"Luomi-Messerer, K. & Markowitsch, J. (Eds., 2006): VQTS model. A proposal for a structured description of work-related competences and their acquisition. 3s, Vienna"

This document is based on the VQTS model. You can read more about the Leonardo Da Vinci project “VQTS II - Vocational Qualification Transfer System II” on their website http://www.vocationalqualification.net/

Matrix of Competences - example

Introduction

A Competence Matrix displays competences in a table according to core work tasks (“competence areas”) and the progress of competence development (“steps of competence development”).
A Competence Matrix is developed via a moderated workshop with experts from the respective areas. The workshop focuses on an empirical investigation of work-related competences within a specific occupational field.
A Competence Matrix can be developed for the national level, or in cooperation between two or more partner countries (international level). In any case, the development is based on the same principles: The goal of a common formulation of a Competence Matrix is NOT to harmonise the training and qualification programmes on offer by different VET providers. However, the (international) transparency and comparability of qualifications and training offers will be increased.

Examples:

The field of “Mechanical Engineering” (or “Mechatronics”) was chosen for the purpose of the VQTS project and the development of a pilot Competence Matrix. The illustrative examples arise from this particular field, however, the VQTS model can also be used for describing and comparing competences in other fields.

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Competence matrix "Mechatronics"

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 (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 (mechanics, hydraulics, pneumatics, electricalmechanics, electronics), set up the connexion technology, and check the effi ciency 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 modifi ed 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 specifi c 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, SPS) 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 computeraided computations (e.g. FEM). He/She can perform cost-benefi t analices (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.

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5. Putting mechatronic systems into operation and providing clients with technical and economic support	He/She can, according to specifi cations and blueprints, put mechatronic devices into operation and provide support to the client in the handover 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 confi gure 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 séquense (including quality assurance)	He/She can supervise process sequences according to specifi cations as web 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-fl ow, 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 fl ow 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 proceses (CIP/KVP).
7. Installing, confi guring, programming and testing hardware and software components for control and regulation of mechatronic systems and facilities	He/She is able to install and confi gure programs for hardware and software components as well as set up simple software control programs (SPS).	He/She can master the selection of hardware and software for mechatronic systems (sensors, actuators, interfaces, communication procedures) and can provide and test simple software control programs (SPS) according to production process requirements.	He/She can integrate and confi gure 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 confi gure 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 specifi c 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	

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Principles for Creating the Matrix of Competences

How is the Competence Matrix table structured?

Competence areas and steps of competence development are described in the table: The left column of the table contains competence areas, based on the various core work tasks. The acquisition of each competence, from beginner level to the “skilled worker” level, is described for each competence area. Each competence described is a “step of competence development”.

What do we mean by competences?

When speaking of “competence”, we adopt a broad understanding of the term: we mean cognitive competences (knowledge), functional competences (skills) as well as social competences (behaviour).

What are competence areas?

One competence area comprises various forms of competences necessary for completing core work tasks in a certain occupational field. Based on core work tasks, a varying number of competence areas are defined, depending on the complexity, range of activities or job opportunities within a certain occupation. We assume that 5-25 competence areas will be defined per occupational field. We consider that a Competence Matrix describes a “dynamic” list of competence areas.
This should allow authorities responsible for the development of a respective Competence Matrix (at the national or international level) to respond to major changes in occupational fields by adding or removing competence areas, or by restructuring the Competence Matrix.

How is the process of developing competences organised in the Competence Matrix?

For each competence area, 2-6 steps of the competence development process are described. The nature of the competence area determines whether it makes sense to differentiate more or fewer steps of competence development. Therefore, no concrete number of steps can be pre-determined. As a consequence, this means that the steps only make sense within one single competence area (horizontally), and that the numbers of steps of competence development for one different competence area does not necessarily correspond to the steps for any other area.
This “flexibility” of the steps also makes it possible to integrate already-existing descriptions of steps for competence development (e.g. Common European Framework for Languages).

Which dimensions are covered in the description of the development of competences?

It is not an easy matter to describe competences, because they depend on a variety of characteristics and may be localised in different dimensions (e.g. in the degree of independence or the assessment of the complexity of a task). Nevertheless, the descriptions of various steps must clearly express the difference from one step to the next for the development of competence within a competence area.
No specific determinants for differentiating the steps are given in advance, however, whenever it is reasonable, certain dimensions are included as reference points for the description of the competence development in addition to the context characteristics (tools, etc). These dimensions are thought of as a continuum. The extent or the degree to which they are achieved by learners characterizes the various steps or enables the differentiation between steps. These are no competences in the stricter sense and also no meta- or key competences, but only dimensions belonging to the respective competence.
Contrary to existing taxonomy systems, the differentiation of vocational competences according to level requires holistic descriptions. In order to avoid isolated descriptions, those dimensions have to be expressed in relation to core work tasks. The following principles have to be taken into account:

- The description of a step of competence development includes not only the degree or specification of one or more dimensions, but also must always be related to the work context.
- The description should not be restricted to competences that can be formulated analytically (e.g. part-competences, isolated tasks), yet cannot be identified in the work context.

Several dimensions are provided as examples below. This enumeration is not complete; additional dimensions suitable for the differentiation of steps in competence development should supplement this partial list.

- Ability to perform independent work tasks: marks the degree of necessary support or instruction;
- Ability to deal with a certain complexity: e.g. “production of simple work pieces” - for example “simple prismatic wrench parts” is less complex than the “production of work pieces under the inclusion of elements of hydraulics, pneumatics and electronics”;
- Ability to deal with quality standard demands: marks the degree to which demands and standards can be taken into consideration in fulfilling work tasks;
- Ability to deal with dynamic situations: for example, are the initial parameters of a problem/system changing or are they constant;
- Ability to deal with intransparency: measures the ability to deal with messy situations or with action situations, the variables of which are not visible from the outset.1

How are competences described in relation to the work context?

The description of the competences on the various steps of competence development takes place in a context-related manner. The competences are consistently formulated in relation to the work process and always align with the core work tasks within the context of the occupational field. Core work tasks are comprehensive tasks within the work context a person with the respective occupational profile has to deal with. This means that work process-related competences are derived empirically from the work practice/work place.
The descriptions of the competences are designed to form a clear picture of how they can be applied in the work context. This is why the term “is able to” is used in the descriptions: Actions that can be carried out are described, or problems that can be solved (e.g. “He/she is able to install, adjust and repair mechatronic aggregates and components in production facilities”). Moreover, the descriptions include – wherever reasonable for the respective competence area or the step of competence development – work-related categories as context characteristics to clarify the work activities in a specific field.
Work-related categories are:

- Objects of (skilled) work: meaning the contents or processes of skilled work (e.g. “assembling complete mechatronic equipment”)
- Tools (e.g. “wrench, drilling or milling machines”), methods (e.g. “test and adjustment methods”) and organisation of skilled work
- Requirements for skilled work and technology in form of rules, norms and laws (e.g. “security requirements”).

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:
A Competence Matrix does not in any way replace a national curriculum. The focus of the descriptions is on empirically derived work-related competences and not on the content of curricula (“in-put”). For this reason, it must be ensured that only those competences are described and differentiated that actually exist in practice. No subjects from the curriculum should be used in the Competence Matrix. Merely analytical descriptions of steps should also be avoided.
Descriptions of vocational competences gain significance only through their relation to the work context. However, the Competence Matrix should be used not only to make the competence profile of the acquirable competences within a training programme / qualification visible but the competence profile of a person in training as well (i.e. the competences acquired so far by a person in training). Therefore, the compilation of competence profiles solely oriented on occupational profiles (i.e. profiles of work tasks or competence profiles of skilled employees in a certain field of

[1] See also the criteria for describing complex action situation of the Kuratorium der Deutschen Wirtschaft für Berufsbildung (Berufl iche Bildung für Europa. Europäischer Qualifi kationsrahmen [EQF] und Leistungspunktesystem [ECVET]. Bonn, March 2005)

work) is not sufficient by itself because the steps of competence development also have to be made transparent.

How are examples used for describing competences?

Experience tells us that understanding between experts from the same skilled work area can be conveyed well by using examples. Thus, “good” examples are an efficient way to ensure the necessary practical relevance to the work context. Descriptions are therefore supplemented – wherever possible – by specific examples. These examples relate to the relevant categories. For this reason, examples are not simply illustrative elements of the description, they also serve an essential purpose. Examples provide the necessary information for characterising the different competence levels and various ways of assessing when an individual has achieved a certain level of competence.

How are soft skills included when describing competences?

Soft skills are inherent in the respective descriptions. They are not described as specific competence areas, but they are integrated in the context-related descriptions because of their relevance in this context. Communicative competences are, for example, expressed by phrases like: “He/she is able to explain…”

How specific or general are the descriptions of competences?

The various competence areas should not be specified in an overly general way (e.g. “building machines”), nor should they be too detailed (e.g. “soldering cables”). They must be formulated so that they promote mutual understanding between skilled workers and practitioners in the respective occupational field.

What style of language is used to describe competences?

For the description of the competences on the various steps of competence development, complete sentences should be used (e.g. “He/she is able to perform basic maintenance tasks on mechatronic appliances and equipments in the production”) and not merely catch phrases (e.g. “maintenance tasks”).

Further remarks

By considering all these principles, it becomes evident how difficult it is to draw up a “good” competence description. Even the examples we have developed in the area of Mechatronics within the VQTS project have not yet completely achieved the necessary requirements. It is also clear that – in particular with regard to the set of dimensions described – all aspects cannot always be considered in a competence description. Rather, pragmatic paths will have to be taken and the comprehensiveness of these descriptions will only become clear through practice. In addition, specific expert knowledge is needed; in particular methodological know-how has to be developed in order to moderate processes for drawing up competence descriptions.

Competence Profiles

- Competence Profiles are formed from particular parts of a Competence Matrix. They generally only cover a limited spectrum of the competences described in the Competence Matrix.
- Competence Profiles are formed by identifying competences that are relevant for a certain training programme or qualification (organisational profile) or are reflecting the competences acquired so far by a person in training (individual profile).
- Organisational profiles are developed from a Competence Matrix by the authorities responsible for the respective training programmes or qualification.
- Individual profiles are developed by the responsible training provider.

Organisational profiles are formed by:

- Indicating the relevant competences of the specific training programme or qualification on the Competence Matrix;
- Entering the corresponding number of credit points to be obtained in the table – credit points represent the time it takes for the student or apprentice to reach a certain stage of competence development; i.e. points reflect the duration of the competence acquisition;

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- Including important additional information on the training programme or qualification when necessary (i.e. specifics of the training).

Individual profiles are formed by:

- Checking which stage of competence development the student or apprentice has reached so far (at a certain point in the training);
- Indicating the already acquired competences of the student or apprentice on the table that also displays the organisational profile of the training programme / qualification;
- Entering the corresponding number of credit points (which reflect the duration of the competence acquisition).

Based on the competence profile of the person in training a **Competence Profile Certificate** can be issued:

- It represents the organisational profile as well as the individual profile.
- It also includes information on the training provider that awards the certificate, the person responsible for issuing the certificate, personal data of the person in training, and the date the certificate was issued;
- In addition, a specially designated field could also be created for further comments, e.g. if competence development is not yet complete for a certain area or step, and the respective credit points have not yet been awarded for this step, it is necessary to note which competences are still missing or have still to be acquired.