

European Qualification Strategies in Information and Communications Technology (ICT) - Towards a European (reference) ICT Skills and Qualification Framework

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Abstract: Innovative ICT developments are changing society to an 'information society' and new opportunities and challenges in all areas of work and life have arisen. In particular, this applies to ICT research, business and work itself. Highly skilled ICT practitioners are needed to manage business and work processes in both the core ICT sector and in industries using ICT. To understand, produce and use the new information and communications technology there is a widespread need to possess a range of ICT competences. One of the major challenges for any types of (formal and informal) skills and qualification development arrangements is to adequately guaranty the supply of ICT practitioners. This, in turn, makes demands on the various provisions of higher education (HE) and vocational education and training (VET) as well as requiring tailored offers for continuing vocational education and training (CVT) and lifelong learning (LLL).

Keywords: Information Society, ICT Practitioner Demand and Supply, European ICT Skills and Qualification Framework, ICT Training and Curriculum Development Guidelines

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Carsten Wehmeyer obtained his University Diploma in 1998 from University of Kassel, Germany, in Vocational Pedagogic in Electrical Engineering and is now a researcher of the Department for Vocational Pedagogic in Electrical Engineering and Informatics at University of Flensburg, Germany. His current research pursuing his PhD degree are new research concepts and empirically based concepts for more work process oriented curricula and vocational education and training concepts in ICT. This work contributes to the proposal for a European (reference) ICT skills and qualification framework.

1. Industry's ICT Skills Needs - Analysis and Synthesis of the Demand and Supply

In recent years the spread and dynamic of information and communications technologies (ICT) across Europe have been steadily increasing. Today the importance of ICT for the EU economy and throughout business, services, domestic and leisure is obvious. The rapid changes in ICT applications and business and work processes lead to substantial changes of the practitioner skills required. Therefore, adequately skilled ICT practitioners are constantly in demand in all European countries and it is one of the major present and future challenges not only to react to this demand but also to provide a tailored framework of ICT skills and qualifications at different levels.

For clarification of this context, it is necessary to identify developments in ICT business and work areas, against the background of different ICT market segments, and relate them to employment and skill needs and ICT programmes and training profiles. The following figure illustrates this relationship and the interaction between the two, showing that the employment needs at different skill and work levels have an influence on the ICT qualifications supply side. The skill needs are an important basis for curriculum consideration at all levels, independent of each European education system. From a separate perspective, ICT training and supply have an influence on ICT work and the potential for employment, which means that education has an important role to play in supporting companies in developing technology and competences.

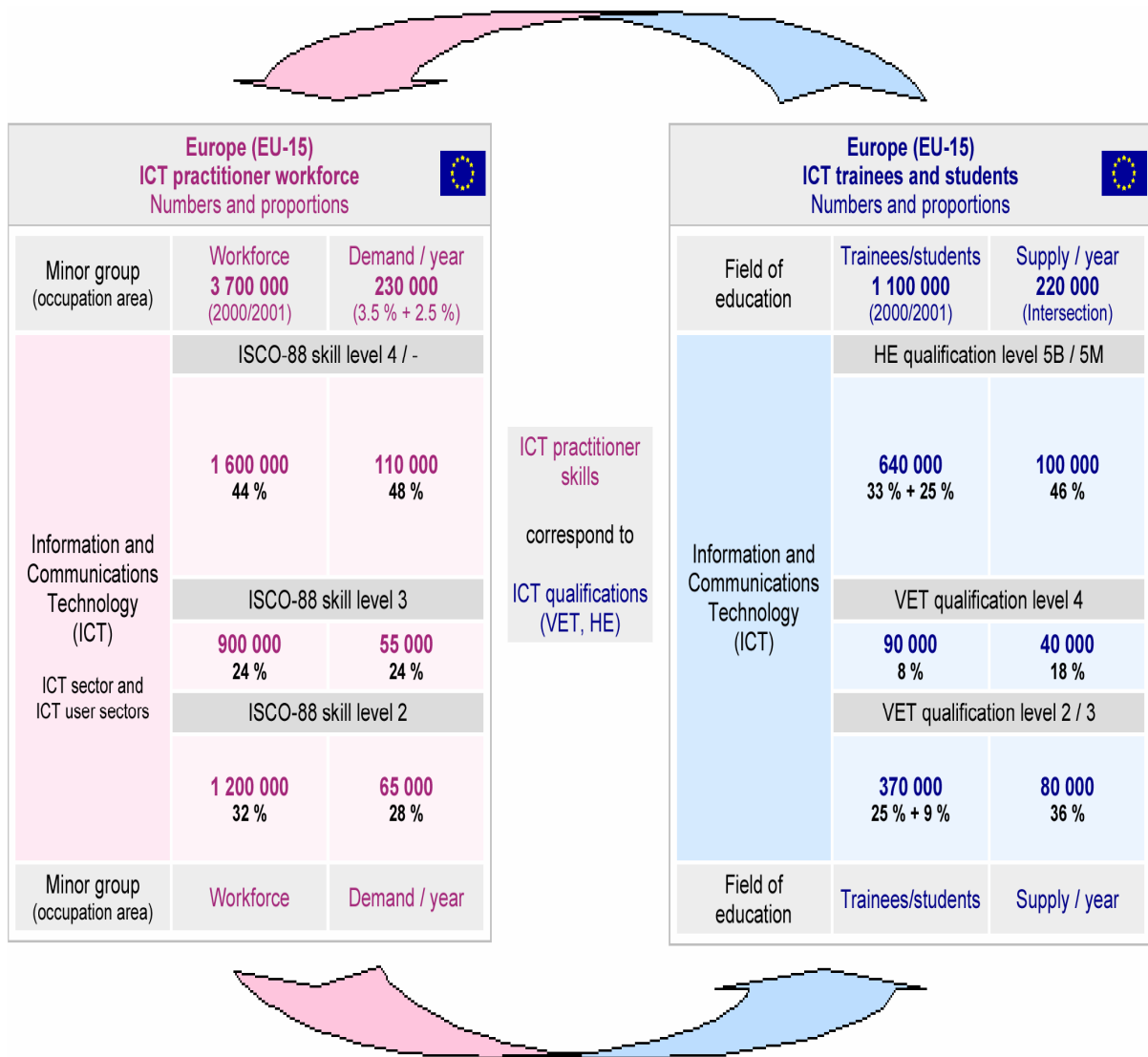


Figure 1: ICT Employment and Demand and Needed ICT Students and Trainees in Europe at Different Levels

Based on comprehensive analyses and definitions of what is supposed to be covered as the European ICT practitioner workforce the EUQuaSIT results allow to more exactly specify in which occupational areas and at which skill levels the workforce of ICT practitioners is employed and needed in European countries. Following the investigated ICT employment and demand of the companies, in 2001 we had some 3.7 million ICT practitioners in Europe, of which “only” 1.7 million work in the ICT sector whereas the majority of 2 million work in the ICT user sectors such as the automotive industry, financing and banking, graphics and media industry. Between 50-70% of the ICT practitioners have a qualification at higher education or degree levels and another 30-50% any type of vocational qualification at sub-degree levels. The demand of ICT practitioners calculated until 2010 - based on a 3.5% growth and a 2.5% replacement demand - can be roughly estimated with some 230,000 ICT practitioners per year.

In correspondence, the comparative approach of the project seeks to compare the demand and supply of ICT practitioners. The reference table above summarises the results and provides the numbers of the ICT practitioner workforce and ICT trainees and students for the years 2000/2001 in a comparative way. Based on these figures and taking into account the duration of training and study programmes respectively and a drop out rate, about 220 000 newly qualified ICT practitioner would be available per year on the European labour market.

ICT practitioners, especially Software Developers, ICT Consultants, Networks Specialists and Database Experts, are needed to manage ICT research, business and work processes in both the core ICT sector (including ICT faculties of universities) and in ICT user industries. Within the variety of ICT business areas and technology the question of responsibilities, tasks and delimitations in the course of ICT business and work processes depending on the skills and qualifications of the ICT practitioners is of crucial importance. The companies itself use for internal ICT employment and skills descriptions different ICT skill levels, mostly between four and eight dividable levels. This refers to different possibilities of skills definitions and delimitations and has in most cases, for instance, a correspondence to the wages of the employed ICT staff. One important indicator of defining the skill requirements within particular occupations is to examine the average level of qualification held by the ICT practitioners.

Especially at the end of 1990's various stakeholders and industry complained about an immense gap of suitably qualified ICT practitioners. Apart from the fact that there simply were not enough ICT practitioners available on the labour market by that time, discussions today more focus on the qualitative aspects in terms of the skills requirements to be more "work-ready" for the tasks and problems in complex ICT business and work processes (ICT skills mismatch). This does not only apply to small and medium sized enterprises but also to the global players on the ICT market such as Microsoft, IBM etc. Both, the practitioner gap and the skills mismatch have been the driving forces for various initiatives with regard to the identification, description and evaluation of industries' ICT skills requirements, one of which is Career Space.

2. ICT skill needs in view of ICT business and work areas at different levels

The Career Space consortium of leading ICT companies and support of the European Commission, beside others, has started and set up a project "to put in place a clear framework ... that describes the roles, skills and competencies required by the ICT industry in Europe". In this sense Career Space has indicated skill needs based on relevant key jobs directly in form of generic ICT skills profiles: "The first step was to develop generic skills profiles relevant to key jobs ..." (CSC / Cedefop 2001, page 3). The framework shows a structure of developed "generic skills profiles ... as well as the level of behavioral and technical skills required to carry out the profiled jobs" (ibid., page 2, 3). The framework focused on ICT skills and skill needs at "professional" level and shows in detail that these skills have a high correspondence to two qualification levels: bachelors and or masters (cf. ibid. page 40, see also in this context the "Bologna Process" on European transparency in the field of higher education, e.g. in CRE 2000).

Basic structure of the ICT Skills Framework of Career Space					
ICT Business Area: Information and Communications Technology (ICT)	Skill Level 2	Skill Level 3	Skill Level 4	Skill Level 5	Skill Level 6
■ Cross Sector				X	X
■ Software & Services				X	X
■ Telecommunications				X	X
■ Products & Systems				X	X
ICT Sectors / LEs	Skill Level 2	Skill Level 3	Skill Level 4	Skill Level 5	Skill Level 6

Figure 2: Basic structure of the European ICT skills framework of Career Space

Taking into account the demand and supply of ICT practitioners at all skills and qualification levels, more investigations were needed to analyze and determine the comprehensive skills requirements in terms of main contents, range of skills and knowledge etc., anticipating certain occupational/professional profiles and skill levels. Within the scope of the EUQuaSIT project in five European countries real ICT business processes (projects, products, services, customer etc.) in companies of different size and sectors were analyzed. These work and skills analyses were realized by interviewing and observing the ICT practitioners concerning their responsibilities, tasks as well specific ICT skills and overall work requirements. As mentioned above also the qualification of the ICT practitioners was of certain importance for the conclusions aimed at. This work orientated approach is based on the assumption that the empirical analysis of a variety of "ICT Business and Work Processes" can be the fundament for a European ICT skills framework. The results of each case study are summarized in the "GAHPA" model structure that describes the ICT business processes in a common sense with a segmentation of ICT work processes, phases of activities and ICT work tasks of involved ICT practitioners (cf. Petersen / Wehmeyer 2004).

According to all investigation results of the qualitative ICT skill needs a work oriented structure reflecting the ICT skill needs in view of the ICT business and work areas was developed. This structure is based on a generic structure of ICT work areas in strong reference to the variety of ICT business areas within the ICT and user sectors. The developed structure is part of the so entitled "GAHFA" model and segments the variety of ICT business areas into the six ICT work areas indicated in the figure below. Because within these ICT work areas job roles, skills and competences are defined at all levels as well as for both, the ICT industry and the ICT user industries in Europe, the subsequent basic structure of a European ICT skills framework can be used to describe all further results in regard to the qualitative ICT skill needs.

Within each ICT work area the ICT skill needs for example in ICT marketing or development or administration or service depend on the concrete content of the ICT business area like "Networks Systems and Solutions" or "Communications Systems, Applications and Services" or "Internet Applications and Services " or "Multimedia Applications and Systems". That means, depending on the different ICT business areas (or topics) there are different ICT skill needs within all ICT work areas. Therefore as an important result in addition to the six ICT work areas the following open list of relevant ICT business and technology (sub-)areas completes the basic structure of the European ICT skills framework as well as defines and clarifies at the same time - by comparing the diversity of ICT business areas in small, medium and large enterprises (SMLEs) of the ICT sector and ICT user sectors - the complex contents of the broad ICT business area in a coherent way.

ICT Business Process	ICT Work Processes	Phases of Activity	ICT Work Tasks	ICT Practitioners (ICT Job / Training Profiles) L2 L3 L4 L5B L5M		
			Use of the "Feet-on-the-floor philosophy"? (A.1.1)			
ICT Business Process	ICT Work Processes	Phases of Activity	ICT Work Tasks	ICT Practitioners L2 L3 L4 L5B L5M		
			Analyse the client's requirements and consulting aimed at harmonisation of the	Senior Design		
ICT Business Process	ICT Work Processes	Phases of Activity	ICT Work Tasks	ICT Practitioners L2 L3 L4 L5B L5M		
			Analyse the system and organisational	Director of ICT Department /		
ICT Business Process	Work Processes	Phases of Activity	Work Tasks	ICT Practitioners (Job / Training Profiles) L2 L3 L4 L5B L5M		
	Project Management (A) Hardware Provision (B) Preparation of the Servers (C) Fine Configuration and Implementation of the System (D) Project Finalising and Accounting (E)	Analysis and Planning (A.1) Quotation Processing (A.2) Project Coordination (A.3)	Clarify routing details with the customer and internally (A.1.1) Plan the project processing and coordinate project meetings (A.1.2) Specify and recommend the technical concept and identify hardware and systems requirements (A.1.3)	Project Manager / Physics Studies (L5M) Project Organiser / Dipl-Physicist (L5M) Project Manager / Dipl-Physicist (L5M)		
			Comparison of Offers (B.1) Hardware Test (B.2)		Organise and verify information for tailored hardware (B.1.1) Document offers and select hardware (B.1.2) Control the receipt of material and deliver hardware components (B.2.1) Assign payments to the supplier (B.2.2)	Purchaser Systems Developer / Information Technology Specialist (L3)
					Hardware Assembly (C.1) Installation of the Software Basis (C.2)	
		Configuration (D.1) Testing (D.2) Implementation (D.3)	Configure the Internet Server (D.1.1) Coordinate and ensure the performance tuning (D.1.2) Test the systems performance (D.2.1) Test the operational reliability (D.2.2) Configure addresses / domain names (D.3.1) Initiate and run the production startup including tests (D.3.2)	Project Manager / Physics Studies (L5M) Project Supporter / Dipl-Physicist (L5M)		
			Delivery (E.1) Accounting and Support (E.2)		Present and describe the solution concept to the customer (E.1.1) Instruct responsible technicians at the customer's (E.1.2) Invoice the work and administer the accountancy (E.2.1) Technical support of the customer (E.2.2)	Project Manager / Physics Studies (L5M) Project Supporter / Dipl-Physicist (L5M)
ICT Business Process		Work Processes	Phases of Activity	Work Tasks	EUQuaSIT - biat ICT Practitioners (Job / Training Profiles) L2 L3 L4 L5B L5M	
		Service and Optimisation (F) Complete and modernise the equipment (F.2)	service (F.1.2) Complete the equipment of ICT products (F.2.1) Modernise the equipment of ICT products (F.2.2)	Computerized Technics (L4)	Service Technician / Diploma Computerized Technics (L4)	
ICT Business Process		ICT Work Processes	Phases of Activity	ICT Work Tasks	EUQuaSIT - NUOV L2 L3 L4 L5B L5M	
			(E.2)	undergo adaptations or current applications according to external developments (E.3.1)		
				EUQuaSIT - Kenteq L2 L3 L4 L5B L5M		
ICT Business Process	ICT Work Processes	Phases of Activity	ICT Work Tasks	ICT Practitioners (ICT Job / Training Profiles)		

Figure 3: "ICT Business Processes" Variety for the Interpretation in a European Comparative Context

ICT Skills Framework of biat GAHFA Model						
ICT Business and Work Areas: Information and Communications Technology (ICT)	Skill Level 2	Skill Level 3	Skill Level 4	Skill Level 5	Skill Level 6	
<ul style="list-style-type: none"> ■ Information Systems, Applications and Services ■ Communications Systems, Applications and Services ■ Sector-specific ICT Solutions ■ Automotive Industries ■ Banking and Financial Services ■ Graphic Arts and Media ... ■ Internet and Intranet Applications ■ E-business and E-commerce ■ Data Management and Databases ■ Networks Systems and Solutions ■ ICT Security Solutions ■ Business (Process) Applications ■ Industrial IT Systems ■ Embedded Systems and Control ■ Multimedia Applications ■ Consumer Electronics ■ ICT Training Solutions ■ ... 	ICT Marketing, Consulting and Sales	X	X	X	X	X
	ICT Business and Project Management	X	X	X	X	X
	ICT Systems and Application Development	X	X	X	X	X
	ICT Integration and Administration	X	X	X	X	X
	ICT Infrastructure and Installation	X	X	X	X	X
	ICT Support and Systems Service	X	X	X	X	X
All Sectors / SMLEs	Skill Level 2	Skill Level 3	Skill Level 4	Skill Level 5	Skill Level 6	

Figure 4: European ICT Skills Framework of the Biat GAHFA Model

Within the European ICT skills frameworks based on the biat GAHFA model the ICT skills from level L2 to L6 must be described and defined in each ICT work area and linked to the ICT business area like "Internet Applications and Services" or "Communications Systems, Applications and Services" or "Data Management and Database Solutions" or also in regard to sector-specific ICT solutions like "Automotive Industries" or "Banking and Financial Services" or "Graphic Arts and Media". For example the ICT skill needs within the ICT work area "Support and Systems Service" linked to the ICT business area "Communications Systems" are different to those linked to the "Automotive Industries". But based on the differences of the ICT skill needs in regard to the six ICT work and the different business areas the skills and competences at all levels show that these can be described in line with a common skill model. In correspondence to all qualitative results on ICT skill needs this general skill model is defined by four skill categories (see figure below). Even though each skill category is important at all skill levels, the corresponding contents in each category must be clearly defined for each level. In a common way the skill needs within the European ICT skills frameworks according the biat GAHFA and the general ICT skill model can be summarized and described for each generic ICT work area.

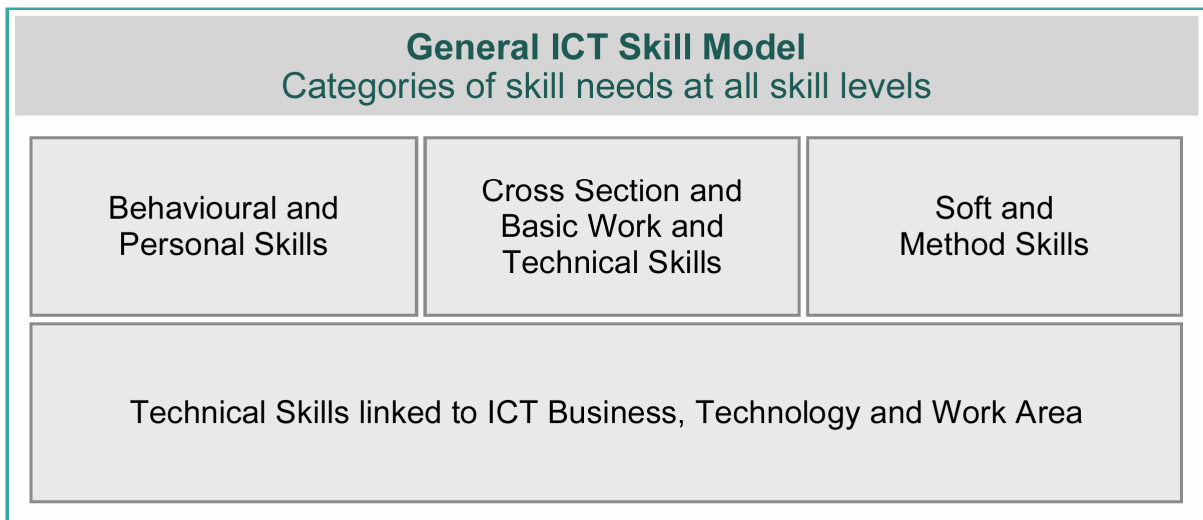


Figure 5: General Model of Categories of the ICT Skill Needs at all Skill Levels

3. Matching the ICT skills framework with a European framework of ICT qualifications

One of the major objectives (and surely also challenges) of the EUQuaSIT project, however, is to implement the comprehensive findings of the ICT work and skills analyses into innovative European ICT qualification strategies such as a commonly accepted European “reference” framework for ICT qualifications, e.g. in terms of tailored qualification profiles / descriptors at adequately defined qualification levels and with transparent learning outcomes / standards including meaningful certificates of acquired ICT skills. Major objectives of such a reference framework of ICT qualifications are, on the one hand, to provide the labour market with transparent information on qualified ICT practitioners and, on the other hand, to improve the qualification-employment transfer of individuals. However, one has to bear in mind that an “adequate qualification (and education)” certainly covers more than just an adaptation to the ostensible needs of the industry, especially when we talk about flexible individuals acting at open labour markets. Nevertheless, prospectively identified industry skill needs constitute the most important orientation to determine tailored qualifications.

As intended with the overall research approach focusing on the interaction of ICT work and ICT qualifications in a first step the outcomes of the skill needs analyses were matched into ICT job and skills profiles that systematically reflect a certain set of skills. The final version of the ICT skills framework covers all those ICT skills profiles that stand for a clear work, task and level description and have a delimitation to other skills profiles. The specification of ICT skills profiles is based on the work orientated analysis of all described ICT skills profiles covered by the investigated reports and studies. Fundament of this profiling work are the identified ICT work areas and fields of activity of the GAHFA skill model. Thus, for this final profiling process decisions had to be made that cover all ICT skill needs at different levels of the ICT and ICT user industries. The complete ICT skills framework including the results of the Career Space work finally consists of the ICT skills profiles shown in the figure below.

ICT Business Area	Work Areas	European Generic ICT Skills Profiles				
		L2	L3	L4	L5	L6
↓ ICT Business Area Technical Skills linked to ... <ul style="list-style-type: none"> ■ Information Systems and Applications ■ Communications Systems and Applications ■ Sector-specific ICT Solutions ■ Automotive ■ Banking and Financial Services ■ Graphic Arts and Media ... ■ Internet and Intranet Applications ■ E-business and E-commerce ■ Data Management and Databases ■ Networks Systems and Solutions ■ ICT Security Solutions ■ Business (Process) Applications ■ Industrial IT Systems ■ Embedded Systems and Control ■ Multimedia Applications ■ Consumer Electronics ■ ICT Training Solutions ■ ... All Sectors / SMLEs ↓ "Soft Skills" <ul style="list-style-type: none"> ■ Behavioural and Personal Skills ■ Cross Section and Basic Work and Technical Skills ■ Soft and Method Skills 	ICT Marketing, Consulting and Sales	ICT Marketing, Consulting and Sales	ICT Marketing, Consulting and Sales	ICT Marketing ICT Consulting ICT Sales	ICT Marketing Management (CS) ICT Sales Management (CS) IT Business Consultancy (CS)	ICT Marketing Management (CS) ICT Sales Management (CS) IT Business Consultancy (CS)
	ICT Business and Project Management	ICT Business and Project Management	ICT Business and Project Management	ICT Business Management ICT Project Management ICT Quality Management ICT Content and Knowledge Management E Business Management	ICT Project Management (CS) ICT Management (CS) ICT Content and Knowledge Management	ICT Project Management (CS) ICT Management (CS) ICT Content and Knowledge Management
	ICT Systems and Application Development	ICT Systems and Application Development	ICT Systems and Application Development Database Development and Administration Multimedia Design	ICT Systems and Application Development Database Development Business Software Development Web Design Multimedia Design Communication Network Development	Research and Technology Development (CS) Software and Application Development (CS) Software Architecture and Design (CS) Multimedia Design (CS) Product Design (CS) Automotive Software Engineering	Research and Technology Development (CS) Software and Application Development (CS) Software Architecture and Design (CS) Multimedia Design (CS) Product Design (CS) Automotive Software Engineering
	ICT Integration and Administration	ICT Integration and Administration	ICT Integration and Administration	ICT Integration and Administration Database Administration ICT Testing	Integration & Test / Implementation & Test Engineering (CS)	Integration & Test / Implementation & Test Engineering (CS)
	ICT Infrastructure and Installation	ICT Infrastructure and Installation Network Installation	ICT Infrastructure and Installation Network Planning and Installation Communications Planning and Installation	ICT Infrastructure and Installation Network Design and Installation ICT Industrial Systems Design ICT Consumer Electronics Design ICT Security Design	Systems Specialist (CS) Radio Frequency (RF) Engineering (CS) Digital Design (CS) Data Communications Engineering (CS) Digital Signal Processing Application Design (CS) Communications Network Design (CS)	Systems Specialist (CS) Radio Frequency (RF) Engineering (CS) Digital Design (CS) Data Communications Engineering (CS) Digital Signal Processing Application Design (CS) Communications Network Design (CS)
	ICT Support and Systems Service	ICT Support and Systems Service ICT User Support	ICT Support and Systems Service Network Administration Web Administration	ICT Support and Systems Service Network Administration Database Administration ICT Training ICT Operation	Technical Support (CS)	Technical Support (CS)
		L2 (number of profiles 8)	L3 (number of profiles 12)	L4 (number of profiles 27)	L5 (number of profiles 20)	L6 (number of profiles 20)
ICT Business Area	Work Areas	European Generic ICT Skills Profiles				

Figure 6: European ICT (Reference) Skills Framework With all Generic ICT Skills Profiles at Different Levels (*CS: Career Space)

The further step focuses on the correspondence of the ICT skill needs expressed and described in the generic European ICT skills profiles on the left hand side and ICT qualifications on the right hand side (see Figure 7). For the concretization of a European (reference) ICT qualification framework the matching of ICT qualifications with ICT skill profiles at different levels is a vital process. In terms of European transparency, all the different qualification and training systems in Europe (and therefore the study and training suppliers) need a reference to which they can appraise and evaluate their qualification programme offers and curricula. The generic ICT skills profiles constituting the skills framework therefore provide the fundamental reference, beside other criteria, for the determination and description of adequate ICT qualifications. However, we need good criteria and an adequate structural approach to clarify the relationships between needed ICT practitioner skills and qualifications and correspondingly for the decision of the profiling of qualifications, their occupational delimitation avoiding unnecessary overlap and their sets of qualifications outcomes. In other words and in the broader sense, the ICT qualifications and outcomes must match the ICT skill needs if not in the short term then at least in the medium term.

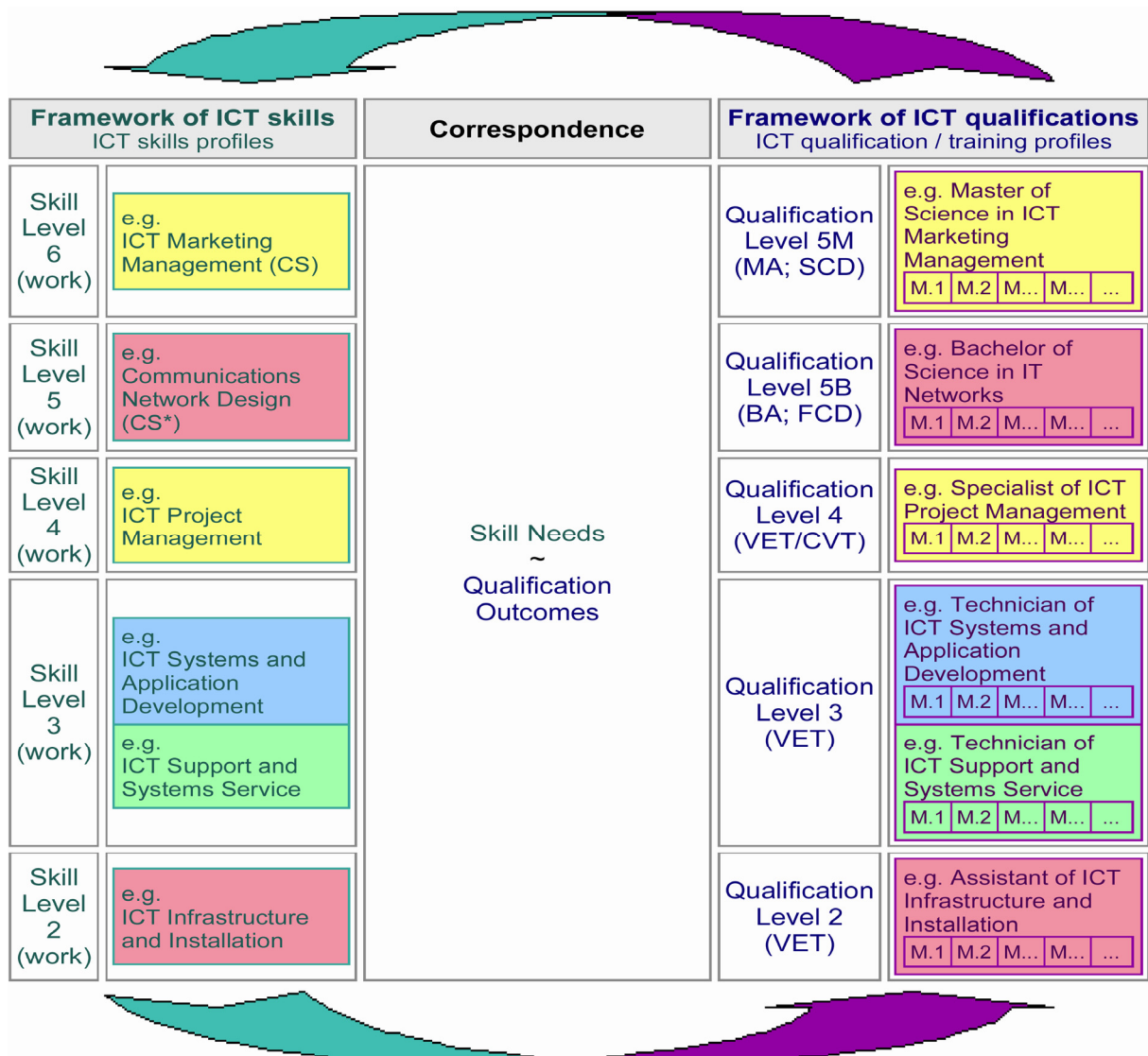


Figure 7: Correspondence of European Frameworks of ICT Skills Profiles and Qualifications

The output of the qualification process are qualifications with competences that qualify individuals for professional activities mainly in a specific ICT work area but also beyond. Therefore both the qualification level and profile must be relevant to the labour market skill requirements. The qualification should be described as a set of competences (knowledge, skills) e.g. within a set of qualification and learning modules (M.1, M.2 ...) required to exercise the occupational tasks, rather than just listing the knowledge to be acquired in the qualification process. Due to this didactical "change" the skill needs as defined in each "generic ICT skills profile" can be in general understood and described as a reference for

defining "outcomes" of the "ICT qualification profiles" (see again figure above). The definition of more work orientated qualification outcomes furthermore allows to implement an adequate credit system based on activity and work orientated assessment as well as quality assurance arrangements. Like in real working life, the qualification framework provides a clear orientation concerning learners career prospects, whether at work or with a training provider. Therefore, positive impact can also be expected for lifelong learning activities of individuals and its recognition.

According to this approach an ICT skills profile in ICT Marketing Management can have its equivalent in an ICT qualification at level 5M Master of Science in ICT Marketing Management. Another possibility for the qualification profiling process is the "clustering" of ICT generic skills profiles (see CSC / Cedefop 2001b, p. 39 et seqq.). An example is the skills profile Communications Network Design that could be assigned to a cluster IT Networks for instance as a First Cycle (FCD) or Bachelor Degree respectively (see *ibid.*). For the qualifications at sub-degree vocational levels the table indicates three different vocational degrees, namely Specialist (Level 4), Technician (Level 3) and Assistant (Level 2). These terms define the level of qualifications based on the idea of a simple level combination of ICT skills and qualifications (cf. Petersen / Wehmeyer 2004). The concrete name of the qualification indicates either a one-to-one equivalence or at least a close correspondence to the work area and skills profile, e.g. Specialist of ICT Project Management (VET level 4), Technician of ICT Systems and Application Development (VET level 3) or Assistant of ICT Infrastructure and Installation (VET level 2).

4. Conclusions

It can be summarized that the comprehensive empirical research activities have been leading to the following outcomes and conclusions, beside others:

- A comprehensive European ICT skills framework with clear ICT skill levels and ICT work and skill specializations (Skill needs up to work tasks) Further questions concern the European acceptance and transfer (labour market, statistics, economy, etc.).
- A general model of categories of the ICT skill needs at all skill levels (with technical skills, behavioral and personal skills, soft and method skills, cross section and basic work skills).
- An ICT skills framework as a work orientated reference for a European framework of ICT qualifications also with clear qualification levels and specializations Further questions also concern the European acceptance and transfer (qualification systems, implementation into ICT study and training profiles, etc.).
- Definition and EU credits of qualification outcomes Further questions concern the ICT curriculum development and certification of qualifications, e.g. vendor-specific qualifications.

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