COMPETENCE MODEL FOR FACTORIES OF THE FUTURE

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Abstract The competence model for the factories of the future connects knowledge, skills and other characteristics necessary for successful work at a given workplace and systematic procedures for their improvement. The purpose of the competence model is to ensure that employees do the right things and that they work successfully. It also strengthens the motivation for life-long learning and intergenerational cooperation. The competencies linked to sustainable development, circular economy, and corporate social responsibility are important components of the competence model. Mismatches in the future skills required for the transition to Industry 4.0 and Society 5.0 are addressed by creating a rich ecosystem of educational approaches and learning materials. An expert system will be developed for the selection of the most appropriate educational approaches for each employee according to the mismatch between their current and desired skills and competencies. In this contribution, the concept of the expert system is presented.

Keywords: circular economy, competence model, factories of the future, sustainable development, expert system.

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1 Introduction

In 1973 David C. McClelland published a study pointing out that, while intelligence affects performance at work, personal characteristics and self-concepts, traits and motives are what make the difference between effective and inefficient work. This phenomenon is noticeable in many areas of the individual's life, including his or her professional career. McClelland defined competencies as characteristics that represent successful performance (McClelland, 1973).

The competence model is used in many areas of human resource management (HRM). A model is a combination of personal characteristics, skills, abilities, knowledge and other individual capabilities that are required for successful and effective performance. It is also important that each competence be clearly defined in the model and include observable or measurable indicators (Skorková, 2016). To establish the model, it is necessary to obtain the relevant information, which can be gathered through surveys, personal interviews and job descriptions.

Meeting the needs of the increasing number of people on Earth using a linear economy seems well beyond the current capacity of our planet. The continued growth of the economy and consumerism is reducing the volume of natural resources that are on the rise, causing habitat loss, species disappearance, and climate changes. This kind of action is not sustainable; therefore, the transformation of the current linear economy into a circular economy is urgently needed. The concept of a circular economy eliminates waste, ensures the longest possible circulation of the product, promotes cascaded use across industries, and provides pure, non-toxic, or at least easier-to-separate inputs and designs, as well as materials with the possibility of reuse and recycling (EMF, 2013).

At the global, EU and Slovenian levels, the concept of a circular economy that is arising from sustainable development activities has become a policy priority (Godina *et al.*, 2018). The foundations of the new business model are more competitive, since they promote sustainable and efficient use and production of resources, green growth, and a low carbon economy. Such a transition offers new challenges and opportunities to transform the economy and create new and sustainable competitive advantages (Lahti *et al.*, 2018).

Companies nowadays also recognize the importance of engaging in corporate social responsibility (CSR). By using CSR, they balance the environmental, social, and economic aspects (Osagie *et al.*, 2014), and this helps to strengthen a brand through philanthropy, social responsibility programs, and volunteer work. It also allows for a stronger connection between employees and the corporation, which contributes to more efficient and successful work (Chen, 2019).

Today's changing problems and challenges of the 4th Industrial Revolution require different thinking, including special, new competencies of employees to manage these challenges. Various competence models are in use for the implementation of needed competencies. In our case, we created the KOC TOP competence model for the factories of the future, with the main aim of ensuring that employees do the right things successfully and deliver as much added value as possible to the organization and society.

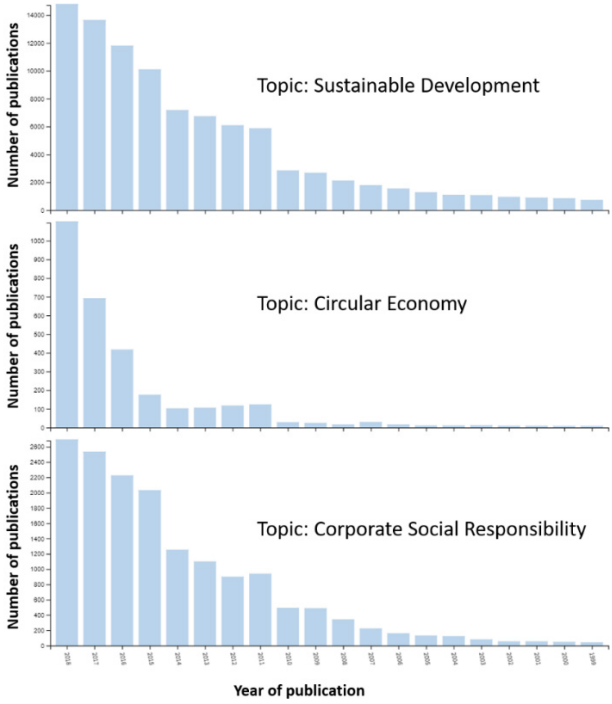

Figure 1: The increasing number of publications on the topic of sustainable development, circular economy and corporate social responsibility over the last 20 years
(Source: Web of Science).

Looking at the numbers, one can see in Figure 1 that the topics of sustainable development, circular economy, and corporate social responsibility have been getting more and more attractive to researchers and society as a whole over the last 20 years.

In this paper, we present the background of the competence model for factories of the future, which is the basis for the operation of the Competence Center established at the Jožef Stefan International Postgraduate School (IPS). We placed special emphasis on competencies linked to sustainable development, circular economy, and corporate social responsibility, which are important components of the competence model for future factories. In the end, the concept of the expert system is presented, allowing the selection of the most appropriate educational approaches for each employee according to any mismatch between their current and desired skills and competencies, as well as the workplace requirements.

2 Competence model for factories of the future

2.1 Basis for the competence model development

Within the Competence Centre at the IPS, we developed a Competence Model for Advanced Technologies in Factories of the Future (KOC-TOP Competence Model). The KOC-TOP Competence Model incorporates the knowledge (expertise, work experience, and functional knowledge), skills, and other characteristics necessary for successful performance in a given workplace, as well as systematic procedures for improving them. The purpose of the competence model is to ensure that employees do the right things successfully and bring maximum added value to the company, and as a result, contribute to business success. It is used in the selection of training for employees to help the company invest in the most promising competencies and build on their competence strengths. The model describes 1) general competencies that relate to the company culture and values; 2) specific vocational competencies common to the particular profession; and 3) key competencies that are most relevant to each job and represent a competitive advantage for the company. The model includes competencies in the following groups: 1) professional competencies; 2) social competencies; 3) leadership competencies; 4) business competencies; 5) change management; and 6) intercultural

competencies, identified as important by the IPS Competence Center partners (Zidanšek *et al.*, 2018).

The preparation of the competence model is based on the needs of the KOC-TOP Competence Center industrial partners, SRIPs action plans and the educational process in Slovenia. The needs were identified by a specially prepared questionnaire. The partner companies have already introduced competence models in their organizations; therefore, their experience and prepared materials have been included in the construction of the KOC-TOP competence model. An analysis of key competencies for the specific function and workplace of the participating partners was carried out. Project partners first assessed the importance of individual competencies for the workplace through internal procedures. Then they evaluated the level of the employees' competencies and the level of the competencies that are required at a particular workplace. Next, training was selected to improve the required competencies of employees at a workplace (Zidanšek *et al.*, 2018). Some training programs were selected for individuals, others for a group of employees.

The rebirth of industry is one of the priority areas in Europe, especially in the context of smart specialization (S4). The future of all of us depends largely on the complete transformation of current manufacturing plants into smart factories, based on the technologies of the future and the circular economy. The transition to a new era begins with human resources. Therefore, KOC-TOP aims to respond to the needs of companies to introduce the competencies of the future that they need in the era of the 4th Industrial Revolution and Society 5.0, as the boundary between the physical and digital worlds is blurred. Hence, KOC-TOP will motivate employees for lifelong learning and towards digital and cultural literacy to effectively acquire the competencies of the future. The target groups in companies that are involved in the process of additional training for employees and acquiring new competencies are primarily decision-makers, personnel, development managers, innovators, technologists, and production workers. The target groups also include employees of other companies, especially manufacturing companies, and other stakeholders (SRIPs, competent authorities, etc.).

KOC-TOP is based on the action plan of SRIP Factories of the Future (SRIP-TOP), which connects companies with research and education institutions for greater competitiveness and a stronger presence on the global market. SRIP-TOP and KOC-TOP, as a common challenge, are developing employee competencies for Industry 4.0 solutions, notably digitalization, automation, robotics, lean manufacturing, and artificial intelligence. This encourages companies to become more involved in value chains. Of particular importance to the S4 focal area Circular Economy are training in automation, artificial intelligence, and lean manufacturing, to help employees acquire the skills to deploy circular economy technologies in the use of secondary raw materials and waste. For the SRIP Circular Economy, sustainable development competencies are also important, which will improve environmental and social responsibility. For SRIP Smart Cities and Communities (SRIP PMiS), technologies such as cloud computing, open and mass data, embedded smart systems, the Internet of Things and the Internet of the Future are key components. In Figure 2, we summarize the relation between KOC-TOP and Slovenian SRIPs, which have in common not only industrial partners but also competencies for the future.

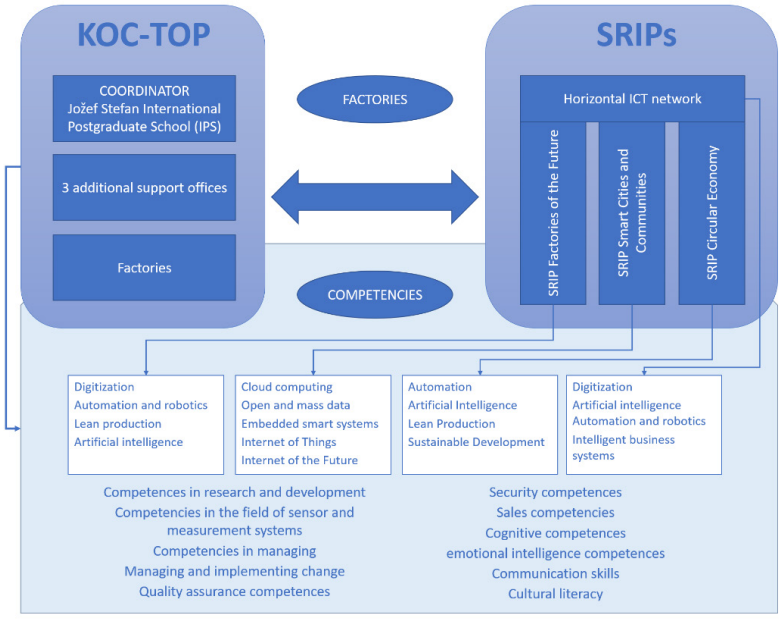

Figure 2: The relation between the Competence Center KOC-TOP and the Slovenian SRIPs.

2.2 Sustainable development, circular economy and corporate social responsibility in Slovenia, the EU and worldwide

The last four years have been the four hottest on record, and the elevated temperature is due to greenhouse gas emissions (UN, 2019). High temperatures cause the melting of ice, and a rise in sea temperature, which is harmful to coral reefs and other marine life. However, the rising temperature is not the only environmental problem in our economy. Other Environmental problems include water, soil, and air pollution, biodiversity loss, excessive land use, and resource depletion (Meadows *et al.*, 2004; Jackson, 2009, McLellan *et al.*, 2014). Climate change and other environmental problems cause high unemployment in certain parts of the world and poor working conditions (Banerjee & Duflo, 2011), and also exert a negative impact on human health.

Governments, factories, and consumers all over the world are increasingly aware of environmental care and are seeing a strategy in the circular economy that can promote clean growth and improve environmental conditions. As a result, governments are enforcing new pollution and waste control laws, along with strategies that apply throughout the product lifecycle (Ruiz-Real *et al.*, 2018). Global resource consumption is increasing year by year, from 26.7 to 92.1 tons in the last 47 years and 9 % of materials are reused today (De Wit *et al.*, 2019). Global plastics production in 2010 was 270 million tons, and global plastic waste was 275 million tons (Ritchie & Roser, 2018). Increasing international cooperation in environmental policy, a better understanding of environmental challenges, and promoting green solutions are the biggest global challenges of today's society (EU Commission, 2019a).

EU trends from 2010 to 2016 show an increase in waste generation (EEA, 2019a). However, more and more waste is recycled each year: in 2010, 36 % of waste was recycled (EU Commission, 2019b), in 2012, 40 % (EMF, 2015) and in 2016, about 55 % (IUS-INFO, 2019). The central framework for EU and national waste policies is the waste hierarchy. The EU has written The Roadmap to a Resource Efficient Europe, which describes the targets that need to be achieved by 2020 (EEA, 2019a). In 2018, the EU set targets in a new circular economy package, which include setting up separate textile collection by 2025, preparing for the reuse and recycling of waste materials by 2020, and increasing the level of preparation for the recycling and reuse

of municipal waste to 55 % by 2025, 60 % by 2030 and 65 % by 2035 (EEA, 2019b). The EU has a strategy on plastics, which states that by 2030 all plastic packaging on the EU market must be recycled (IUS-INFO, 2019).

In Slovenia, the circular economy represents a great potential for the near future, as there are many untapped natural resources. Slovenia's potential stems from its location, landscape, and cultural diversity (Godina Košir *et al.,* 2018).

By engaging in corporate social responsibility (CSR), companies aim to obtain a balance between the environmental, social, and economic aspects of their business practices. To achieve effective CSR functioning, it is necessary to have employees with the right competencies. Osagie *et al.* (2014) analyzed the literature and interviewed CSR professionals to establish the required competencies for CER implementation. The competencies obtained were classified into four domains: 1) Cognition-Oriented Competence Domain (Anticipating future developments regarding CSR related challenges, Understanding of the interdependency between systems and subsystems Understanding CSR drivers, CSR standards, and CSR regulations); 2) Functional-Oriented Competence Domain (Leadership competencies, Identifying and realizing CSR related business opportunity, etc.); 3) Social-Oriented Competence Domain (Realizing CSR-supportive interpersonal processes in CSR integration); and 4) Meta-oriented Competence Domain (Ethical normative competencies, Reflecting on personal CSR views and experiences, etc.) (Osagie *et al.*, 2014).

2.3 Concept of the expert system for training support

Nowadays, artificial intelligence (AI) expert systems are applied in many fields. A computer system that emulates the decision-making ability of a human expert can also be used to resolve complex problems in Human Resource Management (HRM). It can significantly contribute to the reduction of costs for organizations as well as to the efficiency of human resources. In the IPS Competence center KoC-ToP, we proposed an expert system for decision support, which can help HRM to select appropriate training for each employee. A preliminary version of the expert system was presented at the 14th SDEWES Conference in Dubrovnik (Cestnik *et al.*, 2019).

Thus, the employee can improve competencies required for their workplaces in an optimal way based on their previous level determined for each competence and the importance value of the competence for each workplace. In Figure 3 we present an entity-relationship model, also called an entity-relationship (ER) diagram. This is a graphic representation of entities and their relation to each other within the proposed expert system, which will be used in computing regarding the organization of data within databases of the information systems. From the diagram, one can see that different relationships and entities have an important role in training selection, evaluation of company progress as well as in the monitoring of employee career development.

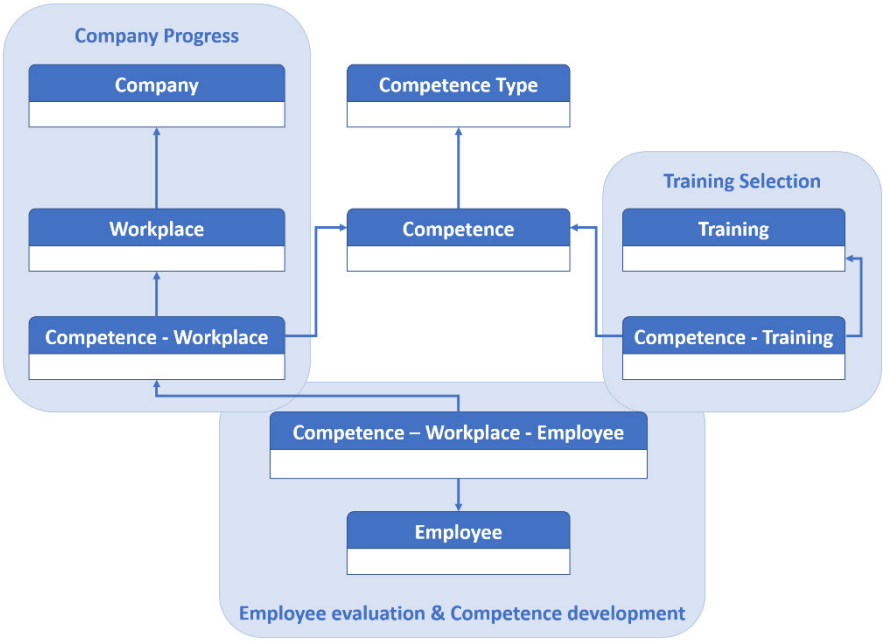

Figure 3: An entity–relationship model for the concept of the proposed expert system.

3 Results and Discussion

3.1 Selection of Key Competencies for KOC-TOP 2019

The selection of key competencies is based on the KoC-ToP 2018 Competence Model and the SRIP TOP, SRIP PMiS and SRIP Circular Economy Action Plan. It has been updated in consultation with companies, SRIPs, and other stakeholders. The strategies of companies recognizing changing HRM challenges were also considered when looking for workers and introducing training to acquire the competencies of smart factories at all levels. The challenges of system integration and the introduction of new technologies have been recognized as important and reflect the common needs of the partnership to enhance the professional competencies of digitization, lean manufacturing, automation and robotization, and artificial intelligence. Business competencies have also been recognized as important, especially in managing the introduction of new technologies, personal and leadership competencies, and the competency for sustainable development, including circular economy and social responsibility. The selection of competencies reflects the synergy between professional, business, personal and interpersonal competencies intertwined with digitization as an overarching connector. The project will also contribute to reducing the shortage of key competencies by using the RESPO expert system to ensure that training is maximally effective for each employee and the whole company. In this way, it will help to achieve the goals of companies in the introduction of Industry 4.0 and the complete transformation and rebirth of Slovenian industry.

Table 1: The list of selected competencies appropriate for sustainability, circular economy and corporate social responsibility.

Key competence
Digitization 4.0 (digitalization of infrastructure, augmented and virtual reality, IoT, technological literacy etc.)
Automation and robotization (design, deployment, and use of robots and workflow for factories of the future etc.)
Competencies of digitized lean production (lean & digital lean, mastery of lean thinking, digitization etc.)
Artificial intelligence competencies (machine learning, knowledge technologies, deep learning, computer vision, robot control etc.)
Competencies in research and development (monetization of development projects, innovation culture, rapid prototyping etc.)
Competencies in the field of sensor and measurement systems for factories of the future.
Competencies in the field of sustainable development (environmental protection, circular economy, social responsibility etc.)
Competencies in managing and managing processes, technologies, human resources and organizations in technologically advanced environments.
Business competencies (accounting, financial, bookkeeping etc.)
Managing and implementing change (workflow, technologies, intelligent business models, strategic development etc.)
Quality assurance competencies
Security competencies (technological and cyber security, occupational health, risk management etc.)
Sales competencies (marketing, improving brand awareness, developing after-sales services etc.)
Cognitive competencies (problem solving, critical and systemic thinking, creativity, lifelong learning etc.)
Emotional intelligence competencies (emotional literacy, psychophysical stability, empathy etc.)
Communication skills (communication with colleagues, clients, public speaking, business presentations, foreign languages etc.)
Cultural literacy (learning about cultures of foreign business environments)

3.2 The importance of KOC TOP 2019 for the Slovenian economy

More than 55 partners immediately contacted the consortium. This enormous interest in cooperation represents a commitment for the partnership to develop KOC-TOP into an important platform for the Slovenian economy. The main activities of KOC TOP will be quality training, support for implementation and information, support in the selection of contractors, assistance in reporting and exchange of good practices. We are also planning to hold conferences open to a wider public that will contribute to greater impact of KOC-TOP by presenting challenges and solutions for future factories. Staff will be involved in sharing good practices, enhancing their skills and preparing for the job market in the factories of the future. A special development program for the Factories of the Future (practical guidance and steps) will be developed, which will also be forwarded to ministries with recommendations for further steps. In pursuit of project sustainability, because of the enormous interest shown in cooperation, we will help to ensure that the factory of the future is further supported by real programs for the rapid and quality development of smart factories in Slovenia. Raising employees' competencies will also have a positive impact on the wider social environment, and through selected training, we will strengthen and promote social responsibility and concern for the environment. We also expect the exchange of industry experts with faculties and institutes, so that future generations of employees will be better prepared for the upcoming working conditions in the industry.

3.3 Expert system in practice

The RESPO expert system in its first version was developed for one company's needs. Its functionalities and end-user experience were verified from two different users. One was the HRM personnel in the company, and the second was staff from the Career Center at the IPS. For the evaluation of the RESPO expert system, the HRM personnel in the company first uploaded their competence model from Excel to the system's database. Then, the required levels of competence for each workplace and the levels of competence achieved by each employee were gathered and entered into the system. Next, the list of available future training programs was entered; attached to each of the training opportunities, there was a list of competencies that the training aims to improve. The first version of the expert system correctly

identified the employees' competencies with the highest gap and suggested the most adequate training that should contribute to improvement in those competencies.

The positive response from the Career Center indicates that the developed expert system can, with some modifications, be transferred to the educational systems. It can have an important role when counselling students to select an appropriate study program and obligatory study courses as well as additional training, which could improve their competence for their future jobs. One of the modifications is the incorporation of learning outcomes for each course within the expert system. Therefore, a special comparison was performed at the IPS, in which the competencies from the KOC-TOP competence model were compared with the learning outcome of courses from the Ecotechnologies study program (Batkovič *et al.*, 2019).

The effects of using the expert decision support system will also contribute to a common Career Platform for employees at the Chamber of Commerce and Industry, which seeks to anticipate competence and staffing needs, develop specific competencies and integrate the economy and education, including new employee training programs.

Although the RESPO expert system is still in the pilot phase, we plan to upgrade it and make it available to the interested public. The basic version of the system will be free of charge, and the possibility of custom upgrading will be provided. The KOC-TOP network will outline ways of managing human resources in technologically advanced environments, including with the help of the RESPO expert system, which will aid in the preparation of a special training program. It will also be available to other stakeholders, which will strengthen the cooperation of knowledge institutions with the economy and policymakers.

4 Conclusion

The competence model for the factories of the future was presented. It connects knowledge, skills, abilities and other characteristics necessary for successful work at a workplace within an organization. The purpose of the competence model is to ensure that employees do the right things and that they work successfully and bring as much added value as possible to the organisation and society. It also strengthens

the internal motivation of employees for life-long learning and stimulates intergenerational cooperation. We focus on the competencies linked to sustainable development, circular economy, and corporate social responsibility, which are important components of the competence model. The concept and first responses from practical use were presented for an expert decision support system, which was developed for the selection of the most appropriate training approaches for each employee according to any mismatch between their current skills and the desired skills and competencies as well as workplace requirements. In this contribution, the concept of the expert system is presented.

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