach that is not solely linked to a certain national context or educational system.
- *Empirical methods are used.* The core work tasks – the basis for 'competence areas' – must be derived empirically by using methods that include work process analyses, company surveys, expert interviews, work-related comparison of existing qualification or occupational profiles and moderated workshops with experts from the occupational field.
- *Analyses of secondary sources.* It might be necessary to prepare the Competence Matrix based on analyses of secondary sources such as competence descriptions that have been gathered empirically in other research projects.
- *Involvement of experts* from the occupational field. Experts from the respective occupational field must be included: from the field of work as well as from the field of education. In order to facilitate mutual trust, different perspectives and expertise should be integrated and experts from different countries should be involved.
- *Further support.* VET researchers or 'Competence Matrix experts' should be involved in the development process to ensure that the principles for developing a Competence Matrix are taken into account sufficiently.
- *The power of language and examples.* The use of clear, holistic, illustrative and work contex-related language in forming the descriptions is recommended. Further, the inclusion of clarifying examples has proven to be useful.

Definition of the Scope of the Competence Matrix

a) Identification of *the sector or occupational field* for which the Competence Matrix will be developed. The available examples are from the fields of 'mechatronics' and 'electronics/electrical engineering'.
b) Decision of the scope of the Competence Matrix *in terms of professional profiles* to be included (Competence Matrix 'mechatronics' focused on the skilled worker level and on VET programmes from secondary level education. The VQTS II Competence Matrix 'electronics/electrical engineering' was broadened to include at least some steps of competence development relevant for HE).

Definition of the competence areas
Competence areas must be identified based on core work tasks derived empirically from the real world of working (work practice/work place). Only holistic competences that actually exist in the world of work are to be described and differentiated. Just as core work tasks have a complex relationship to the work process, competence areas also represent a certain complexity. A balance between general and detailed formulations of the competences areas enhances the mutual understanding between the users of a Competence Matrix.

Definition of the steps of competence development for each competence area

- The descriptions of competence development should clearly illustrate the process of progression from the lower to the higher steps.
- The number of steps of competence development depends on the nature of the competence area. Therefore, no concrete or consistent number of steps can be pre-determined. Consequently, the steps only make sense within one single competence area (horizontally) and a step of competence development for one competence area does not necessarily correspond to the meaning of a step of any other area.
- The descriptions must provide a clear and comprehensible picture of the competence development process, but they should not be too detailed. The differentiation of steps of the competence development is a crucial issue in designing a Competence Matrix: The difference between one step and the next must be clearly described.
- No specific determinants for differentiating the steps are given in advance. However, whenever it is reasonable, certain dimensions are included as reference points to describe the competence development in addition to the context characteristics

Competence Matrix „Electronics/Electrical Engineering“

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Competence areas (core work tasks)	Steps of competence development			
1. Preparing, planning, mounting and installing electrical and/or electronic systems for buildings and industrial applications	He/She can prepare and carry out simple electrical and/or electronic installations (e.g., cables, electrical outlets, connection and distribution systems, modular electronic components, computer components) as well as carry out and check the necessary wirings and mountings.	He/She can plan, prepare and connect electrical and modular electronic installations (e.g., energy supply in private and business premises, incl. lighting; alternating and three-phase current; electronic systems as units, wireless LAN, multimedia systems). He/She can advice the costumer and select the best implementation according to customer specifications.	He/She can plan complex electrical and/or electronically networked installations (e.g., systems of energy distribution, building management systems / KNX, regulation and monitoring systems, building access systems, RFID-systems) and fully wire them. He/She can configure, service and diagnose the functionality of the installation according to customer requirements and for this purpose can use computer-assisted tools.	
2. Inspecting, maintaining and servicing electrical and/or electronic systems and machinery	He/She can carry out basic and scheduled maintenance tasks, inspections and checks at electrical and/or electronic equipment according to maintenance schedules and predefined instructions (e.g., checking voltage tolerances, changing wearing parts in industrial plants, switching and control systems, electrical machinery, computer systems). He/She can use the measuring and testing tools necessary for it.	He/She can carry out and document preventative maintenance and alignment tasks at electrical and/or electronic industrial appliances and systems according to established quality assurance methods (e.g., continuous monitoring of a CNC machine tool)	He/She can analyse and determine availability and condition of electrical and/or electronic systems. He/She can analyse influencing factors on reliability and performance of electrical and/ or electronic systems and find causes of malfunctions (e.g., leakage current analysis, power factor correction, EMC analysis).	He/She can develop and document maintenance and inspection methods for electrical/electronic systems based on production and service process analysis as well as on quality management and customer requirements. He/She is able to develop related maintenance, inspection and quality assurance plans (e.g., optimizing MTBF of a production line, planning reserve power supply).
3. Setting up, putting into operation and adjusting electrical and/or electronic systems	He/She can set up, adjust and put into operation electrical and/or electronic systems (e.g., allocating frequency channels for a TV set, basic settings of a frequency converter or a thermo relay for a motor) following customer requirements and instructions from the technical documentation.	He/She can obtain and set system test parameters for setting up and operating electrical and/or electronic systems and select and carry out test procedures for installation and adjustment (e.g., adjusting interfaces in multimedia system, sensitivity setting of alarm equipment, elevator control unit).	He/She can select, set up and adjust electrical and/ or electronic systems and their control including accompanying sensors and actuators according to requirement analysis (e.g., energy supply systems, drive systems, electrical machinery, radio relay systems).	
4. Designing, modifying and adapting wirings and circuit boards for electrical and/ or electronic systems including their interfaces	He/She can modify, plan and build up simple electrical and/ or electronic circuits according to standards and guidelines (e.g., wiring for rooms, connection diagram of basic motor circuits, simple operational amplifier applications, small programmable control units).	He/She can modify, plan and build up standard electrical and/or electronic appliances according to customer requirements and official regulations (e.g., fire-warning devices, layouts for electrical/ electronic wirings with the help of CAD programmes, energy supply in private and business premises).	He/She can design, build up and improve electrical and/or electronic applications and its interfaces together with experts working in interdisciplinary teams according to EMC standards and confirming tests (e.g., electronic control circuits and equipment, micro-controller applications, PLC and related software).	He/She can design, build up and configure devices, facilities and units for process control systems including related programming and considering complex system requirements (e.g., controlled drive systems, process monitoring, automated production line, real time microcontroller applications for car control, GSM data transmission for monitoring and remote control).
5. Developing custom designed electrical and/ or electronic projects	He/She can develop and propose solutions for simple electrical and/or electronic system based on customer requirements (e.g., lighting installations, power supply unit, basic automation and control systems).	He/She can design electrical and/or electronic systems (e.g., PLC program for industrial applications, microcontroller application, ensuring expansion capability) and provide the necessary documentation (operational, maintenance, safety instructions, function, integration and acceptance tests).	He/She can develop technical solutions for electrical and/or electronic systems and applications (e.g., microcontroller board for heating and air condition, RFID access system, new production line) and provide appropriate documentation and customer training.	
6. Supervising and supporting work and business processes including quality management	He/She can check process steps in the production with suitable process tools (e.g., PPS, ERP, MRP) and carry out quality controls.	He/She can evaluate results of the process monitoring with software tools and determine quality assurance actions (work, production and time schedules).	He/She can develop controlling methods in the production (e.g. PPS, MRP, ERP) and process planning/control and supervision (e.g. CAP) and implement these with the help of software supported systems.	
7. Installing, configuring modifying and testing of application software for setting up and operating electrical and/ or electronic systems	He/She can install programmes for hardware and software environments and carry out simple configuration tasks as well as updates (e.g., starter software, graphical programming for measurement and automation).	He/She can select hardware and software for production systems following the business requirements and test programmes.	He/She can integrate hardware and software into existing system environments and use simulation and diagnostic programs (e.g. implement and adapt a driver for a CAD/CAM interface).	He/She can combine hardware and software to networked system environments and carry out network specific checks of all signals and adapt by means of software (e.g., OPC-Server, process control system).
8. Diagnosing and repairing of electrical/electronic systems and equipment	He/She can carry out standardized test procedures and diagnostic methods using wiring diagrams and test tools and carry out simple repairs at electrical and/or electronic systems (e.g., power measurement, level measurement).	He/She can use testing and diagnostic tools as well as expert systems for the fault diagnosis at electrical and/or electronic systems up to the component level and carry out the necessary repairs (e.g., software control test, spectrum analyzer).	He/She can select and use diagnostic methods for complex electrical and/ or electronic systems and carry out preventative measures for the avoidance of disturbances and malfunctions in arrangement with customers (e.g., detection of bit error rate, over-voltage protection analyse).	He/She can carry out system analyses (e.g., FMEA, FTA) of electrical and/or /electronic systems, determine error types and develop suitable diagnosis and repair methods including preventative measures.

Acronyms

CAD:	Computer Aided Design
CAP:	Computer Aided Planning
CAM:	Computer Aided Manufacturing
CNC:	Computer Numeric Control
EMC:	Electro Magnetic Compatibility
ERP:	Enterprise Resource Planning
FMEA:	Failure Mode and Effect Analysis
FTA:	Failure Tree Analysis
GSM:	Global System for Mobile Communications
MRP:	Machine Resource Planning
MTBF:	Mean Time Between Failures
OPC:	Object Linking Embedding for Process Control
KNX:	Konnex is the most established standard for home and building electronic systems. The Konnex technology is based on the well-tried EIB-System (European Installation bus - EIB)
LAN:	Local Area Network
PLC:	Programmable Logic Control
PPS:	Production Planning System
RFID:	Radio Frequency Identification

Competence Matrix "Mechatronics"

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Competence area	Steps of competence development					
1. Maintaining 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 master the maintenance procedures for mechatronic systems such as the use of service documents and maintenance plans and, if faced with new challenges, can make the necessary adaptations.		He/She can use preventive maintenance to assure the trouble-free operation of mechatronic systems. In addition, he/she can modify operational sequences to implement quality-assurance measures	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 (e.g., sensors, actuators, drives, motors, transport systems, racks) that form a functional group of mechatronic systems.			He/She can master the installation and dismantling of mechatronic systems that use several technologies (e.g., mechanics, hydraulics, pneumatics, electrical-mechanics, electronics), 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 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 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 (e.g., 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 and 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, after considering the enterprise's needs and basic conditions, can put the mechatronic systems into operation, create the necessary documentation, advise the customer on safe operations of the devices, and advise on future technology selection.	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. He/She can review client needs and configure machines that provide solutions. He/She can train the customer where necessary and provide support for safe operating procedures.	He/She can evaluate customer requirements for mechatronic facilities, develop solutions, and can plan the system's implementation and operation.	He/She can direct, including scheduling and time management, the start-up of the project from the creation of a proposal to the client's acceptance.	
6. Supervising and evaluating both the process sequences of mechatronic systems and facilities and the operational sequence (including quality assurance)	He/She can supervise process sequences according to specifications as well as implement any requested quality-control measures.	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 hardware and software for mechatronic systems (e.g., 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. Preparing and distributing the technical information for adjustment of each enterprise's mechatronic systems	He/She can provide descriptions and designs of mechatronic subsystems and is familiar with the basic CAD applications.			He/She can fully understand the management of technical information documents for mechatronic systems and can prepare and adapt these documents according to an enterprise's specific operating requirements.		He/She is able to analyse complex operational sequences separately in order to understand the connections and draw up maintenance and production procedures. He/She can understand that the system parameters are important for the equipments' functions and can independently assess and document the wear and general conditions of the mechatronic equipment.
9. 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 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 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 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