EasyChair Preprint
№ 9632

Engineering Competencies Expected in the Digital Working Places

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January 29, 2023

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Abstract— **Technological advances over the past decade have revolutionized the way we work today. All those changes brought about by the Industrial Internet of Things (IIoT) are modifying production structures and systems, sometimes even fundamentally, business models. In recent years, networked production processes have been integrated into devices capable of communicating with each other, and the industrial production sector has had a technological revolution in smart data management. logistics, real-time decision-making. These changes must be followed by the education system and in many other areas, and the relevant requirements should be part of the training output requirements. Competencies that support engineering students' future employability should also be coherently built into the present curricula to further bridge the gap between expected and real competencies.**
In my research, I have applied qualitative research design - content analysis - to be able to draw conclusions from the interviews have been conducted with twenty-two business representatives.

Keywords—Industry 4.0 skills, engineering students' competencies, companies' expectations, content analysis

I. INTRODUCTION

Industry 4.0 has brought a paradigm shift and industrial-economic transformation that has fundamentally changed the world as we knew it. It has made use of artificial intelligence virtual, augmented reality, and smart devices connected through 5G and cyberspace. The concept of security has taken on a whole new meaning, not only at the individual level but, nationwide, and globally as well.

The rapid emergence of digital technology has transformed the way we used to work and, at the same time, the institutional structure.

Employers' expectations and recruitment processes focus on useful skills and hard and social competencies, not necessarily just qualifications. As employees are expected to work on a wider range of tasks not only closely related to their initial competencies, qualifications, and/or training, employers often need to consider skills beyond the knowledge provided by formal education - whether soft or hard skills. [1] This transformation of the work environment is changing job profiles and therefore requires employees to have a wide range of competencies. [2] In Industry 4.0, the importance of job profiles requiring higher education will increase, while jobs requiring low skill levels will be replaced by mostly automated processes. Therefore, business experts and researchers agree that competence development is essential for students and workers applying for jobs requiring higher skills. [2] One of the key challenges in education is adapting to Industry 4.0 [3] [4] To address this challenge, Erol, Jäger, Hold, and Sihn [5] propose a scenario-based learning concept for students based on competencies from the literature. The Fraunhofer Institut für Materialfluss und Logistik [6] analyzed German companies following a holistic approach and proposes a set of competencies divided into two domains: competencies that companies need to acquire and competencies that employees need to adapt to. Other authors also analyze the work done in Industry 4.0 by identifying the competencies that have become important. [7] In addition, a clear description of the relationship and relevance between these competencies can serve as a basis for future competence development. [8] Industry 4.0 is associated with the further development of production machinery, which requires adapted competence profiles for engineers. These changes in production, the transformation of business processes, and new ways of communicating and interacting with new IT processes and structures, also require new ways of managing people, which also require tailored competence profiles.

Different industries have changed their industrial production and the related labor supply and retraining to different degrees. There is no denying the impact of COVID-19, both in the field of work and education which accelerated digital skills development. [9] A new form of work and education has emerged, in response to health and safety conditions, through home office and distance learning, which has brought new opportunities and challenges.

Those workers and institutions that were able and willing to take advantage of digital technology have made remarkable progress. [10] In fact, these developments have led to a significant reduction in expenditure on the one hand, but also to new challenges, notably cybersecurity issues outside of the offices. The security landscape has changed dramatically over the last 6-8 years. Sources of data about individuals can be easily combined, for example by linking financial assets and medical data. [11] So engineers with updated knowledge and skills in cybersecurity are in high demand, especially if those skills are compassed with soft and social skills.

These technical changes are modifying the workforce and its new skill sets. [12] The collapse of the oil price in early 2020 has severely affected even highly experienced workers with crucial skills. Large companies are introducing digital solutions in part to address the shortage of technically skilled workers. The newly introduced home office as a practice has also shown that achieving operational excellence depends on the combination of technology and a technically skilled workforce.

In Table I. I have listed the roles and the most important competencies of Industry 4.0 based on my literature research, choosing only those which relevant to the higher education curricula in line with the European Bologna System and can be integrated into present practices.

TABLE I NEW COMPETENCIES OF INDUSTRY 4.0

Definition, role, and importance of competencies related to Industry 4.0	
S. Erol, A. Jäger, P. Hold, K. Ott, W. Sihn, 2016	**Need to define Industry 4.0 competences**
D. Baneres és J. Conesa, 2017	companies are also looking for people **with soft skills**, as they are aware of the link between the former and the successful maintenance and execution of the work
L. Prifti, M. Knigge, H. Kienegger, és H. Krcmar, 2017	**competencies** that **companies** need to acquire and competencies that **workers need to adapt** to.
T. J. B. Blayone, O. Mykhailenko, R. vanOostveen, O. Grebeshkov, O. Hrebeshkova, és O. Vostryakov, 2018	industry stakeholders need **advanced digital technology knowledge and skills,** known as 21st-century skills
European Commission, 2018	Digital Competence Framework
Némethy, K. és Poór, D.J.2018	**entirely new competencies** must be developed to fit the changing requirements of a **convergent media environment**
M. Hernandez-de-Menendez, R. Morales-Menendez, C. A. Escobar, és M. McGovern, 2020	"other skills" have also become employability competencies, pointing towards **interdisciplinarity**
E. de Prada Creo, M. Mareque, és I. Portela-Pino, 2020	professionals and researchers agree that **competence development is essential for students and workers applying for a higher-skilled job**
R. E. Duarte és L. Rodríguez, 2021	**communication through digital technologies** or **problem-solving** that requires online research to identify the problem so that students can propose relevant solutions,
E. De Prada, M. Mareque, és M. Pino-Juste, 2022	**critical competencies in decision-making, communication, problem-solving and analysis, teamwork, and self-management.**

These transformations have had to be matched by changes in education to ensure that engineering students in this new situation are trained to replace the many disappearing or varying professions with the right skills and competencies. Adapting higher education output requirements to Industry 4.0 competencies, introducing new courses and subjects, and expanding adult education and training, in line with the implementation of lifelong learning, and expanding adult education and training would be a sound solution for these challenges.

II. METHODOLOGY

The aim of the research is to collect and scientifically analyze the skills required by industry, to explore the influence of Industry 4.0 on the changes needed in the professional and scientific curriculum, and to assess the adequacy of university education in light of industrial competencies and output requirements.

This part of my research employs an explanatory qualitative study based on semi-structured in-depth interviews with twenty-two representatives of Hungarian and multinational companies. I worked with human resource experts, managers, and regional experts. Based on their answers given, the research has reached a level of saturation that can be used as a basis for establishing broader correlations and drawing conclusions. However, because of the low number of participants, the data cannot be considered representative. The interviews were conducted between 2019 and 2022 either in person or by telephone in case of COVID-19 restrictions.

The interviewed companies are mainly active in the security engineering field or closely related to the automotive engineering industry. The company selections were made with the aim of ensuring that the competencies expected by the industry are relevant to the training of engineering students. The interviewees responded in full anonymity, in accordance with the current EU regulations, and the GDPR in force. I interpreted the transcripts using the content analysis methodology.

TABLE II INTERVIEWED COMPANIES

Companies' form	Number of companies	Interviewees' positions
Multinational	5	HR Manager/ Training Development Manager
Large enterprise	5	HR Manager, Head of Area Department, International Director
Governmental institutions	5	Area Manager
SME	7	Managing Director/Owner
Total	22	

One of the now-recognized capabilities of qualitative research is that it adds a new dimension to the results that cannot be achieved by measuring statistical variables alone, since, for example, one of the key questions in my study was what company representatives would like to see as more effective workforce training, what elements they would add to training, which is not something that statistical or numerical graphs are suitable for measuring since it is a matter of forming an opinion or a proposal.

Limitation of research: In my research, I analyzed 22 in-depth interviews with business representatives. The research was not a convenience sample, as I only interviewed entities with engineering profiles closely related to safety and mechanical engineering students' employability skills so the generalisability of the conclusions beyond these fields is limited. Furthermore, the competencies indicated by the companies are not generalizable either, given that the selection criterion was to analyze the views of representatives of the engineering and safety-related industries, who represent only a narrow sector of the industry, and the study did not undertake to cover the entire industrial spectrum within the industry.

III. RESULTS

After analyzing the content of the interviews, I have drawn the following conclusions.

1. The relevance and potential of university education are double: on the one hand, it does not have the full capacity to cover the full industrial competence fit with the right skills, because industrial innovation is much faster than the

transformation of higher education, while at the same time higher education institutions have the right resources to train the scientists and innovators and leaders of the future industries. It is therefore proposed that instead of full market coverage, global competencies, English, cyber security, and technical practical skills should be taught in a much broader range of subjects, especially in engineering. One respondent said: "The current labor market is changing very rapidly. We are not preparing students to learn new things, acquire new qualifications and continuously deepen their own competencies and keep up with professional trends at least every 5-6 years." (I12) So, skill development is not only dependent on higher education curricula but also on students' commitment.

2. Others see the main problem as a lack of basic competencies, such as self-awareness, self-management, and branding, or a lack of systems thinking approach, the acquisition, and mastery of which should not be the task of higher education alone or primarily, but rather the acquisition of a set of competencies starting from the beginning of studies, i.e., from primary school. "We also need to break away from tradition in a very serious way in education. Old, outdated methods and bureaucracy should be reduced." Instead, robotics, smart logistics, problem-solving, and project-based methods should be introduced.

"Improving language skills has also of utmost importance, as the world has become global, and borders have disappeared."(I5) It is also clear from the responses that students themselves are responsible for how much they benefit from their university years, i.e. how receptive and motivated they are in certain subjects, and what their indicators are on the issue of individual responsibility.

3. Still others made specific recommendations. They were the ones who called for a deeper knowledge of practical-technological skills, where it is not so much the responsibility of industry as of higher education to change the direction of training. They also stressed the importance of the design or problem-based education, where students work in groups on a project or problem in the framework of a semester, at the end of which they must report on the solutions offered by the group, based on criteria previously set.

Several respondents stressed the importance of improving communication and presentation skills during their university years, as well as teamwork and flexibility to adapt to change. Linked to the same idea is the thematic view that it is not enough for students to fight for a B, but that the goal should be to develop motivated groups of students who are genuinely interested in the profession. "for BSc, to regulate the practical period in more detail and to control the real work, to broaden the mentoring program by assigning students from the relevant department to tutors."

"For the MSc, to give more planning and independent project design tasks - project planning in Hungarian and English, to teach IT support for projects in practice", (I7) so that graduates can be easily integrated into the global workforce as well as into virtual or augmented workplaces.

Scores for skills, active participation in teamwork, and self-awareness or closely related emotional intelligence indicate that respondents consider both soft and hard skills as important factors for employability.

IV. SUMMARY

The aim of this research is to establish the output requirements for the employability of graduate engineers in terms of the soft and professional skills required by the labour market. In addition to hard skills (professional knowledge, IT, or technical knowledge), soft skills (personal qualities that enhance an individual's interactions, work performance, and career prospects) are expected in digital marketplaces.

The findings are presented considering the changes needed in higher education institutions and the importance of closer interaction and cooperation between companies and universities. [13]

In the era of digitalization, which is also overshadowed by other circumstances such as the COVID-19 pandemic or real war, the role of smart technologies is accelerating not only globally but also in areas of local employability. [14] Intercontinental trade and globalization, environmental sustainability as a major global issue, smart cities, growing economic and social inequality, and political tension or uncertainty could dramatically affect how jobs and career opportunities evolve. [15] Universities are not always able to keep pace with these changes and to change their curricula accordingly, even though there are many innovative and forward-looking subjects and courses available in the current education system. [16] One solution, it is suggested, could be to emphasize the teaching of digital skills as well as soft skills, in addition to general knowledge. It would also be important that these skills are not only taught in higher education but also start at the primary level. [17]

The current employment environment and the increased number of flexible working hours require employees and graduates to be more market-oriented. [18] With the current state of today's labour market, it is becoming increasingly difficult for individuals to differentiate themselves from their competitors. The global trend of digitalization also can provide many career-seeking students with the opportunity to spread their skills and competencies across the world and across industries and organizations if their personal determination are coupled with industry-expected soft and hard skills.

REFERENCES

[1]   L. Prifti, M. Knigge, H. Kienegger, és H. Krcmar, „A Competency Model for "Industrie 4.0" Employees", o. 15.

[2]   „Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group - acatech - National Academy of Science and Engineering". https://en.acatech.de/publication/recommendations-for-implementing-the-strategic-initiative-industrie-4-0-final-report-of-the-industrie-4-0-working-group/ (retrieved July 7, 2022).

[3]   B. P. G. Szűcs, K. Kovács, és J. Abonyi, „A negyedik ipari forradalom hatása a kompetenciacserélődésre", *Vezetéstudomány / Budapest Management Review*, köt. 52, sz. 1, o. 56, 2021.

[4]   S. Criollo-C, A. Guerrero-Arias, Á. Jaramillo-Alcázar, és S. Luján-Mora, „Mobile Learning Technologies for Education: Benefits and Pending Issues", Applied Sciences, köt. 11, sz. 9, Art. sz. 9, jan. 2021, doi: 10.3390/app11094111.

[5]   S. Erol, A. Jäger, P. Hold, K. Ott, és W. Sihn, „Tangible Industry 4.0: A Scenario-Based Approach to Learning for the Future of Production", 2016, doi: 10.1016/J.PROCIR.2016.03.162.

[6]   „acatech, Fraunhofer Institut für Materialfluss und Logistik, equeo GmbH: Kompetenzentwicklungsstudie Industrie 4.0. Report (2016) (retrieved July 7, 2022).

[7]   „Guo, Q.: Learning in a Mixed Reality System in the Context of ‚Industrie 4.0'.JOTED 3, 92-115 (2015) - (retrieved July 7, 2022.).

[8]   „Educating engineers for industry 4.0: Virtual worlds and human-robot-teams: Empirical studies towards a new educational age | Semantic Scholar". https://www.semanticscholar.org/paper/Educating-engineers-for-industry-4.0%3A-Virtual-and-a-Richert-Shehadeh/dcb2352caf8a64b732cc7847c895e9032a30a83c   (retrieved July 7, 2022.).

[9]   Garai-Fodor M. (2022): "The Impact of the Coronavirus on Competence, from a Generation-Specific Perspective", ACTA POLYTECHNICA HUNGARICA 19 : 8 pp. 111-125. , 15 p.

[10]   H. Nordal és I. El-Thalji, „Modeling a predictive maintenance management architecture to meet industry 4.0 requirements: A case study", Systems Engineering, köt. 24, sz. 1, o. 34–50, 2021, doi: 10.1002/sys.21565 -pdf-download-free-book-5821c5b.pdf (retrieved on October 23, 2022)

[11]   G. Culot, G. Nassimbeni, G. Orzes, és M. Sartor, „Behind the definition of Industry 4.0: Analysis and open questions", International Journal of Production Economics, köt. 226, o. 107617, aug. 2020, doi: 10.1016/j.ijpe.2020.107617.

[12]   É. Beke, "Trends in cyber-attacks, with special focus on health care," NATIONAL SECURITY REVIEW: PERIODICAL OF THE MILITARY NATIONAL SECURITY SERVICE, vol. 5, no. 2, pp. 33–44, 2019.

[13]   „Expected Competences of Smart Factories in the Age of Digitization (MTMT)". https://m2.mtmt.hu/gui2/?mode=browse&params=publication;3193149 8 (retrieved March 30, 2022.).

[14]   M. Clarke, „Rethinking graduate employability: the role of capital, individual attributes and context", Studies in Higher Education, köt. 43, sz. 11, o. 1923–1937, nov. 2018, doi: 10.1080/03075079.2017.1294152.

[15]   C. Succi és M. Canovi, „Soft skills to enhance graduate employability: comparing students and employers' perceptions", Studies in Higher Education, köt. 45, sz. 9, o. 1834–1847, szept. 2020, doi: 10.1080/03075079.2019.1585420.

[16]   I. Römgens, R. Scoupe, és S. Beausaert, „Unraveling the concept of employability, bringing together research on employability in higher education and the workplace", Studies in Higher Education, köt. 45, sz. 12, o. 2588–2603, dec. 2020, doi: 10.1080/03075079.2019.1623770.

[17]   K. Robson, „Motivating Professional Student Behavior Through a Gamified Personal Branding Assignment", Journal of Marketing Education, köt. 41, sz. 2, o. 154–164, aug. 2019, doi: 10.1177/0273475318823847.

[18]   Fodor M ; Jäckel K.(2018): "What does It Take to Have a Successful Career Through the Eyes of Generation Z - Based on the Results of a Primary Qualitative Research", International Journal of Lifelong Education and Leadership 4 : 1 pp. 1-7. , 7 p.