Creating jobs for future computer professionals

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Abstract. *The constant need for harmonization and improvement of competencies in changing labour market conditions leads to an increased need for standard definition/description for particular occupation. An occupational standard is a document that outlines the competencies required for a specific job. It is generated using a well-defined methodology and data collection. This article describes the process of developing occupational standards in four areas: 1) management of information security and privacy systems, 2) distributed and interactive systems, 3) management of business system transformation and innovation, and 4) data technology and artificial intelligence.*

Keywords. Occupational standards, future jobs, ICT

1 Introduction

Computer science trends like cloud computing, information security and big data collection and storage are creating new jobs and better career opportunities. Innovation, support for high-value industries, and a major reliance on continual technological improvement characterize the ICT sector. In order to create new employment, ICT experts will need to combine new digital talents with managerial skills and trends such as digital leadership, big data, cloud computing, the Internet of Things and smart systems.

Data science has become one of the essential components of the information science (Sonavane, 2021). It is a key area for future careers and the role of data science is emerging across the globe. People in today's world require a broader set of skills to work, interact, access data, goods, and services, and participate in social and civic activities (European Commission, Directorate-General for Employment, 2019). Digital skills on higher level during pandemic of corona virus become a prerequisite for many jobs. But still, there is a lack of digitally skilled people. The U.S. Bureau of Labor Statistics projects 11% growth for computer and information technology occupations from 2019 to 2029, a faster-than-average growth rate (Simmons, 2022). The forecast for 2020 was a deficit of more than 500.000 information and communication technology professionals in Europe (The Future of Work - Trends, Challenges and Potential Initiatives, 2021). IBM research data shows that data science accounts for 28% of all digital jobs by 2020, but also, they revealed that on average, each of these places remains unfilled for up to 45 days due to a lack of talent (Hopping & Curtis, 2018).

The McKinsey Global Institute research in 2020 shows that many firms in Europe are competing for well-educated and digitally fluent professionals (Smit et al., 2017). Still, a lot of research papers show that there is a lack of professionals with computer science degree in Europe comparing to USA. A report by PwC indicates that demand for data scientists is clearly growing, especially in less developed markets, and that there will be an additional 2.7 million jobs created in the data science and analytics industry in the period from 2020 to 2023 ("PwC's Global Artificial Intelligence Study: Sizing the Prize," 2022).

This is a reason why in some research papers practitioners and scientists strongly recommended data science curriculum also in high school. The importance of computer science to the national curriculum has been addressed by some states in USA with the aim that teachers who work with students become more aware of the professional opportunities available to their students upon graduation (Morreale & Joiner, 2011).

These data show that new skills and expertise will be required for future occupations, as well as a rise in demand for ICT specialists. As a result, there is a need for education and training that will produce adequate employees, meet labour market demand, and enhance ICT skill levels.

The goal of the study described in the article is to evaluate the labour market in order to determine the skills that employees in the field of information technology require. The following questions guided the research:

- Will workers dealing with information security and privacy systems management, distributed and interactive systems management, business system transformation and innovation, and data technology and artificial intelligence be required?

- What are the most important tasks that persons in these jobs should perform?
- What knowledge and skills should these professionals have?

This article describes the process of developing occupational standards according to the Methodology for developing occupational standards proposed by Croatian Ministry of science, education and sports.

2 European Qualifications Framework

The European Qualifications Framework (EQF) is a common European reference framework aimed at making qualifications easier to read and understand across countries and systems. The EQF's core are its eight reference levels, which are defined in terms of learning outcomes, namely: knowledge, skills, and autonomy-responsibility. Learning outcomes describe what people know, understand and can do at the end of a learning process (European Centre for the Development of Vocational Training, 2022).

All types and levels of qualifications are encompassed by the EQF. The level increases in accordance with the level of proficiency, with level 1 being the lowest and level 8 being the highest. The EQF was implemented in accordance with the Recommendation on the European Qualifications Framework for Lifelong Learning, which was adopted by the European Parliament and the Council in 2008 and revised in 2017.

The EQF has been a driving force behind the creation of comprehensive national qualification frameworks based on learning outcomes. All countries that have accepted the EQF presume that such national frameworks are required to make their qualifications comparable across sectors and countries. National qualification frameworks of 35 countries have been formally linked ('referenced') to the EQF by September 2021 (European Centre for the Development of Vocational Training, 2022).

Also, the EQF aims to improve qualification transparency, comparability, and portability. The framework acts as a translator between various qualification systems and their levels. It is meant to help students, workers, job applicants, companies, labour unions, education and training providers, qualification recognition organizations, government agencies, and international institutions (European Commission, Directorate-General for Employment, 2019). Qualifications serve a number of functions. They indicate to employers what their holders know and can do in theory ('learning outcomes'). They may be required for entry into certain regulated professions. They assist educational and training authorities and providers in determining an individual's level and content of learning. They are also significant for an individual as a symbol of personal achievement. As a result, qualifications play an important role in improving employability, mobility, and access to higher education (Council recommendation of 22 May 2017 on the European Qualifications Framework for lifelong learning and repealing the recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning, 2017).

2.1 Croatian Qualifications Framework

The Croatian Qualifications Framework (CROQF) is a tool for regulating the qualification system in the Republic of Croatia (Ministry of Science and Education, 2022). The placement of Croatian qualifications at various levels not only determines their relationship, but it also allows for the linking of Croatian qualifications levels to the levels of the EQF and the levels of the European Higher Education Area Qualifications Framework. The CROQF lays the groundwork for the development of Recognition of Prior Learning (RPL), or the recognition and validation of non-formal (organized activity, but no public document) and informal (unorganized activity, everyday experience) learning (Zakon o Hrvatskom Kvalifikacijskom Okviru, 2013), as well as the mandatory implementation of a quality assurance system and clear quality assessment procedures.

CROQF creates the necessary quality assurance elements and instruments to serve as a long-term base for creating a suitable system at all levels, as well as for all types and forms of learning and education (Nove Boje Znanja - Strategija Obrazovanja, Znanosti i Tehnologije, 2015).

The Croatian Qualifications Framework Act establishes and governs the CROQF, as well as the qualifications system in the Republic of Croatia, by introducing standards qualifications based on occupational standards and consisting of sets of learning outcomes (Zakon o Hrvatskom Kvalifikacijskom Okviru, 2013). The Ordinance on CROQF Register specifies the process for proposing and evaluating occupational standards, qualifications, and sets of learning outcomes via sectoral councils (Ordinance on CROQF Register, 2014).

3 Methodology

Development of occupational standards according to CROQF is prescribed with Methodology for developing occupational standards and includes Occupational standard survey. In Methodology are described guidelines for the following activities related to the organization and implementation of the survey (Ministarstvo rada i mirovinskog sustava obitelji i socijalne politike, 2021):

- Adjustment and optimization of the survey
- Conducting the survey

- Systematization of collected information and data
- Formalization of occupational standard proposal

All activities are described in general in (Čalopa et al., 2020) and adjustment and optimization of the survey with a case study is also described in detail.

3.1. Conducting the survey

The survey that is adjusted to a specific occupation(s) should be used in guided survey and structured interview with future employers and current employees. The purpose is to obtain all relevant information for development of occupational standard(s) from their perspective. The following tasks will ensure the desired outcome:

- Selection of employers and employees for guided survey and structured interview
- Preparation of survey leader and assistant for guided survey and structured interview
- Conducting the guided survey and structured interview
- Systematization of information and data through preparation of report about conducting the survey
- Selection of employers and employees

The goal of the first task is to select the sample of employers and employees that will reflect majority opinion about knowledge, skills and competencies needed for occupational standard(s). For selection of employers are used principles of representativeness (number, size, business sector, nature of business activity and spatial distribution of employers), accessibility and willingness to cooperate. Principle of representativeness should be always used first, and other two only in rare cases at the expense of representativeness. Selection of the representative of each employer organization is also very important, and this should be a leader that has knowledge about all jobs of an occupation. When selecting employees, principle of representativeness should also be taken into consideration, as well as expertise of employee, and a sample should represent a population of employees in occupation(s). A number of employers and employees should be similar. It is expected that a total number of interviewees will be eight to twenty, depending on occupation.

3.1.1. Preparation of survey leader and assistant

Guided survey and structured interviews should be conducted in person and therefore education for survey leader and assistant is needed. They should have detailed knowledge about the structure and the contents of the survey, as well as about the goals of the process. Members of the group that adjusted and optimized the survey should participate in conducting, possibly as leaders. Leaders and assistants must understand the importance of confirmation and supplementation of information as well as detailed description of occupation(s).

3.1.2. Conducting the guided survey and structured interview

This task includes introducing employers and employees to tasks in the survey so that they can answer properly. Through guided survey are gathered opinions about elements developed by expert group and through structured interview is gathered new information. All terms in the survey (e.g. key task) must be explained and understood by employers and employees and they must estimate for each key task (a) the frequency of performance and (b) level of expertise needed. Information about revision of key tasks is also welcomed. All questions should be addressed during the survey. Some elements can be accepted, others rejected or modified. Survey leader and assistant should guide the survey to achieve its goals.

3.2. Systematization of collected information and data

The process of systematization begins already during conducting the survey with gathering notes. The goal is to develop lists of key tasks, knowledge and skills for occupational standard(s). Along with information obtained from employers and employees during the survey, for achieving this goal experts that adjusted and optimized the survey can be included. Two main tasks of systematization are:

- Development of key tasks list
- Development of knowledge and skills list

3.2.1. Key tasks list

After the analysis of gathered data, it can be established that some of the suggested key tasks are not performed at all in a specific occupation(s) – they can be removed from the list. For the tasks that are performed very rarely or rarely can also be suggested to be removed, and those that are performed often or very often are definitely the key tasks.

Considering the level of expertise, for often and very often performed tasks it should be analysed if those tasks for which basic level of expertise is needed are in fact those that are performed with the leadership or supervision of others. Tasks for which medium level of expertise is needed should be those mostly performed independently, and tasks for which advanced expertise of level is needed, are those that should show leadership and management of others. If those relationships are not visible, descriptions of key tasks should be adjusted. The same procedure is valid for key tasks that are not suggested in survey but are added during guided survey and structured interview.

3.2.2. Knowledge and skills list

Similar to key tasks, it should be firstly established if some suggested knowledge and skills are not needed for specific occupation(s) so that they can be removed from the list. Knowledge and skills that are necessary for specific occupation(s) are mainly those that are on

the list, but some optional knowledge and skills can also be included if they are really important for successful performance of a certain key task.

The level of expertise needed in knowledge and skills is also analysed. It is expected that basic level of expertise will be mostly needed for optional tasks. As with key tasks, adjustment of description of knowledge and skills may be needed and also the same procedure is valid for knowledge and skills that ae not suggested in survey but are added during guided survey and structured interview.

4 Results

The survey procedure was made for four areas for which the following names of occupational standards were proposed:

- Management of information security and privacy systems - Information Security and Privacy Architect

- Distributed and interactive systems - Distributed and / or Interactive Systems Architect

- Management of business system transformation and innovation - Business Systems Transformation Architect

- Data technology and artificial intelligence - Intelligent Information Systems Architect

After the survey, the analysis of data began, where the first step was to define the key tasks of a particular standard of occupation. As described, during the survey, respondents were asked for each key job to state the frequency of performance of each task and the level of expertise required. Based on the total answers of the respondents, each key task could be divided into three categories: candidate for the standard of occupation, candidate for expulsion and the need to discuss. After the analyses and consultations with experts in the field, key tasks were defined:

1. Information Security and Privacy Architect - 17 key tasks

2. Distributed and / or Interactive Systems Architect - 13 key tasks

3. Business Systems Transformation Architect - 16 key tasks

4. Intelligent Information Systems Architect - 14 key tasks

Here is example of defined key tasks for Information Security and Privacy Architect:

1. Planning the deployment and monitoring of information security and privacy systems, as well as the resources required to implement and monitor them

2. Creating an organizational structure for integrating data security and privacy systems into the business system

3. Organizing teamwork of information security and privacy

4. Planning and developing competencies in the domain of data security and privacy

5. Analysing the current situation's (in) compliance with the information security and privacy system's requirements

6. Identifying and assessing the risks associated with data assets

7. Risk management planning for the information system's operation (in crisis conditions)

8. Examining the information system's integrity in terms of security and privacy

9. Managing roles and authorities to ensure that information resources are used safely

10. Reporting to the Management Board on the business system's security and privacy status

11. Participation in sales and/or procurement activities with security and privacy concerns

12. Involvement of stakeholders in the development of information security and privacy systems

13. Collaboration with the company's personnel

14. Communicating with regulatory bodies and exchanging information with businesses and professional organizations

15. In the development, improvement, or innovation of products or services, collaborating to ensure that security and privacy standards are met

16. In quality assurance, defining security and privacy indicators

17. Raising awareness of the importance of data security and privacy in terms of health and the environment

There were two approaches to summarizing knowledge and skills. The first method refers to a situation in which a framework (international or national Body of Knowledge (BoK), occupational standard) with specified categories existed for a specific field. The card sorting method was used in this situation. The second approach was to define 3 types of knowledge/skills in the absence of comparative standards or frameworks (presented in Figure 1):

a. Specific – innovative knowledge/skills in relation to the new occupational standard – clustering method was used in order to define this type of knowledge/skills

b. Informatics - cards sorting method was used with categories and subcategories based on the European e-Competence Framework (*The E-Competence Framework - ITPE*, 2022)

c. Generic (Key/Long Learning) - cards sorting method was used with categories based on the European key competency framework for lifelong learning (Council Recommendation of 22 May 2018 on Key Competences for Lifelong Learning, 2018).

Occupational standard/Sets of competencies	Specific	Informatics	Key /Long Learning
Information Security and Privacy Architect	Information Systems and Business Strategy Alignment Service Level Management Product/ Service Planning Incident and problem management Information Security Strategy Development Information security risk management Data security management	Modeling, reengineering and improving business processes Personal and professional development in the IT profession Monitoring technological trends and innovations in informatics Professional and socially responsible behavior in the IT profession Cooperation and communication in informatics	Citizenship competence Entrepreneurial competence
Distributed and/or Interactive Systems Architect	Integration of distributed and/or interactive system components Distributed and/or interactive system engineering Architectural design of distributed and/or interactive system Distributed and/or interactive system design Distributed and/or interactive system support and upgrade Distributed and/or interactive system development Service developmnet in the field of distributed and / or interactive system for third parties	Design of technical and communication infrastructure and information system platform Professional and socially responsible behavior in the IT profession Monitoring technological trends and innovations in informatics Software development Cooperation and communication in informatics Development and project Management in informatics	Mathematical competence and competence in science, technology and engineering
Business Systems Transformation Architect	Information Systems and Business Strategy Alignment Business Plan Development Technology Trend Monitoring Documentation Production System Engineering User Support System upgrade support Purchasing Personnel Development Project and Portfolio Management Risk Management Business Change Management	Software development Monitoring technological trends and innovations in informatics	Entrepreneurial competence
Intelligent Information Systems Architect	Effective application of methods and techniques for the intelligent information systems development based on statistical approach to artificial intelligence Life cycle management of intelligent information systems with the application of the principles of information and software engineering Development, implementation and management of solutions for storage and processing of data, information and knowledge using distributed and cloud platforms Design, develop and manage databases and knowledge bases and provide efficient ETL, OLTP and OLAP processes for large data sets Integration of heterogeneous data from different sources and their preparation for further analysis and use Application of methods and techniques for the intelligent information systems development based on a symbolic approach to artificial intelligence Programming for artificial intelligence and data science Business application of artificial intelligence and data science methods	Software development Monitoring technological trends and innovations in informatics Professional and socially responsible behavior in the IT profession	Mathematical competence and competence in science, technology and engineering Personal and social competence and competence to learn how to learn

Figure 1. Defined knowledge/skills for occupational standards

5 Conclusion

Standardization of occupations and qualifications at national levels and linking them with international standards is important, because it improves their quality, allows mutual recognition and enhances world labour market. Those standards should follow the evolution of the areas for which they are developed so that they can ensure the education of professionals who can meet the requirements of the chosen occupation.

The proposed occupational standards for four areas listed above are an important step in monitoring trends such as:

(1) a growth in the number of security threats and attacks (e.g. stalking, cyberbullying, information warfare, industrial espionage, identity theft attacks),

(2) a rise in the number of monitoring sensors in the environment and intelligent networking of machines and other devices (with the help of the industrial Internet of Things, cloud computing),

(3) improvement of the sophistication of technology that supports business processes, autonomous decision making, and real-time asset and process monitoring (virtual and augmented reality, artificial intelligence, advanced robotics, autonomous robots, simulation, digitization and system integration), and

(4) an increasing number and types of data collected and analysed (machine learning methods and techniques, in-depth data analysis, technologies for integration, storage and processing of data, recognition of behavioural patterns)

The recognition of these specialists in the Republic of Croatia, as well as in Europe, has been ensured thanks to the Methodology of the Croatian Qualifications Framework. In other words, the duties, knowledge, and abilities that ICT professionals should possess were defined, independent of which faculty they attended.

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References

Council recommendation of 22 May 2018 on key competences for lifelong learning, (2018). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018H0604(01)&from=EN

Council recommendation of 22 May 2017 on the European Qualifications Framework for lifelong learning and repealing the recommendation of the European Parliament and of the Council of 23 April 2008 on the establishment of the European Qualifications Framework for lifelong learning, C

189 Official Journal of the European Union 189/15 (2017). https://ec.europa.eu/ploteus/sites/eac-eqf/files/en.pdf

Čalopa, M. K., Lovrenčić, S., Mekovec, R., & Picek, R. (2020). The Occupational Standards Development According to CROQF*. Central European Conference on Information and Intelligent Systems, 73–80. https://www.proquest.com/conference-papers-proceedings/occupational-standards-development-according/docview/2531366478/se-2?accountid=17242

European Centre for the Development of Vocational Training. (2022). European qualifications framework (EQF). https://www.cedefop.europa.eu/en/projects/european-qualifications-framework-eqf

European Commission, Directorate-General for Employment, S. A. and I. (2019). The European Qualifications Framework: supporting learning, work and cross-border mobility 10 th Anniversary. https://doi.org/10.2767/750617

Hopping, C., & Curtis, J. (2018). Data scientist jobs: Where does the big data talent gap lie? | IT PRO. ITPro.Co.Uk. https://www.itpro.co.uk/careers/28929/data-scientist-jobs-where-does-the-big-data-talent-gap-lie

Ministarstvo rada i mirovinskog sustava obitelji i socijalne politike. (2021). Metodologija za izradu standarda zanimanja i skupova kompetencija.

Ministry of Science and Education. (2022). About CROQF - CQF. http://www.kvalifikacije.hr/en/about-croqf

Morreale, P., & Joiner, D. (2011). Reaching Future Computer Scientists. Communications of the ACM, 54(4). https://doi.org/10.1145/1924421.1924448

Nove boje znanja - Strategija obrazovanja, znanosti i tehnologije, (2015).

Ordinance on CROQF register, (2014). https://www.azvo.hr/images/stories/novosti/Pravilnik_o_Registru_HKO-a.pdf

PwC's global Artificial Intelligence study: sizing the prize. (2022). In PwC. https://www.pwc.com/gx/en/issues/data-and-analytics/publications/artificial-intelligence-study.html

Simmons, L. (2022). Top 6 Computer Science Trends in 2021. https://www.computerscience.org/resources/computer-science-trends/

Smit, S., Tacke, T., Lund, S., Manyika, J., & Thiel, L. (2017). The future of work in Europe. In The Future of Work in Europe. https://doi.org/10.4324/9781351146609

Sonavane, A. K. K. (2021). Study of Emerging Role of Data Science in Business Intelligence. Design Engineering, 6.

The e-Competence Framework - ITPE. (2022). https://itprofessionalism.org/about-it-professionalism/competences/the-e-competence-framework/

The future of work - Trends, challenges and potential initiatives, 12 (2021).

Zakon o Hrvatskom kvalifikacijskom okviru, (2013). http://www.kvalifikacije.hr/sites/default/files/documents-publications/2021-03/ZHKO_2021_pročišćeni.pdf