ANALYSIS OF THE POSSIBLE APPLICATION OF ASSISTIVE TECHNOLOGY IN THE CONCEPT OF INDUSTRY 4.0

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Abstract: *With the development of assistive technologies in the past, people with disabilities have considerably increased the degree of mobility while doing their daily activities. According to the EU Council Directive 2000/78 / EU and the Employment Guidelines, every person with disabilities is important to provide employment opportunities and equal access to the wider community. Therefore, this paper will make an analysis of currently available research on the possibilities of applying Universal Design and forms of assistive technologies whose task is to enable greater involvement of people with disabilities in the field of employment. Based on the collected conclusions of the conducted analysis, the experience of users using assistive technology in their workplace will be presented. In addition to mentioned, the representation of information and communication technologies and its features will depend on the usage scenarios and the perspective of the future development of new services in the work processes of persons with disabilities and Industry 4.0.*

Key words*: Industry 4.0, Mobility, Universal Design, Assistive Technologies*

1. Introduction

According to the Report on persons with disabilities in the Republic of Croatia, on 14.03.2017, lives 511,850 people with disabilities, representing 11.9% of the population [1]. Out of these numbers, there are 243,206 persons in working age 19-64, while 10,583 are employed according to the criteria set out in the Regulations on the content and method of keeping a record of employed persons with disabilities (NN75/18). The latest available data for the EU area available through EUROSTAT indicate that 38.7% of people with disabilities aged 25-65 are employed in the EU [2]. One of the key objectives of The European strategy for persons with disability (2010-2020) is an area of employment which aims to ensure the increase of the number of disabled workers in the labor market and to ensure better access to workplaces [3]. It is also important to note that according to the EU Council Directive 2000/78 / EU and the Employment guidelines, every person with disabilities must provide employment opportunities.

The current development of information and communication technology and its application in the field of production and logistics enables persons with disability to provide an accessible work environment. The area of accessible environment

development is possible by introducing assistive technology (devices and services) into new industry 4.0 concepts.

2. Assistive technology and universal design

Assistive Technology (AT) is based on the application of information and communication (IC) technology to meet daily needs and actively engage in everyday activities of persons with disabilities and older persons. Definition of AT is considered [4]:

- **Assistive technology Device** - Any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of person with disabilities.
- **Assistive technology Services** - Any service that directly assists a person with a disability in the selection, acquisition, and use of an assistive technology device.

Assistive technology devices are available in categories to address functional capabilities of person with disabilities. These categories include, but are not limited to:

- **Academic and Learning Aids**: Electronic and non-electronic aids such as calculators, spell checkers, portable word processors, and computer-based software solutions that are used by person who has difficulty achieving in the educational curriculum.
- **Aids for Daily Living**: Self-help aids for use in activities such as eating, bathing, cooking, dressing, toileting, and home maintenance.
- **Assistive Listening Devices and Environmental Aids**: Electronic and non-electronic aids such as amplification devices, closed captioning systems, and environmental alert systems that assist person who are hard of hearing or deaf with accessing information that is typically presented through an auditory modality.
- **Augmentative Communication**: Electronic and non-electronic devices and software solutions that provide a means for expressive and receptive communication for person with limited speech and language
- **Computer Access and Instruction**: Input and output devices, alternative access aids, modified or alternative keyboards, switches, special software, and other devices and software solutions that enable person with a disability.
- **Environmental Control**: Electronic and non-electronic aids such as switches, environmental control units, and adapted appliances that are used by person with physical disabilities to increase their independence in all type of environment.
- **Mobility Aids**: Electronic and non-electronic aids such as wheelchairs (manual and electronic), walkers, scooters that are used to increase personal mobility.
- **Pre-vocational and Vocational Aids**: Electronic and non-electronic aids such as picture-based task analysis sheets, adapted knobs, and adapted timers and watches that are used to assist person in completing pre-vocational and vocational tasks.

- **Recreation and Leisure Aids**: Electronic and non-electronic aids such as adapted books, switch adapted toys, and leisure computer-based software applications that are used by person with disabilities to increase participation and independence in recreation and leisure activities.
- **Seating and Positioning**: Adaptive seating systems and positioning devices that provide person with optimal positioning to enhance participation.
- **Visual Aids**: Electronic and non-electronic aids such as magnifiers, talking calculators, Braille writers, adapted tape players, screen reading software applications for the computer, and Braille note-taking devices that assist person with visual impairments or blindness in accessing and producing information that is typically present in a visual (print) modality.
- **Working environment**: A working environment in which a person with disabilities can exercise the right to work and equal opportunity to participate in society.

Universal Design is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability. An environment (or any building, product, or service in that environment) should be designed to meet the needs of all people who wish to use it. This is not a special requirement, for the benefit of only a minority of the population. It is a fundamental condition of good design. If an environment is accessible, usable, convenient and a pleasure to use, everyone benefits [5].

The 7 Principles of Universal Design were developed in 1997 by a working group of architects, product designers, engineers and environmental design researchers, led by the late Ronald Mace in the North Carolina State University. These Principles are:

- Equitable Use,
- Flexibility in Use,
- Simple and Intuitive Use,
- Perceptible Information,
- Tolerance for Error,
- Low Physical Effort,
- Size and Space for Approach and Use.

The purpose of the Principles is to guide the design of environments, products and communications.

3. Industry 4.0 concept

Industry 4.0 refers to a fourth industrial revolution (following water/steam power, mass production and automation through IT and robotics) and introduces the concept of "cyber-physical systems" to differentiate this new evolutionary phase from the electronic automation that has gone before [6]. The figure 1 shows perspective of Industry 4.0 and possibilities for futures in manufacturing and industries. This mean connection people, business and things through Internet of Things - IoT technologies. Industry 4.0 encompasses end-to-end digitization and data integration of the value chain: offering digital products and services, operating connected physical and virtual assets,

transforming and integrating all operations and internal activities, building partnerships, and optimizing customer-facing activities.

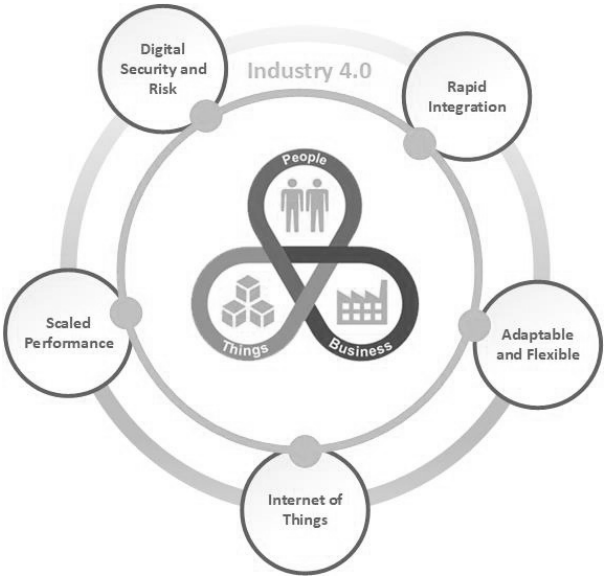

Figure 1. Industry 4.0 in Perspective [6]

The capabilities of deployment and implementation of Industry 4.0 technology and the advantages that can boost business operations in various industries have been explored in Global Digital Operations Study 2018 (PWC). The research is focused on three areas: Ecosystem, New technologies and Digital culture [7].

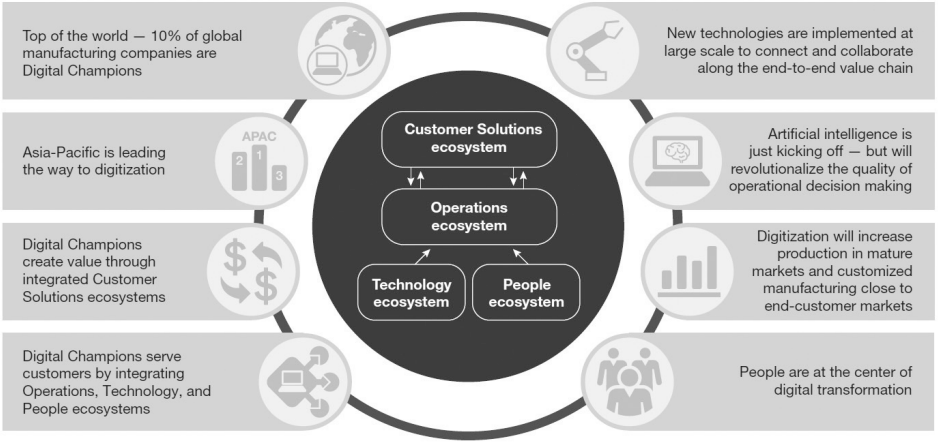

Figure 2. Eight key findings of the Global Digital Operations Study 2018 [7]

The research was attended by 1,550 directors of various companies from 26 countries around the world. Based on the obtained data 8 key areas are defined for the preparation and introduction of the Industry 4.0 concept (Figure 2). As shown in Figure 2, one of the key factors is the human factor that represents the center of digital transformation. According to data, 27% of respondents believe that their employees have a satisfactory level of knowledge in the field of application of IC technology. For the success of the business using Industry 4.0, four key layouts are also important: Customer Solutions, Operations, Technology, and People. Each of the four ecosystem layers represents a cluster of activities, some occurring inside the organization and some outside. These activities are tied together through common digital connections and practices.

The Customer Solutions ecosystem: In this grouping, also called the business model and customer value layer, companies put forth the distinctive products and services that they can best offer customers or consumers. They do this through personalization, customization, enhanced features, improved logistics, creative revenue models, and innovative designs and applications. This layer also includes external entities that the company is integrating into its solution to create additional value.

The Operations ecosystem: Also called the solution enablement and value chain efficiency layer, this cluster encompasses the physical activities and flows that support the Customer Solutions ecosystem. These might include product development, planning, sourcing, manufacturing, warehousing, logistics, and services. Any external partners that are part of a company's operations, including contract manufacturers, logistics partners, and academia, are part of this ecosystem.

The Technology ecosystem: This is an enabling ecosystem that covers IT architecture and interfaces as well as digital technologies and drives or supports improvements and breakthroughs in the Customer Solutions, Operations, and People ecosystems. It includes such pivotal technologies for Industry 4.0 as artificial intelligence, 3D printing, the Industrial Internet of Things (IIoT) and sensors, augmented and virtual reality, and robots, shown in Figure 3.

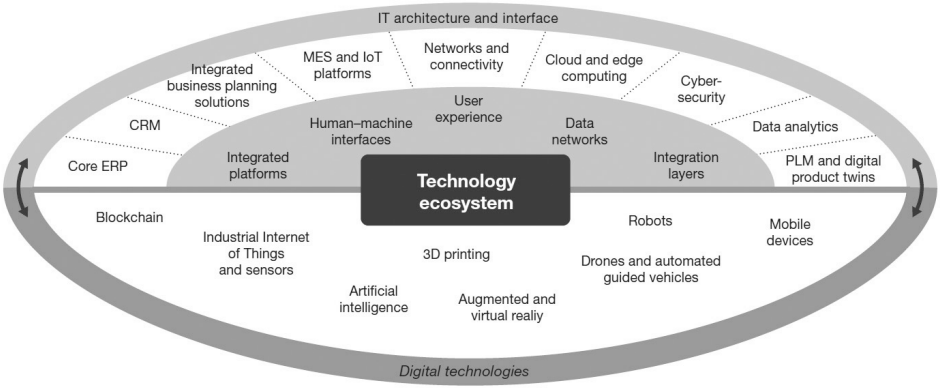

Figure 3. Overview of Technology ecosystem in Industry 4.0 [7]

The People ecosystem: Another enabling layer, this is the domain of organizational competence and culture. This ecosystem covers skills, mind-set and behavior, and

relationships and skill sources, as well as career development to support digital transformation. The People ecosystem enables and supports the efforts of the other three ecosystems. As a result, the contours of the People ecosystem can best be viewed through the lens of how digitization affects a company's strategic direction (its solutions) and its performance (its operations). By assessing these factors, a company can determine the types of workers and skills that will be needed to support its efforts to improve value chain results and operational outcomes (Figure 4). Importantly, the People ecosystem must encompass external as well as internal staff.

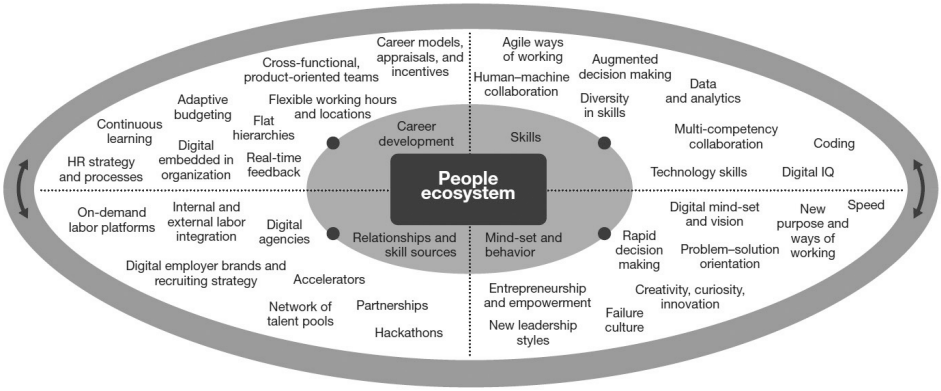

Figure 4. The key elements of People ecosystem [7]

The most important skills are workers exhibit diverse skills. They work in agile ways, and the organization has strong capabilities in data analytics, human– machine interaction, and technology-supported decision making. There are formal pathways for increasing the workforce's digital IQ.

4. Possibilities of applying assistive technologies in Industry 4.0

Industry 4.0 as a new concept based on the ever-increasing use of IC technology does not exclude the role of workers but requires greater competence in knowing the characteristics of IC technology in manufacturing and logistics processes.

4.1 Analysis of the possible application of assistive technology in the workplace

Persons with disabilities can qualify for the labor market in the Industry 4.0 environment [8]. This research suggests the importance of organizational structure of companies and preparations for inclusion of disabled people to work in the Industry 4.0 environment. Lifelong learning programs are also prepared for people with disabilities to work in Industry 4.0 environment [9]. In this paper a model for company's implementation that opens new possibilities for lifelong learning is proposed. The goal of the project „*Developing an Information System for Assistive Technology Apps"* is to create an easy, accessible way for Seven Hills employees to find and search for assistive technology apps they can use in their daily work [10]. The skills and competences of

workers required to work in Industry 4.0 environment and the role of IC technologies in such workplaces have been researched from the aspect of creating greater flexibility and creativity of workers [11]. The research conducted in 67 companies in Austria aimed at gathering insight into the working activities of an older group of workers and persons with disabilities and the opportunities for working in the industry of Industry 4.0 [12]. The results of the research defined the specific demands of workers depending on their needs and the working environment they are in. It also shows an environment in which people and technologies work together in new organizational challenges. Research of the possibilities of applying assistive technologies in the working environment was made on a sample of 205 users (74% female, 26% male), spent by The Social Insurance Institution of Finland [13]. The median age of the research group was 50 years. The participants had a physical, visual, or hearing disorder or a communication problem. Over half (59%) of the respondents used a computer for over four hours a day. Most (75%) had a desktop computer, and every fifth (22%) had a laptop. Office programs involving word processing, spreadsheets, or presentation graphics were used by 72% of the workers. Industry 4.0 is a coordinated push for automation in Smart Factories and other Cyber-Physical Systems (CPS). The increasing complexity of frequently changing production environments challenges shop floor workers to perform well [14]. The paper describes the possibilities of improved work possibilities using Augmented Reality (AR) technology in the industry 4.0 concept as an abundance of assistive technology.

4.2 Perspectives on the assistant technologies development in the Industry 4.0

Based on the analyzed researches and opportunities of the Industry 4.0 concept, it is possible to implement new IC services as a form of assistive technology for workers (people with disabilities) with the aim of performing effective tasks during the work.

Table 1. The analysis of IC services and assistive technologies depends on the type of disabilities

Type of disabilities	Assistive technologies	IC Services
Visually Impaired	• Screen reader • Text to speech • Screen magnifiers • Video magnifiers • Accessible Identification Systems • Color identification	• JAWS • Window eyes • Zoom text • OrCam MyEye 2 • Sunu band • Ruby XL
Hearing, Voice, Speech, or Language Disorders Impaired	• Assistive Listening Systems • Augmentative and alternative communication devices • Alerting devices	• AVA software • The MegaBee • Roloquo2Go • GoTalk Express 32
Motor Skill Impairments	• Sip-and-Puff Systems • Graphic Organizers • Math Tools	• Sip and Puff Switch Solutions • Ginger and Ghotit software

Table 1 provides an analysis of IC technologies and services and assistive technologies depending on the type of user damage.

Creating a working environment for persons with disabilities is the first step to their involvement and equality. The working environment should provide support and enable persons with disabilities to achieve greater potential and productivity in what they are doing. The company and employers must adopt working culture and provide a tailored environment for persons with disabilities depending on their damage. Physical availability is of utmost importance, with the aim of enabling mobility and independence of movement in the work environment. According to defined user requirements, it is necessary to define the assistive technology and functionality of the service and continuous training and monitoring of the work of the employees (persons with disabilities). Employee competences when using assistive technology in the work environment include [15]:

- Awareness of Technology: Gather information on the types and features of AT,
- Awareness of Disability: Identify the strengths you can capitalize on and the limitations for which you need to compensate,
- Awareness of Job Tasks: Identify the essential functions of the job and the tasks AT will need to assist you in accomplishing,
- Awareness of Training: Determine how the device operates and who can instruct both the user and co-workers,
- Awareness of Maintenance Options: Gather information on the AT to be implemented and evaluate its durability, maintenance, and repair schedules,
- Awareness of Funding Options: Determine who is responsible for paying for a device and identify potential sources of funds for the purchase of AT.

The direction of the development of smart warehouses and smart production systems within the concept of Industry 4.0 is due to the increasing use of contemporary IC technology and services. The most commonly used IC technologies are Cloud Computing, Internet of Things, Big Data, and Artificial Intelligence. By applying these technologies, the goal is to enable greater productivity, flexibility of workers and environments, better product quality and performance of all processes and tasks [16].

5. Conclusion

The growing challenges in developing new contemporary IC technologies require education and adaptation of all users and environments in which they are used. Work environments where persons with disabilities are in the role of workers need to adapt to the guidelines of universal design and user requirements. Industry 4.0 concepts define the direction of development of manufacturing and logistics environments according to the ever-increasing use of IC technologies and services. A person with a disability who is in the role of a worker can by using assistive technologies (devices and services) raise the degree of quality of work and thus the quality of life. The analysis carried out in this paper can be used as a basis for future research in this area with the aim of further developing assistive devices and services. The concept of Industry 4.0 provides an opportunity for greater involvement of people with disabilities in manufacturing processes and logistics.

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Sadržaj: *Razvojem asistivnih tehnologija, osobama s invaliditetom znatno se povećao stepen mobilnosti prilikom obavljanja svakodnevnih aktivnosti. Prema direktivi veća EU 2000/78/EU i Smernicama za zapošljavanje svakoj osobi s invaliditetom važno je osigurati mogućnost zapošljavanja i jednaku mogućnost u uključivanju šire društvene zajednice. Stoga će se u ovom radu napraviti analiza trenutno dostupnih rešenja i usluga, temeljenih na Univerzalnom dizajnu i obliku asistivnih tehnologija, i inovativnih korisničkih uređaja čiji je zadatak da omogući veću uključenost osoba s invaliditetom u domenu zapošljavanja. Na temelju prikupljenih zaključaka sprovedene analize biće prikazana iskustva korisnika koji koriste asistivnu tehnologiju na svom radnom mestu. Osim navedenog, prikazaće se zastupljenost informaciono-komunikacionih tehnologija i njenih karakteristika u zavisnosti od scenarija korišćenja kao i perspektive budućeg razvoja novih usluga u procesima rada osoba s invaliditetom u okviru koncepta Industrije 4.0.*

Ključne reči: *Industry 4.0, Mobilnost, Univerzalni dizajn, asistivne tehnologije*

ANALIZA MOGUĆNOSTI PRIMENE ASISTIVNIH TEHNOLOGIJA U OKVIRU KONCEPTA INDUSTRY 4.0

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