Tackling the Challenges of ICT Innovation and Talents for Industry 4.0

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Abstract: ***In the last years, the ICT innovation, research and development area has changed drastically. Nowadays, the ICT is part of the industry 4.0, health care, education, training etc., and has as such a crucial role in all parts of our lives. Developing products and services, conducting research and innovation activities, where ICT has a supporting role, means that in addition to the ICT domains, researchers and developers have to acquire domain specific knowledge from different application sectors, such as health, energy or education. This means that traditional ICT education and training are not providing all the competences needed and are therefore inefficient in meeting the needs of the industry and economy. New, innovative models of education and training are necessary and they should include solution oriented design thinking and prototyping. In addition, a short review of ICT-based innovation activities and good practices at UL FE is given.***

Index Terms: creativity, ICT, innovation, IoT, skills and competences, talents.

1. INTRODUCTION

INFORMATION and communication technologies (ICT) play an important role in today's economy, transforming practically every sector of the industry [3].

In the last years, the ICT innovation, research and development areas have changed drastically. Communication and information technologies and services have become a commodity in most parts of the world. Broadband networks, wired and wireless, as well as datasets, accessible via open APIs, are increasingly available as resources all the time and from everywhere, similarly as mains wall plugs and water from a tap.

There is still basic research within core ICT domains, however it is present in fewer areas, i.e. mobile, quality of experience, software defined networking/radio, cyber security etc. A great deal of research has moved to applicative, interdisciplinary areas, where ICT plays just a part, although an important one, of the solution.

As shown later on, nowadays ICT is a part of health care, automotive industry, education, training etc., and has, as such, a crucial role in all parts of our lives.

The trends in ICT go towards the Internet of Things (IoT). The number of connected devices already exceeds the world population; and, according to forecasts, it should increase to more than 30 billion by 2020. The development and expansion of the IoT is mainly due to three underlying factors: (i) a significant increase in the processing capacity of electronic devices (i.e., Moore's Law), (ii) proliferation of communication technologies that power the connectivity of a large number of devices into a common network, and (iii) cloud software that enables large-scale data processing and extraction of actionable information.

At the same time, the commoditization makes technology more affordable to everyone, which fosters tinkering and has the potential to level the playing field between established companies and start-ups. In such environments, the market differentiation is more than ever a function of creativity and innovation.

Developing products and services, conducting research and innovation activities, where ICT has a supporting role, means that in addition to ICT domains, researchers and developers have to acquire domain specific knowledge from different domains. This means that the traditional ICT education and training are not providing competences needed and are therefore inefficient in meeting the needs of the economy. Therefore, new, innovative models of education and training are necessary.

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2. ICT AS PART OF INNOVATION IN ALL DOMAINS

There is still basic research going on in the field of core ICT domains; however, it focuses on very specific topics, such as next-generation mobile technologies, quality of experience, software defined networking, software-defined radio, cyber security, etc.

These researches try to advance the state of the art and remove various inefficiencies, but on a larger scale, they do seem to be subject to the law of diminishing returns. At the same time, a great deal of ICT-related research has moved to applicative and interdisciplinary areas, where ICT serves just as a background infrastructure and enabler for the domain-specific solution.

ICT has become an indispensable part of all parts of our lives. As the Figure 1 shows, it is part of health care, industry, education and training, etc.

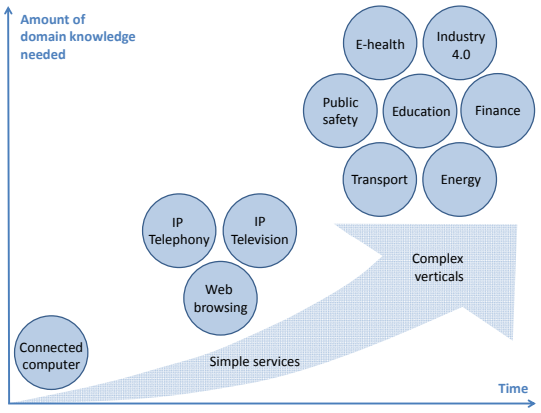

Figure 1: ICT in various economy sectors

Conducting research and innovation, where ICT has the role of supporting and enabling services means that researchers have to acquire specific knowledge from a number of different domains. Moreover, for this time, money and competences are needed.

Today, competitiveness and innovation depend on mastering a wide range of information and communication technologies. Firstly, it has become possible to deploy ubiquitous sensing solutions to gain awareness of many industrial processes, as well as to disrupt entire industries. There is a plethora of already available devices that can collect and share data, for example: (i) vehicles, home automation equipment, city infrastructure, (ii) wristbands and smart watches, smart textiles, and other wearables, (ii) industrial robots, cameras, sensors, etc.

However, data collection is only the first step on the way to obtain actionable information. Data needs to be transferred, stored and processed, for which many novel approaches have appeared, such as map-reduce, in-memory processing, stream mining, etc. In addition to that, knowledge of basic machine learning techniques, mathematics/statistics and visualization is needed for almost any work in that area; this has led to a new profession of data scientist – an expert versed in the above skills that can extract knowledge from the data.

However, before processing the data, one has to know what questions to ask. For this, a suitable domain knowledge is needed, which can be either provided by an expert in the field, or inferred by observing the processes, conducting interviews and performing requirements engineering.

Only once the whole chain is completed, resulting data and algorithms can be used to close the feedback loops and drive complex systems in an optimal manner.

3. INDUSTRY 4.0

Lately, the term that describes the above-mentioned ICT innovation used for growth in industry has a name – Industry 4.0. Industry 4.0 is a trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, the Internet of things and cloud computing. Industry 4.0 creates what has been nicknamed a "smart factory". Cyber-physical systems monitor physical processes, create a virtual copy of the physical world and make decentralized decisions. Over the IoT, cyber-physical systems communicate and cooperate with humans and with each other in real time; and via the Internet of Services (IoS), both internal and cross-organizational services are offered and used by participants of the value chain [11,12].

4. HUMAN RESOURCES AND DEVELOPMENT

The field of human resources development is extremely important especially in the domains of ICT/IoT and Industry 4.0 for two reasons. (i) Not only Slovenia, but also the entire European Union is suffering from a long-term lack of ICT experts to fill the need for more than 500.000 ICT jobs [2]. This has a direct impact on the weakening of innovation and competitiveness of industry and economy. (ii) This area requires very dynamic change or adaptation of competences, since we can never talk about one branch, but a distinctive inter-branch or multidisciplinary approach in ensuring appropriate competences. This approach requires close engagement of the industry and economy, education as well as other governmental and non-governmental organizations in attaining both formal and non-formal knowledge and skills.

The Generation X was followed by the generation of the millennials. The millennials represent individuals born between the early 1980s and early 2000s. However, the Generation Z (post-millennials or digital natives) is different

and therefore they need different ways of motivation. Some of their most important values are togetherness and visual communication. What is very important for them is the need to make things, not just share them, as it was the case in the former generation.

The modes of work have changed radically over time, as is also shown in Figure 2. The figure is based on UK data and statistics [4]. Workers entering the labor market need different motivation compared to those already in the labor market. This also changes the work process and consequently the competences employees should have in order to get involved in the working environment as soon as possible. As it can be seen from Figure 3, the most important competences in 2015 were complex problem solving, coordinating with others, and people management. By 2020, these three will be replaced by complex problem solving, critical thinking, and creativity [4].

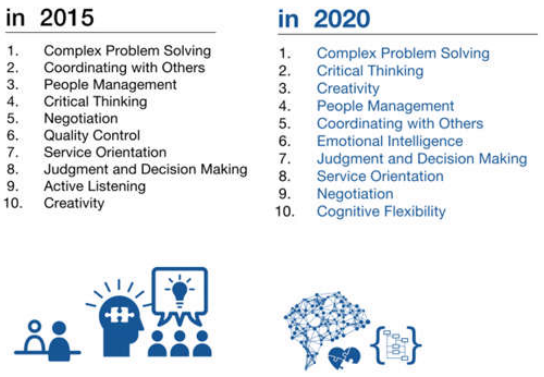

Figure 2: Top 10 skills in the fourth industrial revolution in 2015 and 2020 [5]

The learning process must adapt to new needs of today's generations and to new needs of the labor market. All these key processes, changes, and technologies (digital technology, Industry 4.0, IoT, ICT) are also strongly reflected in the field of personnel acquisition, education and training, which can follow and shape new research, development, and business opportunities. This also implies digital transformation of the school and research system.

Furthermore, the transformation of the school and research system will also have to bring, in addition to the new teaching methods, better collaboration of the school system and engagement with companies (co-curricular programs, interconnection of personnel, and integration into the pedagogical and work process) [6]. It is about connecting at all levels (kindergarten, primary and secondary school, apprenticeship, practice, scholarships, higher education, incubators, accelerators, technology parks, related organizations, and companies).

The key areas to be addressed in solving these issues are listed below:

a) Improving and extending ICT subjects in elementary and secondary schools, increase the number of hours and opportunities for practical learning of the ICT/IoT technical content.
b) Preparation of study programs for teachers in elementary and secondary schools.
c) Upgrading and extending university programs and courses in the field of the ICT/IoT and increasing the number of enrollment places.
d) Preparation of specialized educational programs for the ICT/IoT and Industry 4.0 companies.
e) Increasing the creative and fabrication literacy of people (f-literacy).
f) Planned and coordinated promotion of the ICT/IoT field among young people, with a special emphasis on the promotion of the ICT/IoT field among girls.
g) The IoT devices in schools: schools should be equipped with the IoT devices and lectures on them should be included in engineering, computing, and/or science.

5. *Innovation and Activities Belonging to Talents at LTFE and LMMFE*

In this chapter, we give a short review of ICT-based innovation activities and good practices at the Laboratory for Telecommunications (LTFE) and the Laboratory for Multimedia (LMMFE) at the Faculty of Electrical Engineering of the University of Ljubljana. In relation with the above-mentioned issues, we are focusing on:

a) Prototyping: MakerLab [7] and the national FabLab network [10]
b) Learning by doing: within the course Interdisciplinary projects [8]
c) Multimedia: new study program for next generation talents [9].

MakerLab is an open prototyping laboratory for students and creators, who organize work in the laboratory, prepare content, teach their peers and other creators, and participate in innovative projects. MakerLab follows basic principles for teaching science, technology, engineering and mathematics (STEM) courses to Millennial and Generation Z students, like learning by doing, teamwork, interdisciplinary projects, solving the real life problems, and collaborating with start-ups and well-established corporations.

In 2016, MakerLab offered support to over 150 students and other creators, both through preparation of practical seminars and final projects, and through self-initiative projects. In addition, more than 15 free of charge workshops with more than 250 participants were organized. Participants gained knowledge in the field of ICT/IoT product design and development.

The main goal of the MakerLab is to encourage young people to start exploring new technologies,

enroll into technology study courses as well as to actively involve themselves in participating in innovative educational and development projects.

Some of the most prominent and innovative projects of the MakerLab are Olympic Countdown Clock, SmartFroc, and T.A.F.R.

Olympic Countdown Clock is an interactive countdown clock that was counting down to the start of the Olympic Games in Rio de Janeiro in 2016 and is currently counting down to the start of the next games in Pyongyang. For this project, two custom developed embedded platform were used, each of them controlling a set of LED matrix displays. The clock is connected to the Internet, which allows us to replace the displayed content remotely and to monitor the operation of the clock through several sensors inside the sculpture. The project was realized in cooperation with the Slovenian Olympic Committee and the clock is installed in Ljubljana.

SmartFroc is an adjustable chair for children aged 1-10 years and features built-in weight sensors that allow adults to measure a child's weight through a smartphone application. The chair has four built-in load sensors that, in combination with a custom developed Bluetooth 4.0 electronics board, measure the child's weight and sends the data to a connected smartphone. The electronic board is neatly hidden inside the chair's legs. The project was developed in cooperation with Slovenian wood product manufacturer.

T.A.F.R. is an autonomous farming robot that monitors plants, applies fertilizers and pesticides and helps with everyday work at the farm. With a robotic helper, the chores on the field get cheaper, are done faster, and can be remotely managed.

Fabrication labs (or FabLabs) represent prototype environments for promoting innovations and inventions in the fields of modern digital technologies, ICT and IoT applications. They help increase creative literacy, which means that people can use new high-tech tools. They are dedicated for creators, students, researchers, and entrepreneurs who want to express their creativity in the form of development of innovative products with high benefit. In addition to the basic tools found in classical workshops, FabLabs have modern equipment such as 3D printers, CNC milling machines and laser cutters. Modernly furnished rooms represent only the first step; mentors that help creators overcome problems on their way and through education involve inexperienced creators in the FabLab form the second step. The third step represents linking of creators to groups that encourage formation of ideas and mutual motivation to stay on this difficult journey. Networks of related laboratories, exchanging knowledge flows, and equipment form the fourth step, which also opens up important opportunities for linking with the industry and financing the projects in the early stages of product development. FabLabs enable industry, and especially small and medium-sized enterprises, to test their ideas before entering the path of digitization.

Knowledge in engineering – most importantly communications, programming and media skills – upgraded by participatory team student work, learning by doing and design thinking with prototyping are essential parts of the Multimedia study program and Interdisciplinary projects course at the Faculty of Electrical Engineering, University of Ljubljana.

The students and youngsters are motivated to participate at different innovation activities by interesting topics and mostly by the ability to work on real and "cool" projects. For some of their activities they also earn ECTS credit points, but as we see from experience, this is not their main motivation.

For the innovation activities other than study programs, we currently do not have any systematical funding scheme in place. We are covering the costs from participation in Horizon 2020 and Interreg projects. Such kind of financing, from project to project, is not well suited for this kind of activities. Our goal is that National Slovenia FabLab network become recognized as an innovation priority in Slovenia and thus get national system funding. Similarly, our goal is to have the course Interdisciplinary projects more intensively backed by university in terms of logistics and finance.

6. CONCLUSION

ICT/IoT technologies and services have become a commodity and are transforming all and every sector of the industry and economy (digitalization). Therefore, competitiveness and innovation needed for Industry 4.0 depend on mastering a wide range of ICT/IoT skills and competences.

However, conducting research and innovation, in different domains in which the ICT/IoT has the role of a supporting and enabling service, requires from the researches to have specific knowledge from a number of different domains as well as a broad and open perspective of issues and possible solutions.

Matching the Industry 4.0 needs for talents and innovation with the needs and perspectives of the generations X, Y and Z is a challenging task.

Some of the most important values of the new generations are togetherness, communication, sharing and (very importantly) a need to create and make things by themselves.

Transformations of the industry and economy combined with the drive and motivations of young generations, implicates the need for transformation (how the educational and innovation processes run) at universities.

The steps to tackle the challenges of the ICT

innovation and the ICT talents for the Industry 4.0 that we, at the University of Ljubljana, Faculty of Electrical Engineering, have already taken are: (i) MakerLab (prototyping), (ii) the course Interdisciplinary projects (team work, design thinking, inter- and multidisciplinary solutions), and (iii) new Multimedia study program to prepare young talents for new workspace reality such as innovation, changing of the domains, shorter term commitments, solution design, etc.

Our ongoing efforts focus on involving many more students from the whole University of Ljubljana to participate in Interdisciplinary projects course, increasing the share of female students, and setting-up a national Slovenia FabLab network.

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