ANALYSIS OF **EMERGING TECHNOLOGIES** FOR IMPROVING **SOCIAL INCLUSION** OF **PEOPLE WITH DISABILITIES**

Prepared by:

INNOSID

Innovative Solutions based on Emerging Technologies for Improving Social Inclusion of People with Disabilities

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Preface

Jurica Babic
INNOSID project coordinator

“Joy comes from using your potential”

- William Shutz, an American psychologist

They say that every man is the architect of his own fortune. To a certain degree, this statement makes sense. For example, if you learn and train hard, you will most likely get a good job you love and have a successful career. The only “minor detail” is that such a statement assumes that all people have a level-playing field, meaning that each person has equal opportunities to succeed in life. Indeed, all people struggle at some point of their lives and, as highly influential Canadian astronaut Chris Hadfield advised, we should be optimistic and “cut them some slack”.

It is well known that people with disabilities (PWD) face many barriers and challenges that prevent them from achieving their full potential. Individuals from such a vulnerable group may even struggle for an extensive period which has a detrimental effect on social inclusion. Again, we need to be optimistic and “cut them some slack”, but we should also take action and investigate how we can solve a major societal challenge and provide a level-playing field for all, especially PWD. Given the complexity of such a challenge, the social inclusion of PWD is much easier said than done as contributions should come from the collaboration of different stakeholders, including academia, industry, government, and civil society.

In this report, my colleagues pushed the envelope with research on how emerging technologies can improve social inclusion of PWD. At first glance, it may sound weird to use the terms “social inclusion”, “emerging technologies” and “PWD” in the same sentence as it sounds a bit futuristic. However, this report will demonstrate to you that there is a lot of potential in harnessing emerging technologies for the benefit of PWD. We wanted to make sure we broke down this “puzzle” in pieces so that everyone can learn something new and useful. Fundamental questions inspired the authors. What do we even mean by emerging technology? What does it mean to improve social inclusion of PWD? How can technology help PWD? Given the peculiarities of emerging technologies, is there a structure we should consider when designing and implementing an innovative solution aimed for PWD? Such questions are multidisciplinary in nature, so we relied on contributions from the authors who have strong research skills in technology and social inclusion. The additional strength of the report comes from the fact that the authors come from diverse backgrounds, including six higher education institutions and one non-governmental organization, from five EU countries (Croatia, France, Hungary, Portugal, Spain).

Even though putting together the report was a remarkable task undertaken by my colleagues, it is worth mentioning that it was just one of the deliverables from the project entitled “Innovative Solutions based on Emerging Technologies for Improving Social Inclusion of People with Disabilities”. However, the report is the foundational deliverable which is invaluable and serves as a strong basis for the remaining project activities. I thank Erasmus+ for giving us the opportunity to strengthen and support research on disability as well as to increase public awareness and understanding of the importance of social inclusion of people with disabilities. I sincerely hope readers will be empowered by this reading.

Executive summary

The INNOSID project's goal is to improve the social inclusion of people with disabilities (PWD) by creating innovative IT solutions based on emerging technologies (ET). In order to reach that goal and come up with a social innovation that would address the needs of PWD and positively impact not just PWD, but their families and caretakers, as well as the society, a well-structured framework is needed. This framework should explain what the key entities involved, and their relationships are. Also, the framework should describe the process and the approach needed for the development of social innovation based on ET.

Since the goal of these social innovations based on ET is to improve quality of life of PWD by including them in all aspects of life, in order for the framework to work, the world's mindset needs to be changed. So as to achieve this, people need to be educated about social inclusion of people with disabilities, the awareness about social responsibility needs to be raised, and all of this needs to be a subject of matter from a young age in a sense that this is put in educational curriculum, for example, and workshops for students are organized etc. This report is one step closer to that because it serves as a body of knowledge related to ET and their application for improving the quality of life of PWD. It is relevant not only to the scientific audience but to the general public as well.

1

New technologies, including information and communication technology (ICT), assistive technology (AT), and emerging technologies (ET), need to be available and suitable for use by people with disabilities as well as accessible and affordable to them. This is recognized by many international organizations and bodies who are responsible for many policy frameworks and legislatives that are in line with previously mentioned, as it is described in the *Introduction* chapter of the report. As this report is a study on ET for improving social inclusion of PWD, the *Introduction* chapter also describes the keywords, such as people with disabilities, social inclusion and ET, from a broader perspective in order to understand the connection between them. The role of technology for society in general and especially for PWD is described. ET are recognized as technologies that have the potential to serve as a means for achieving the full inclusion and participation of PWD in society.

2

The second chapter of this report, entitled *Emerging technologies,* gives an overview of the following ET: Virtual Reality, Augmented Reality and Mixed Reality, Holography, Internet of Things, 5G, Artificial Intelligence, Robotics, and 3D printing. They are recognized as the ones that can play a significant role considering social inclusion as a domain of application. In this report, they are elaborated from various points of view, and their effect on everyday society has been provided. In the chapter, technical aspect on these technologies is presented, meaning that for each technology a short development history, current state along with several real-life examples as well as an overview of the promising future applications is provided. This gives a reader a very good view of what are the capabilities, as well as limitations of each emerging technology.

3

Social inclusion of people with disabilities is the title of the third chapter in this report. That chapter is aimed at, firstly, defining the social inclusion of PWD from different aspects, and secondly, explaining what the different approaches and methods for improving the social inclusion of PWD, as well as for raising awareness about their needs and barriers they face, are. A definition of disability and other crucial facts, such as heterogeneous needs of PWD, have been provided to give a better understanding of the life of PWD to the non-disabled persons. Barriers in key areas such as education and employment have been listed along with solution examples for minimizing those barriers as well as good practices and commendable examples aiming at removing them. Furthermore, the importance of engagement of many parties, such as parents, families, communities, for the inclusion of people (especially children) with disabilities, is emphasized. The process of sensitization to eliminate discrimination against people with disabilities has been provided together with many examples of good initiatives for sensitization about PWD. Many different methods and practices of social inclusion for people with disabilities are described that can be very motivating for the reader, especially because awareness of these topics is still insufficient.

4

The next, fourth chapter in the report (*Social inclusion and technology*), reveals the opportunities that technology, both emerging and mainstream, brings for social inclusion. Technology has always had a great impact on people's lives. Even though one would think everyone could benefit from every technological product or service, that is not always the case. Innovative approaches are necessary if one wants to take a step closer to removing the barriers that lie ahead of an inclusive, sustainable and accessible society. Having said that, this chapter provides examples of assistive technological solutions for people with disabilities based on ET mentioned in chapter *Emerging technologies*. Additionally, examples of good practice are provided describing some of the projects related to ET that have the sole purpose of improving social inclusion and promoting equal opportunities. This chapter also brings an example of a good practice from Croatia that relates to the development of the ICT-based solutions for inclusion of persons with complex communication needs, as well as continuous research and development activities for exploring the potential of emerging technologies for the social inclusion of PWD.

5

Ecosystem for innovative solutions based on emerging technologies for improving social inclusion of people with disabilities is the title of chapter five of this report. After the explanation of what social innovation means for the society and which areas can benefit from social innovations, the conceptual framework for social innovation based on emerging technology has been introduced. From this, a reader can identify the key entities involved in this "social innovation ecosystem" and understand why it is necessary that all relationships between them work successfully in order to achieve sustainability. The social innovation ecosystem has changed its approach and met some of the needs of PWD. Developing innovative ideas with the goal of improving human well-being can be used to provide effective solutions for the challenges PWD come across. This would not be possible without the involvement of the civil society as the key entity in the social innovation ecosystem, which is described in this chapter. In order to help define how one can develop an impactful social innovation based on ET for social inclusion of PWD, the necessary model representing key entities and their relationships as well as a prototype-driven process for the development of ET-based product for social inclusion of PWD are described. This model and process emerged from a more generalized conceptual framework for social innovation based on ET proposed in this chapter.

1

Introduction

Technologies in general and their assistive capabilities in particular, play a significant role for people with disabilities and their social inclusion. It is expected that emerging technologies will contribute to assistive technologies by reducing or removing the constraints that characterize existing solutions, as well as opening up entirely new ones [1]–[6]. This report aims to explore such opportunities by investigating the potential of emerging technologies for the sake of improving social inclusion of people with disabilities. The presented research is carried out within the ERASMUS+ project entitled *Innovative Solutions based on Emerging Technologies for Improving Social Inclusion of People with Disabilities* (INNOSID). The INNOSID project is based on the 10-year-long operation of the ICT-AAC Competence network in Croatia[1] whose members cooperate in education, research, development and innovation with the aim of developing an inclusive society. The ICT-AAC Competence network's activities are expanded with this project through the internationalization and use of emerging technologies.

The project's consortium consists of six higher education institutions and one non-governmental organization from the domain of persons with disabilities from five European countries: Croatia, France, Hungary, Portugal and Spain. More about the INNOSID consortium partners can be found in the Appendix A of the report. The report, in whose activities all INNOSID partner countries participated, provides an analysis of emerging technologies for improving the social inclusion of people with disabilities.

The focus of this chapter is to introduce the topics of interest by explaining the key theoretical concepts from both technical and societal aspects. Keywords, such as people with disabilities, social inclusion and emerging technologies, are defined and introduced from a broader perspective in order to understand the connection between them. In addition, the end of this chapter will outline its significance for interested readers.

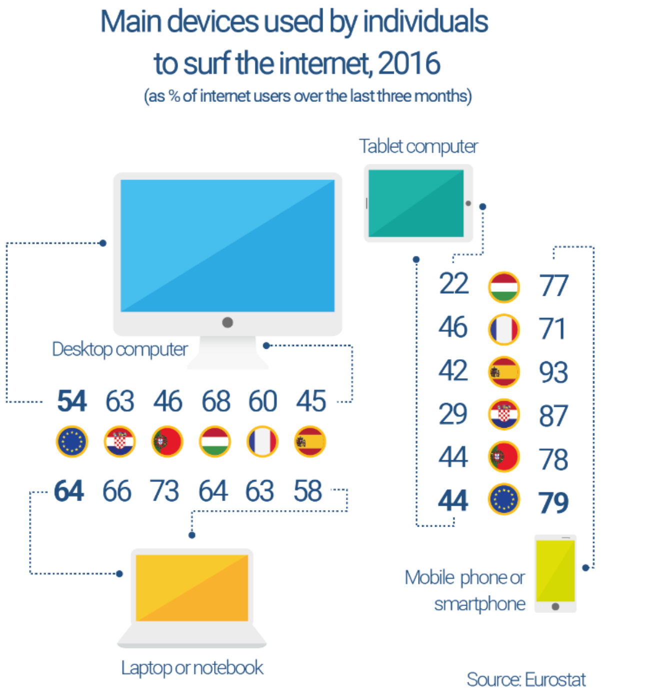
As the reader of the report will be able to see, the report is designed to provide, in addition to text, numerous examples related to different statistics, infographics, various visual representations of the described, as well as examples of good practice and case studies, mostly related to partner countries. Purpose of that is to enable the reader to better understand the topics that are extremely important and should not be neglected, especially because they concern each person and because each of us can play an important role in change for the better.

1.1 The role of technology in society

We are living in an era where technology plays an increasing role in society. The rapid growth and development of technology have affected how people experience everyday technological advances. Historically, technology has evolved at an exponential rate, which can be seen from the progress of the enabling technologies. In general, enabling technologies refer to the equipment and/or methodology that, alone or in combination with associated technologies, provides the means to generate giant leaps in performance and capabilities of a user [7]. Some of the significant enabling technologies of the modern era are, for example, an elevator that allowed for higher buildings resulting in an increase in population density, a telephone that enabled long-distance communication, the Internet that enabled device connectivity across the globe and also enabled new forms of social interactions and information sharing [8].

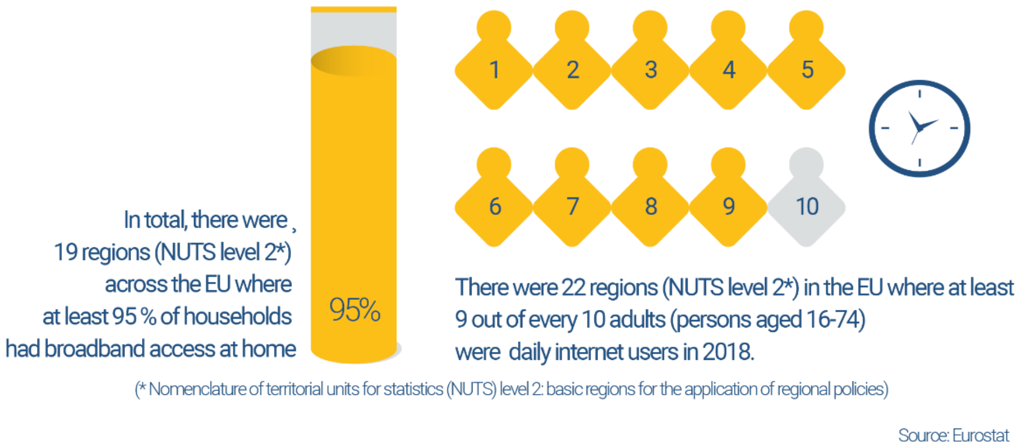
[1] http://www.ict-aac.hr/index.php/en/

Not only that technological advances are happening at an exponential rate, but the rate at which newly commercialized technologies get adopted by new customers is also getting bigger. Nowadays, new ideas and products are spreading and are adopted faster than the "older" technologies (e.g. telephone) due to increased connectivity, instant communication, and established infrastructure. Computers, mobile phones, the Internet, smartphones, social media, are all examples of "modern" or today's common technologies that showed fast-rising adoption rates. For example, the first touch screen tablet that achieved significant success amongst consumers was the iPad, released in 2010. Its success encouraged other companies to release their own tablet versions soon after. Although the global demand for tablets has witnessed a steady decrease after shipment peaked in 2014, it was estimated that 144 million tablets were shipped worldwide in 2019, which is more than sevenfold the increase on the figure shipped in 2010 [9], [10].



As of January 2020, it is estimated that there are 5.19 billion unique mobile phone users, which makes 67% of the global population. Furthermore, almost 4.54 billion people were active Internet users, encompassing 59% of the global population, while 3.80 billion people, or 49% of the global population, were active users of social media [11].

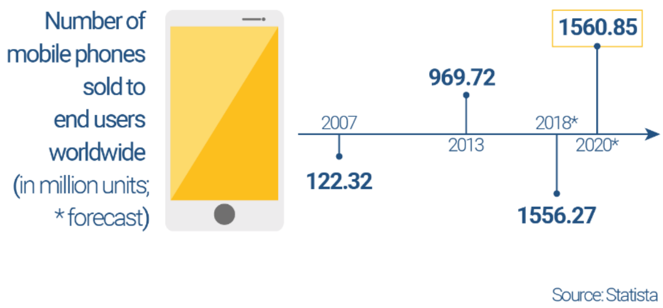
Because of the exponential progress of enabling technologies related to computing power, big data, connectivity of devices, the performance of the Internet, etc., it is not hard to believe in predictions which say that the world will be unrecognizably different in just a few decades.



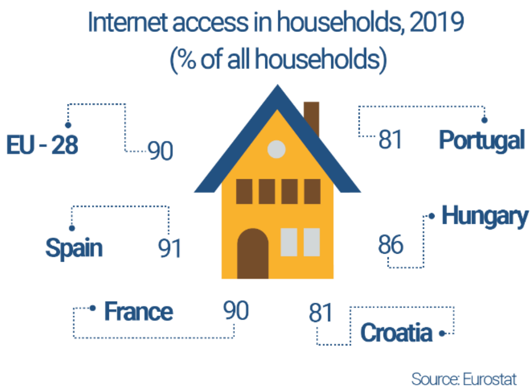
The question we should ask ourselves is **how to take advantage of this technological progress for higher goals, i.e. to improve the quality of people's lives**. Assistive robots, virtual teachers and/or students, billions of connected smart sensors in our homes and workplaces, self-driving cars, are just some of the technological examples which can become a part of our everyday life. Therefore, the responsibility in terms of designing and developing solutions based on these technologies that are becoming more and more powerful is getting bigger every day [12].

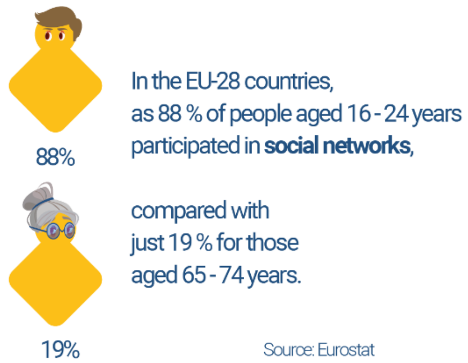
Technology that especially impacted people's lives through history and radically changed the way people communicate is Information and Communication Technology (ICT). ICT, as a technology that enables transfer and utilization of all kinds of information, presents the most penetrating generic technology of today. It includes computers and communication networks, as well as technology for sensing, processing, storing and displaying information such as data, voice, image, text, etc. As such, ICT is widely recognized as a technology without which we could no longer imagine usual day-to-day activities and whose use has an impact on various aspects of society, as well as on different aspects of an individual's life.

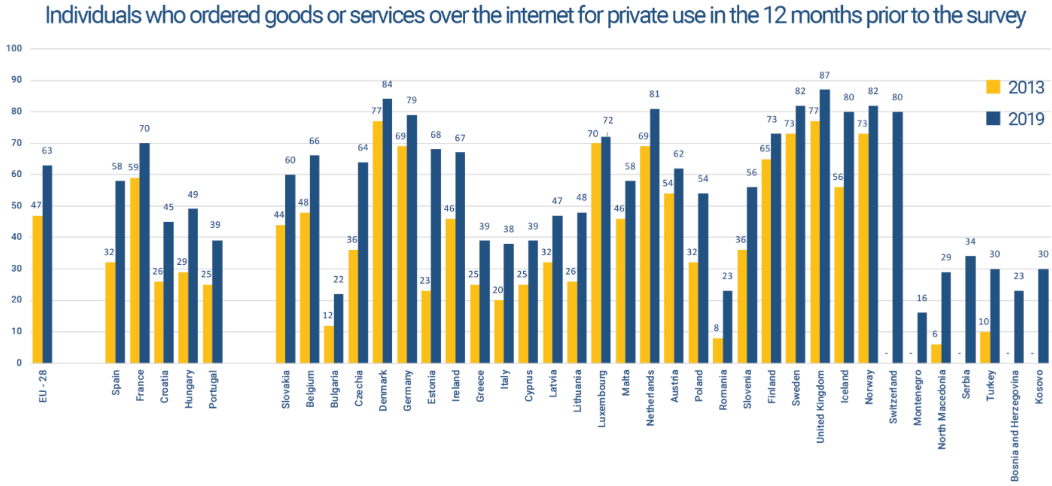
Today's generations would especially find it difficult to imagine life without ICT associated with the digital age, e.g. without **smartphones** whose number of users worldwide surpasses three billion and is forecast to further grow by several hundred million in the next few years [13].

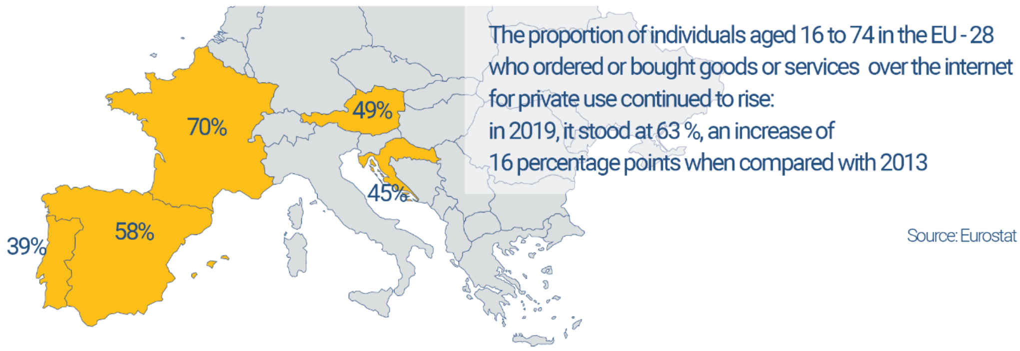


Today's generations would especially find it difficult to imagine life without ICT associated with the digital age, e.g. without **smartphones** whose number of users worldwide surpasses three billion and is forecast to further grow by several hundred million in the next few years [13]. The **Internet** has become a crucial part of people's lives as its influence on individual consumers, and large economies, grows. It continues to transform the way people connect with others, share information, socialize, read the news, watch movies, organize trips, buy/sell products etc. In combination with mobile devices, the Internet-enabled smartphone and tablet users to access and share information while moving. According to Statista, in 2019, Internet users worldwide spent a daily average of 122 minutes on their mobile devices, with social networking and watching online videos being the most popular activities [14].

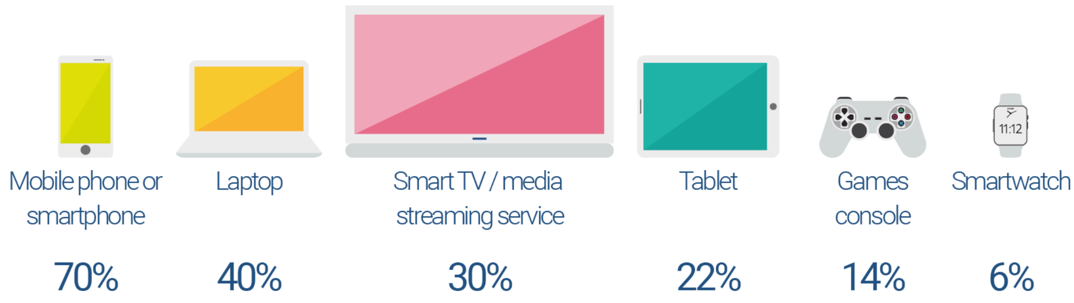








Increased media device usage due to the COVID-19 virus outbreak among internet users worldwide as of March 2020

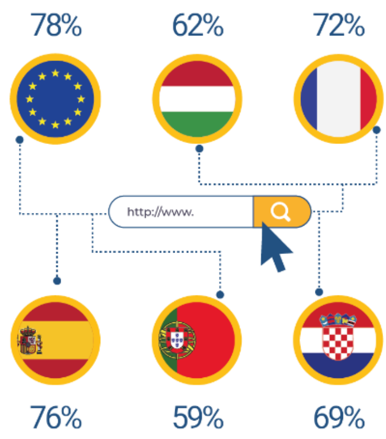


Source: Statista

In addition to being used for leisure activities, the useful applications of the Internet in combination with different ICT tools can be found in many different domains. Education is the first one worth mentioning because education is a fundamental human right to which every person is entitled to [15]. Many are the benefits of using ICT as a tool in education. For example, education is becoming more accessible because the Internet makes it possible to reach educational material and learning opportunities no matter the place and the time. Also, the quality of education is being improved since different ICT tools make learning more interactive and engaging which can affect learning outcomes [16]. The Internet has also found its way to facilitate research. The process of gathering and sharing knowledge, as well as keeping up with the latest discoveries, has become much easier and faster than it was before the Internet.

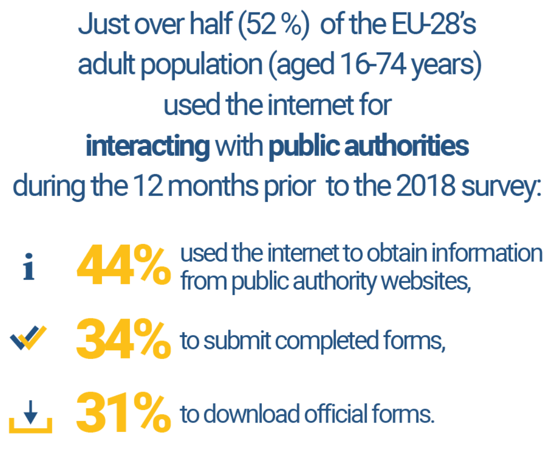
People's workplaces have also changed a lot: different ICT tools affected workers' efficiency across every industry, online communication tools have made it easier for employees to connect and communicate at any time, different management systems have made it easier to organize business etc.

Enterprises with a website, 2020 (% of all enterprises)



Source: Eurostat

Many countries have established electronic public services, such as e-Government [17], to facilitate access to information from all public authorities to their citizens, as well as to simplify and accelerate communication and digital interaction between citizens/businesses and administration.



Source: Eurostat

Inevitably, technology plays a big role in people's lives. So, it is important to understand how to harness ICT to fully benefit the well-being and quality of life of people, as well as positively influence economic growth and social development. That being said, ICT has been recognized as an enabler of the sustainable development whose essence lays in reconciling of economic efficiency, social inclusion and environmental responsibility. In 2015, all United Nations member states adopted the 17 Sustainable Development Goals[2] as a part of the 2030 Agenda for Sustainable Development. Present report [18] concludes that *science and technology* play an

[2] *Sustainable Development Goals*, https://www.un.org/sustainabledevelopment/sustainable-development-goals

important role in achieving the Goals by the year 2030. Together with *governance*, *economy and finance*, and *individual and collective action*, they have been identified as actors who need to work together on the necessary transformation towards sustainable development. Digital revolution is also recognized as a key enabler of sustainable development in the years to come where a big role is played by new digital technologies [18]. The European Commission has recognized the benefits of connecting European Union member states in the field of advanced digital technologies in order to take advantage of the possibilities these technologies offer. The support is provided by the new Digital Europe programme through which capital investments will be increased in the next priority areas: *supercomputing*, *artificial intelligence*, *cybersecurity*, *advanced digital skills*, and *ensuring a wide use of digital technologies across the economy and society* [19].

Contributions of the digital revolution can have both positive and negative outcomes, which is why the priority should be to develop science, technology and innovation road maps and write the principles of digital transformation for sustainable development [18]. Some possible negative outcomes can be associated with reinforcing the existing inequalities and introducing new ones, especially regarding the full and equal participation in the society of people with disabilities worldwide. To avoid having them excluded from the society, people with disabilities need to have the appropriate access to digital infrastructure and accessible ICT, which should not be difficult to achieve if ICT is considered in line with the *Convention on the Rights of Persons with Disabilities (CRPD)* [20] and if developers and designers of technological solutions prioritize accessibility for all [18].

The society is already in the process of adapting to digital transformation, which affects all sectors of the economy, and is changing our life, work and communication. The process of integrating digital technologies in all business areas of an organization must also include educating individuals, i.e. employees, as well as their users. That is why, nowadays, being a computer illiterate person and a person with a lack of digital skills means not being able to participate in the modern society, i.e. being a person who has no opportunity to make full use of their potential in all aspects of life. Although there are relevant institutions which recognized the necessity and usefulness of inclusive computer literacy, e.g. the European Commission [21], UNESCO [22], and OECD [23], there are still groups of people with difficult access to basic computer education, e.g. people with disabilities, older people, unemployed people, people living in remote places etc.

1.2 The role of technology for people with disabilities

Combination of technological progress, globalization and population ageing is causing the transformation of the society to which the world needs to adapt. While making moves to ensure that the world is in pace with these changes, it is important to ensure equal opportunities for all vulnerable communities. **Social inclusion** is defined as “the process of improving the terms on which individuals and groups take part in society—improving the ability, opportunity, and dignity of those disadvantaged on the basis of their identity” [24]. A disadvantage of a person can be defined on the basis of age, gender, disability, race, ethnicity, origin, religion, or economic or other status. When term *social inclusion* is mentioned in this report, it will mainly refer to people with disabilities. According to UN’s CRPD **people with disabilities** include those “who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.” [20].

When talking about facing various obstacles in terms of participation in community life, one of the most vulnerable groups are people with disabilities (PWD). According to the World Health Organization (WHO), about 15% of the world’s population (or over one billion people worldwide) lives with some form of disability. Since previous estimates made by WHO in the 1970s, the global disability prevalence figure has risen for about 10%. Some of the reasons behind the rising number are ageing of the population and the rapid spread of chronic diseases, as well as improvements in the methodologies used to measure disability [25]. These numbers prove the importance of taking appropriate measures to provide this group of people with the conditions for a more independent and quality life. When used to help people with disabilities to overcome barriers they encounter throughout their lives, ICT becomes a valuable tool in the context of improving the quality of their life, reducing social exclusion and increasing participation in all aspects of the society.

In order to fully take advantage of different ICT tools, ICT accessibility for people with disabilities needs to become a priority for many. This need has been recognized by ITU that issued a *Model ICT accessibility policy report* designed as a tool for national policy-makers and regulators to create their own ICT accessibility policy frameworks [26]. This is also aligned with the article from the UN's CRPD which says that the States Parties are obligated "To undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies, mobility aids, devices and assistive technologies, suitable for persons with disabilities, giving priority to technologies at an affordable cost;" [20]. ITU model policy report defines Assistive Technology (AT) as "any information and communications technology, product, device, equipment and related service used to maintain, increase, or improve the functional capabilities of individuals with specific needs or disabilities" [26]. Compatibility of ICT tools and services with assistive technologies needs to be ensured in order to achieve ICT accessibility. For example, a screen reader is an AT which converts digital text into synthesized speech, and whose compatibility with websites is required in order to help visually impaired people to perceive information that appears on the websites [26].

Assistive technologies are commonly classified according to the degree of knowledge complexity on how to use them. Such a classification includes assistive technology ranging from low-tech to high-tech. The low-tech AT includes all tools that consist of few mechanical parts and do not require a power source, e.g. magnifiers, custom cutlery holders, prescription glasses, pictorial visual scheduler, cards with symbols and words, etc. High-tech AT includes more complex devices and equipment that may have a digital or electronic component or are based on the use of sophisticated computer programs, e.g. electrically powered wheelchairs, alternative mice, devices for alternative and augmentative communication (communicators), voice recognition software, eye tracking and eye control technology, etc. These are all examples of technologies that are already in use and/or development. More sophisticated technologies as a result of technological progress are becoming more and more relevant for the development of new assistive technologies. An example of technology used "for Good" is Artificial Intelligence (AI). ICT tools with incorporated AI methods can automate accessibility tasks in order to tailor the design and method of use of each tool to every user. That way, ease of use and support for people with disabilities can be provided, which can be one step closer to the accessible ICT [27].

1.3 Introducing emerging technologies

Technological development is characterized by different concepts and qualifications of technologies. When their sources are in science, they describe novelties (e.g. quantum computer). When sources are political or managerial, they need not always be something new, but something well known that has not received enough attention at the right time (e.g. digital, digitalization, digital transformation). The following three attributes are most commonly associated with technology: future, emerging and enabling.

The term "future technology" usually stands for technology which is in the early stages of research, many times just a vision or an idea that is expected to produce results in the longer term. As the BBC Science Focus Magazine writes, "floating farms, brain wave passwords, and coffee-powered cars are just some of the incredible inventions and innovations that will shape our future" [28].

Emerging technologies are "new technologies that are currently developing or will be developed in the next five to ten years, and which will substantially alter business and social environment" [29]. This term usually refers to technologies that already have or are expected to have a significant social and economic impact; the technologies whose development is ongoing and practical applications are still limited.

Enabling technology is "an invention or new innovation that can be applied to drive radical change in the capabilities of a user or culture. These are fast developing technologies that range in various fields" [30] as it was described at the beginning of this chapter.

For INNOSID project, the most important are emerging technologies. Considering social inclusion as a domain of application, it is assessed that the following emerging technologies play a significant role: Virtual Reality, Augmented Reality and Mixed Reality, Holography, Internet of Things, 5G, Artificial Intelligence, Robotics, and 3D printing. They are further elaborated in this report from various points of view.

All these technologies "belong" to ICT or are ICT-related and enabled – ICT is a generic term that encompasses many specific technologies. One need only recall that "Information and Communication Technology, abbreviated as ICT, covers all technical means used to handle information and aid communication. This includes both computer and network hardware, as well as their software" [31]. Furthermore, all these technologies have the potential to serve as a means for achieving the objectives of Sustainable Development Goals related to full inclusion and participation in society of people with disabilities. Innovative approaches are necessary if one wants to take a step closer to removing the barriers that lie ahead of an inclusive, sustainable and accessible society. Besides "traditional" social inclusion methods and practises, different methods and solutions for social inclusion of people with disabilities based on abovementioned emerging technologies are further elaborated in this report.

One can identify that the innovativeness of this report is determined by the fact that it is in close relation to the "emerging technologies" which are in its nature innovative. Besides that, it explores the potential of emerging technologies for improving the social inclusion of people with disabilities.

Since emerging technologies are often in an early stage of research and development, and their practical applications are still limited, especially in the domain of social inclusion, this report carries an added value for readers interested in the topic as not many (or any) similar studies can be found.

This report serves as a study, i.e. body of knowledge, related to emerging technologies and their application for improving the quality of life of people with disabilities. Given the topics addressed in this study, it is intended not only for the scientific audience but for the general public as well. Furthermore, it may be of special interest to students who want to pursue their education in the STEM field and become social innovators one day. Also, the study may encourage ICT professionals to have an impact on making the quality of life better for PWD by designing smart products which improve their social inclusion.

2

Emerging Technologies

This chapter focuses on emerging technologies [32], [33], but in order to get a clear picture, it is useful to first consider them from a broader perspective. Namely, something that was "future" yesterday, today may be "emerging", and tomorrow "enabling" – this is a characteristic of the technological scene.

Take the Internet, for example, where all three attributes intertwine. At the same time, the future of the Internet is being explored (research projects on Future Internet, Next Generation Internet, etc.), something is already emerging (Internet of Everything), and the Internet as it is, is an enabler for innumerable services and applications. The motivation for development comes not only from increasingly "better" hardware, software and networks – just as important are the user needs. Thus, the Internet Society has identified "Drivers of Change" (technological, economic, regulatory, security and network related challenges) and Impact Areas (Digital Divides; Personal Freedoms and Rights; and, Media, Culture and Society) important for the future of the Internet. Another, also illustrative, case are mobile networks: five generations in operation in 30 years, the 6th one in the laboratories. Looking at the Internet, the Internet of Things (IoT) can be defined as an emerging technology, while it is the fifth generation of mobile technologies (5G) for mobile networks. IoT and 5G are new technologies that are currently developing and implementing, which will affect society and the economy by influencing changes in many areas, including social inclusion.

There are technologies that have shown their potential in some specific applications, while they can be considered as emerging in others. It stands for technologies that are based on computer-generated images, i.e. Virtual Reality (VR), Augmented Reality (AR) and Mixed Reality (MR). Virtual characters, objects, scenes and worlds move from entertainment (e.g. computer games, films and shows) to education, healthcare, industry and other domains, including solutions for people with disabilities helping them in social inclusion.

Holography, also from a group of visualization methods, was invented in the 1960s (Dennis Gabor, the Nobel Prize in Physics for his invention and development of the holographic method (1971)). Holography is a scientific discipline in the field of optics that made it possible to record three-dimensional light fields and reproduce them with all the features of the original object or scene (Photo lenses create a two-dimensional image!). Computer-generated holography is a method and technology for recording (original object or scene), creating (artificial object or scene), and presenting holograms. Holograms can be presented or printed on a suitable surface (2D) or reproduced on a three-dimensional display (3D). Holograms (can) extend the capabilities of computer-generated applications (entertainment), or expand them (learning and training), but also open some quite new ones (communication). Much more research is needed, especially in the field of social inclusion.

Many improvements and entirely new possibilities are made possible by the application of artificial intelligence and machine learning as a specific set of algorithms. Artificial intelligence (AI) "refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)." [34]. Machine learning (ML) as a part of AI is characterized by algorithms that learn from data, create models and apply them to new data in order to infer, recognize, predict or decide for the purpose of solving the problems they are intended for. Artificial intelligence is not a visible or palpable artefact, it is hidden behind software and hardware products, however, in some applications its effects are noticeable (e.g. recommendations based on previous experience), but some solutions are not even possible without it (e.g. autonomous driving). Many existing applications and services for people with disabilities can be significantly improved by using artificial intelligence for personalisation, automatic adaptation to specific needs and operational simplification. Many new ones are in use, and many more will be coming.

All the emerging technologies that have been treated so far have not been presented as machines or machines been required for their operation. The next two, robotics and 3D printing deal with machines, robots and 3D printers – their manifestations are in the physical world.

According to Encyclopedia Britannica: "Robot is any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner. By extension, robotics is the engineering discipline dealing with the design, construction, and operation of robots.”. The use of robots to assist people with physical disabilities and the elderly is well known. Humanoid robots play a role in the therapeutic treatment and education of children with autism spectrum disorders.

The 3D printing produces an object from its computer model successively adding material layer by layer. Some examples of use in the context of social inclusion are as follows: 3D printing of health care devices and items for people with disabilities, 3D printing of tactile versions of reading materials (Braille), artistic paintings, picture books and other for visually impaired people, and people with neurological problems where tactile sensing can help.

The technologies discussed here are not the only emergent technologies; there are more in the information world – virtual world (e.g. blockchain, cryptocurrencies) and the physical world (e.g. nanotechnology, smart materials, hydrogen technology, gene technology). Future technologies will offer new opportunities for human-machine interaction.

Many of today's solutions are based on multiple technologies; a good example is wearable device domain: from smartwatches and smartphone-based sensors to devices for monitoring physiological data and Medical Internet of Things. It is not difficult to see more technologies, each with its function: Internet of Things (sensing, collecting and communicating data), 5G (real-time networking), artificial intelligence and machine learning (data analysis, patterns and (ir)regularities recognition, reminding and alerting). In the future, there will be more and more solutions based on the “technology mix”.

It is evident that interdisciplinary, multidisciplinary and transdisciplinary research, involving ethics and privacy issues, is increasingly important.

This chapter deals with selected emerging technologies, as follows: Virtual Reality; Augmented Reality; Mixed reality; Holography; Internet of Things, 5G; Artificial Intelligence; Robotics; 3D printing.

2.1 Virtual Reality (VR)

There are several definitions of virtual reality (VR) depending on how precise the description of this technology is. According to a simple definition, VR can be considered as an artificial digital environment that completely replaces the real world. It provides a simulated experience for the user that can be similar to or completely different from the real-world. The two most frequent application fields of virtual reality are entertainment (i.e. video games) and education (i.e. medical, industrial or military training).

Generally, standard virtual reality systems require either virtual reality headsets or multi-projected environments to generate realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment (Figure 2-1). A person using virtual reality equipment can have different experiences in the artificial environment such as visual impression, the opportunity to look or move around, and interaction with virtual features or items. VR headsets consist of a head-mounted display with a small screen in front of the eyes, but they can also be created using specially designed rooms with multiple large screens. Virtual reality typically incorporates auditory and video feedback but may also allow other types of sensory and force feedback through haptic technology.

Figure 2-1 iMotion is a motion controller that creates haptic feedback by hand-and-arm interactions through a “virtual touchscreen” [35]

Jacobson suggests to classify virtual reality in the following way: immersive virtual reality; desktop virtual reality (i.e., low-cost homebrew virtual reality); projection virtual reality; and simulation virtual reality [36]. If we accept this classification, there are countless fields in which VR can be applied. The next section introduces some interesting applications and use cases involving VR technology.

Relaxing patients with medical VR

The anxiety of patients at a hospital or during medical treatment is not only uncomfortable but often interferes with the activity of a physician who is required to focus on conducting the treatment. The fear of being in pain and the unknown outcome of the upcoming procedures also discourages patients from attending the doctor's office. Applying VR can be an appropriate solution in helping patients (including children) relax and suffer to a lesser extent in such situations.

Researchers in the UK have done an experiment involving 80 people who needed their cavity filled or a tooth pulled. Three groups were created: two groups that could explore a beach or navigate a city with VR headsets, while the third group was the control one. Everyone in the study got pain medications or sedation if necessary. Patients were surveyed both immediately after their appointments, and a week later. Researchers found that the people that immersed in the coastal VR reported less stress and pain than the rest who were either navigating through the virtual cityscape or the ones in the control group [37].

Figure 2-2 The virtual coastal environment [37]; a child at the dentist [38]

Similar results were obtained at the St George's Hospital in London, where patients undergoing surgery had the option to use VR headset prior to and during their operation, which improved their overall hospital experience. Other studies with patients suffering from gastrointestinal, cardiac, neurological and post-surgical pain have shown a decline in their pain levels when using VR to distract them from painful stimuli.

VR in improving clinical skills

Applying VR in teaching and learning is not a dream anymore. In medical programs, a range of manipulative clinical skills can be practiced through the use of haptics (sense of touch), such as tooth drilling, needle insertion, bone surgery, and instrumentation for gum diseases [39], [40]. A good example is HapTEL – an award-winning robotic project in dentistry that enables students to learn practical dental procedures in virtual reality. The near realistic systems replace older traditional manikins enabling the student to see an anatomical mouth in 3D, feel the different layers of the tooth when drilling, and hear the dental drill. The dental drill is placed on a robotic arm, and stereoscopic screens produce the 3D image [41].

Figure 2-3 HapTEL equipment [41]

Stanford Medicine introduced the usage of a new software system that creates a 3D model by combining MRI (Magnetic Resonance Imaging) and CT (Computed Tomography) images. The model can be used to help the patients understand their illness, steps of their surgery, the cause for their condition, and even to reassure them.

Furthermore, the models can be manipulated as well, just like it would be in a virtual reality game. This special environment developed by a Colorado start-up Surgical Theatre helps train residents and assist surgeons in planning the upcoming operations (Figure 2-4).

The three-dimensional representation of the imagery eases surgeons' planning and improves the accuracy of the surgery, with the aim of producing safer procedures. According to the news from 2017, Stanford Medicine doctors have used the VR technology mainly for the brain and spinal cord because these organs are stable and lend themselves to imagery — unlike other body parts, which move with blood flow and breathing [42].

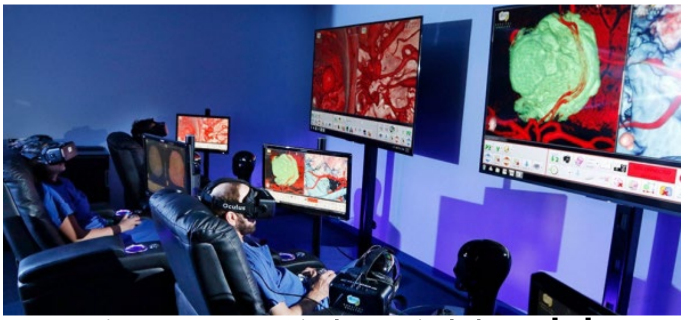


Figure 2-4 Doctors in the Surgical Theatre [42]

A special VR-based learning framework

A complete VR based study platform called MaxWhere is also available for innovative educators who would like to improve the effectiveness of their teaching over the classical tools of e-learning. Besides serving visualization purposes, MaxWhere's strength lies in its ability to present complete electronic notes on smart slides in 3D space. Through MaxWhere, a powerful combination of interactive 3D visualization, working environments fit to specific workflows and e-learning can be achieved without the need of wearing special glasses [40].

Figure 2-5 The virtual space developed with MaxWhere for a course Digital dentistry at the University of Debrecen

Another study has found that people have a better memory of an image if it is inserted directly into a 3D virtual space than if it is inserted into a webpage [43].

2.2 Augmented Reality (AR)

Augmented reality (AR) is the blending of computer-generated perceptual information into real-world environments. The basic idea of AR is to superimpose graphics, audio and other sensory enhancements over a real-world environment in real-time blurring the lines of reality (Figure 2-6).

In most cases, smartphones or tablets provide the primary platform creating the popular opinion that AR should be used only for entertainment. The majority of people have already heard about Pokemon Go (a popular AR game for mobile phones), the Google SkyMap may sound familiar as well (an application that overlays the information about constellations, planets and more as you point the camera of your smartphone or tablet toward the sky). According to a Statista report, the AR market across the globe is predicted to nurture from 6 billion to 198 billion U.S. dollars by the year 2025. Next section will demonstrate that this technology can be applied in many different aspects, from business or warfare to medicine, proving that the possibilities of AR tech are limitless [44].

Figure 2-6 Superimposed information in an AR app [45]

AR-enabled bus stop display

Recently, commuting Londoners' day is made more fun with an AR-enabled bus stop display. Travellers were rather surprised when they were shown, for example, a prowling tiger, a meteor crashing, or an alien tentacle grabbing people off the street (Pogreška! Izvor reference nije pronađen.). The only goal of the project was to give the commuters an unbelievable, fun experience [46].

Figure 2-7 The transparent wall of the bus shelter with the superimposed images [46]

AR in the US Army

The United States Army gives its soldiers an improved situational awareness with the use of AR technology. The innovative solution, called "Tactical Augmented Reality" (TAR), is essentially an eyepiece that helps soldiers precisely locate their positions as well as the locations of others — both friend and foe.

According to the experts, TAR will one day replace night-vision goggles, as it enables soldiers to see in the dark. The handheld GPS system that soldiers carry today to approximate their positions can become obsolete as well. The eyepiece is connected wirelessly to a tablet that soldiers wear on their waist. If a soldier is pointing his or her weapon, the image of the target, plus other details, such as the distance to the target, can be seen through the eyepiece [46].

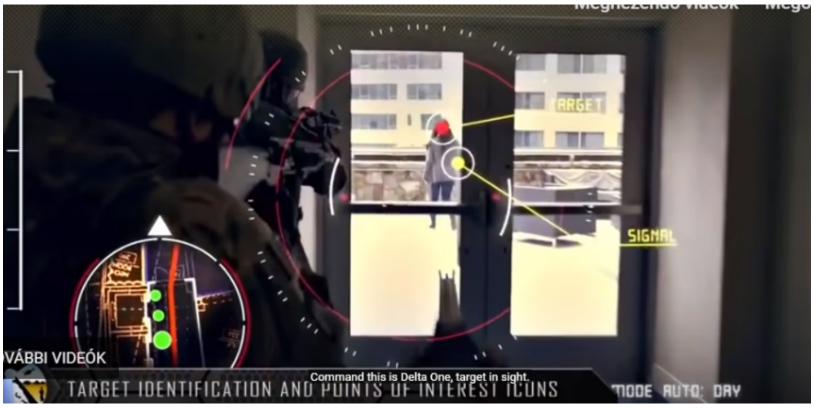


Figure 2-8 Superimposed additional information [47]

Tourism supported by Augmented Reality

Sightseeing and tourism industries are ideal application areas for augmented reality. The typical process is to augment a live view of displays in a museum with facts and figures about the art or history exhibits. The sightseeing can be enhanced in a similar way: tourists can use their smartphones' camera to see facts, figures and additional information presented live as an overlay on their screen. These applications use GPS and image recognition technology to look up data from an online database. In addition to information about a historic site, there are applications that look back in history and show how the location looked like 10, 50 or even 100 years ago. Many people experience difficulties in travelling to a foreign destination without having a tour guide. However, with AR technology, smartphones can represent the translated information into a language the user selects [48].

Reducing perceived waiting time

Visiting theme parks is usually very attractive for families but could be very unpleasant when people get frustrated due to being stuck in queues. A brand new application has been recently developed, an augmented reality game to be played in the theme park's queue, and an in-the-wild study using log data and interviews demonstrated that every minute playing the game was perceived to the same extent of about 5 minutes of not playing.


Figure 2-9 Prototype queue game [49]

The game is designed for Android or Apple smartphones. A person standing in the queue, holding a smartphone in hand can point the camera towards the special AR markers that are placed on the sides of the queue every few meters. While scanning a marker, an AR 'portal' opens above the marker and can be seen through the mobile device's screen. The game starts by generating enemies, and the queue members' task is to (individually or in a group) tap on the screen to destroy enough enemies before the portal closes again. The game gradually intensifies with more and stronger enemies [49].

Investments in VR and AR

According to International Data Corporation (IDC), in 2020, 18.8 billion dollars are estimated to be ready for investing in augmented and virtual reality technologies. They estimate that, in 2020, China will spend the highest budget for these emerging technologies, reaching about 5.8 billion. The United States follow China, with 5.1 billion dollars and Western Europe with 3.3 billion dollars [50].

Regarding medical applications, these technologies have been used to curb anxiety by simulating phobias in a safe, virtual environment. The review from [51] explored the differences between VR exposure-based therapy (VRET) and AR exposure-based therapy (ARET). Although AR has proven itself to be a medium through which individuals suffering from specific phobia can be exposed "safely" to the objects of their fear, without the costs associated with developing complete virtual environments, for some more advantageous exposure-based therapies, it may be said that the use of VRET is more appropriate.

Furthermore, according to a report by Reports and Data, the investment of AR and VR in the healthcare domain might reach 7.05 billion dollars by 2026. With the adoption of some AR/VR solutions in this domain, the healthcare industry has transformed. Besides the constant ICT advancement, innovative diagnostic techniques, neurological disorders, and increased disease awareness are also recognized as a significant factor stimulating market demand [52].

2.3 Mixed Reality (MR)

Mixed reality (MR) is a combination of real and virtual worlds in order to produce new environments and visualizations, where physical and digital objects co-exist and interact in real-time. Mixed reality merges VR and AR by overlaying images or videos over a screen showing reality through a mobile camera, smart glasses or a headset. A mixed-reality experience is enabled by wearable MR devices and involves either the real world or a fully virtual world. The ability to interact with both physical and virtual objects gives mixed reality technologies a huge number of potential applications – for example in schools, colleges, and hospitals, in industry or in retail departments like e-commerce and fashion [53].

This technology is still not as widely available as separate VR and AR devices or software, although there are some real-world examples of mixed reality technologies in use today. Currently, one of the most popular MR devices is HoloLens 2 from Microsoft, a wearable holographic computer (Figure 2-10). The mixed reality on HoloLens 2 combines an untethered device with apps and solutions that help people across a business to learn, communicate, and collaborate more effectively.

Figure 2-10 HoloLens 2 from Microsoft [54]

Next sections demonstrate some MR applications, although it has to be noted, that the concepts of AR and MR are often merged or are improperly used as synonyms. AR is an experience where virtual objects are superimposed onto the real-world environment via smartphones, tablets, heads-up displays, or AR glasses, while MR is already a step forward in the digital revolution because the virtual objects are not only placed in the real world, but they can be interacted with and they respond as if they were real objects. Unlike augmented reality, users can interact with virtual objects in mixed reality [55].

MR in orthopaedic surgery

As VR and AR have lots of applications in medicine, the potential of applying MR is also remarkable. The collaboration of innovative high-tech technologies promises extra benefits for humans; that is why it focuses on research teams. According to a publication of a Chinese medical team from 2019, the first case of combining MR and 3D printing technology was in total hip replacement. They proposed a new method for real-time automatic registration of MR technology combined with 3D printing technology, which provides favourable conditions for better application of MR technology in clinical medicine [56]. The potential for mixed reality applications in healthcare and medicine cannot be overstated. Aside from pre-procedural planning and enhanced visualization during critical surgeries, medical education, and healthcare can also benefit from MR.

Entertainment

There are several companies like Magic Leap, Lucasfilm, and Industrial Light and Magic who are looking to delve into mixed reality entertainment. Magic Leap uses a special effect called Dynamic Digitised Lightfield Signal to make MR. This tech projects images directly into the eye, without the need for it to bounce off an object (Figure 2-11) tricking the brain into thinking the object is there when in reality, it is just a projection [53].

Figure 2-11 An example of Magic Leap in use [57]

Mixed reality start-up 8i created a lifelike hologram of John Hamm for the Sundance Film Festival and a Buzz Aldrin hologram for SXSW (South by Southwest – Annual conglomeration of parallel film, interactive media, and music festivals and conferences organized jointly that take place in mid-March in Austin, Texas, USA). Their app called Holo is expected to make many more applications for musicians, brands and celebrities. The Holo app can be downloaded to your phone to create your own 3D animations [58].

Education

Several mixed-reality applications seem to be of use in education to help students learn through interaction with virtual objects. Teachers can instruct students remotely by using 3D projections and simulations. The Microsoft HoloLens was used by Case Western Reserve University in Ohio to teach anatomy to medical students [31].

Figure 2-12 HoloAnatomy app at Case Western Reserve University [59]

2.4 Holography

Introduction and general description

Holographic projection is a promising emerging technology that will bring major changes in many different fields such as education, medicine, science, etc. To explain how holographic projection works, it is necessary to define a hologram. The hologram is a physical recording of an interference pattern which uses diffraction to reproduce a three-dimensional light field, resulting in an image which retains the depth, parallax and other properties of the original scene [60]. There are three types of holograms: reflection, transmission and hybrid holograms [61]. Reflection holograms are the most common type in which the hologram is illuminated by a "spot" of white incandescent light, held at a specific angle and distance which is located on the viewer's side of the hologram. The typical transmission hologram is viewed with laser light. Light is directed from behind the hologram, and the image is transmitted to the observer's side. The image can be very sharp and deep. Hybrid holograms include every type of hologram ranging from reflection to transmission types.

Holograms in education

Analysis of the usage of holograms in education [62] has shown that holograms have a positive effect on students' cognitive development. Holographic projections hold students' attention because they allow an object to be studied from different angles which indirectly results in an increased understanding of the subject's material. This is why some suggest the use of the pyramidal holograms for educational purposes [63]. The pyramid would be made of glass or any other transparent, solid material, and the base would be made of a reflective surface (Figure 2-13). It would be placed on a screen of smartphone or tablet device and display the hologram. Smartphone screen displays a three-dimensional object whose reflection bounces off the mirror base, and the object is seen as a hologram. In addition to holograms, some also suggest using *Hand Gesture Control* which would allow users to interact with the holograms and therefore utilize the full potential of this technology.

Figure 2-13 Example of pyramidal hologram

Holograms in medicine

Holograms have found their application in medicine where magnetic resonance images and computed tomography are presented and displayed in three dimensions. Research conducted among physicians who use holograms [64] has shown that this enhanced visualization enables faster learning, more accurate interpretation of images and faster emergency response.

The simple application presented in [65] displays heart rate using a pyramidal hologram. Information about heart rate was collected using sensors embedded in the smartphone camera that measures the pulse using photoplethysmography. Photoplethysmography is a simple optical method that can detect changes in blood volume. The relevance of this information is checked using a specific algorithm [65]. As the end product, users can see a simulation of their own heartbeat (Figure 2-14).

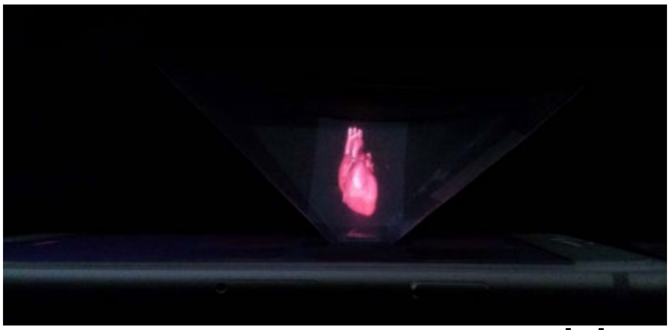


Figure 2-14 Pyramidal holograms in application [65]

Holographic interfaces

Three-dimensional (3D) displays by light-ray reproduction, or so-called light-field 3D displays, and holographic 3D displays reproduce real or virtual 3D images and allow 3D perception with all the depth cue of human vision. One of the promising applications of such 3D displays is a 3D human interface. A user can directly interact with the reproduced 3D images, which provides a rich and appealing experience, and that is promising as a next-generation interface scheme. The preliminary results of the experiment and example of three-dimensional interfaces are presented in [66].

Authors have created a holographic screen which allows users to interact directly with the hologram. In the experiment, the focus was on functional testing, so users had to choose between two answers like "y" and "n" (Figure 2-15). In comparison to traditional interfaces, holographic user interfaces have proven their worth. The study showed that the participants found the holographic interfaces more attractive and more natural to use.

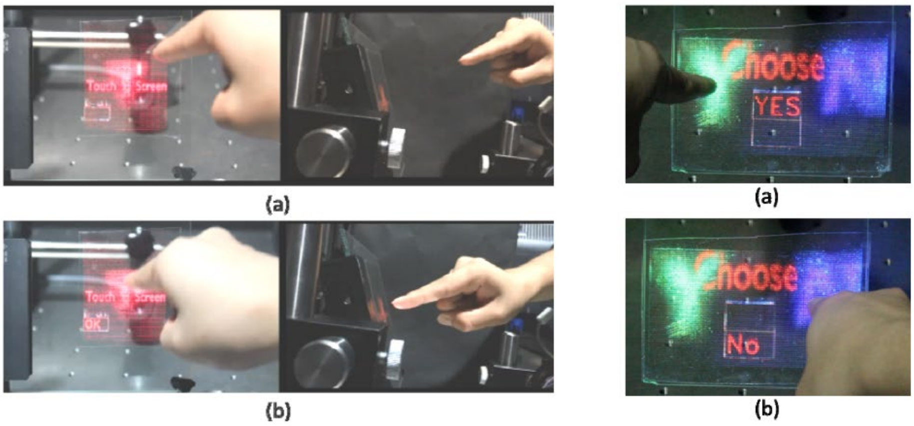


Figure 2-15 Holographic interface [66]

Holograms represent one of the emerging technologies which have proven to be both attractive and useful. So far, no research has been conducted to show how this technology can help people with disabilities or how accessibility can be realized on holographic interfaces. Therefore, the applicability and potential of this technology for the purpose of raising the quality of life of people with disabilities is yet to be researched as well as the ways in which accessibility can be implemented into holograms.

Hologram workshop

The University of Dubrovnik in cooperation with Informatics club Futura has organized a workshop where students had to make pyramidal holograms and implement scaled-up interactive holographic interfaces which were used for playing games, watching videos or making custom holograms. The whole workshop's agenda is available online in the form of a tutorial[3]. The workshop was conducted in Croatian and adjusted to the students' needs.

The first workshop was held as a part of the course Ergonomics of Computer Equipment. The course is held in the first year of the graduate study Applied/Business Computing. The participants of the second workshop were the last year of elementary school students, and the workshop was a part of their Informatics course (Figure 2-16).


Figure 2-16 Hologram workshop with elementary school students

Students were asked to fill out a short survey about their experience with holograms and test applications from the workshop. The first 6 questions were regarding personal information (e.g. which school there were

[3] https://www.instructables.com/id/Interactive-Holograms/

attending, what year, etc.). The rest of the questions were regarding holographic technology and application testing.

The first holography related question was about the students' knowledge of holograms and projections prior to the workshop (Figure 2-17). 41,5% of the students claimed that they have never heard about it or they have only just heard about it, while 59.1% of them had enough information to understand the presentation materials. None of the students was well acquainted with the topic prior to the workshop.

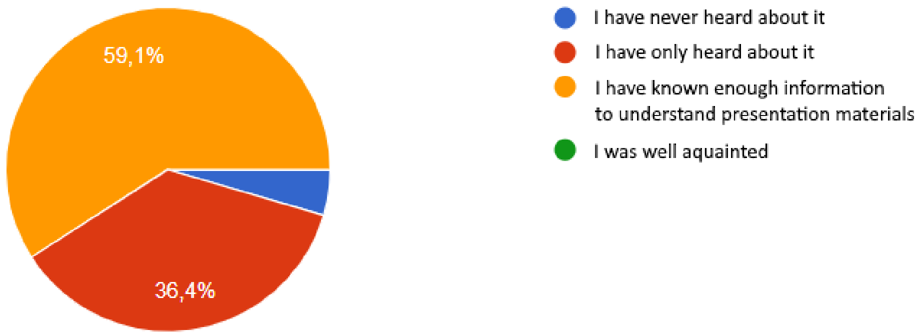


Figure 2-17 Students' answers on their knowledge on holograms and projections prior to the workshop

Next, students were asked whether the holographic pyramid was hard to make. They could rate the experience from 1 to 5, where 1 means that it was easy to make while 5 means it is extremely difficult. 81.8% of them answered that it was easy or fairly easy to construct the holographic pyramid.

One of the questions was where they could see the use of holograms and holographic technology in everyday life. The most common answers were that students had seen it as a helpful tool in science class or at museums.

2.5 Internet of Things (IoT)

Internet of Things (IoT) is defined as a global infrastructure for the information society, which enables advanced services by interconnecting things (virtual and physical) using existing technologies[4].

IoT is a term used to encompass all devices, i.e., things, that have a unique identifier and are connected to the Internet. The main characteristics of such devices are that they are capable of communicating using a specific software – IoT platform and transmit data over the network. The so-called things operate as sensing devices or actuators. Sensing devices have sensors for measuring some physical phenomena, and they can be equipped with processors for basic data manipulation. Actuators are capable of performing certain actions in the environment they are located in. They all must be secured since the data generated or used on those devices should be consistent and immutable.

IoT has a wide area of use, from smart homes (houses that are equipped with the interconnected devices that can be accessed remotely from anywhere over the Internet using any kind of a network device) providing the inhabitants with assisted home management, enabling maintenance of good health, and allowing inhabitants to be independent (in case of people with disabilities, the elderly, etc.) [67], all the way to the agricultural sensing in the fields. Since IoT devices should be operative without human input for a long period of time, e.g., various sensors deployed over a wide area, they use multiple techniques to conserve energy. The most important to consider, regarding energy consumption, is the communication protocol used for transmitting data. Nowadays, most of the IoT devices use one of the following protocols:

[4] https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

- Bluetooth Low-Energy (BLE), branded as Bluetooth Smart having the same capabilities as standard Bluetooth technology with significantly reduced power consumption [68], due to the lower range
- Zigbee, most commonly used to establish a network of sensors, i.e., ad-hoc network without an Internet connection, with extremely low power consumption and simple interconnection of everything [69], and
- LoRaWAN (Long Range Low Power Wide-Area Network) that uses licence free radio frequency for communication between all the devices [70].

Besides choosing the right protocol for communication, it is important to decide how to implement it. The most energy-consuming tasks in the IoT architecture are sending data and acting based on the data received. Devices can be divided into two categories:

- sensors or transducers, which convert physical phenomena into electrical impulses, and
- actuators, devices that convert electrical impulses gained from sensors into physical phenomena - action.

An example of an IoT solution for detecting fire in early stages is depicted in Figure 2-18. IoT devices serve as a detection tool for environmental parameters, i.e., temperature, humidity, light intensity, and smoke. Using advanced machine learning techniques and neural networks, possible fire is detected. To confirm this statement, image processing is performed. Image is provided from another set of IoT devices, digital cameras. If the detected fire is confirmed, than the warning message can be sent and processed in the early stages of forest fires [71].

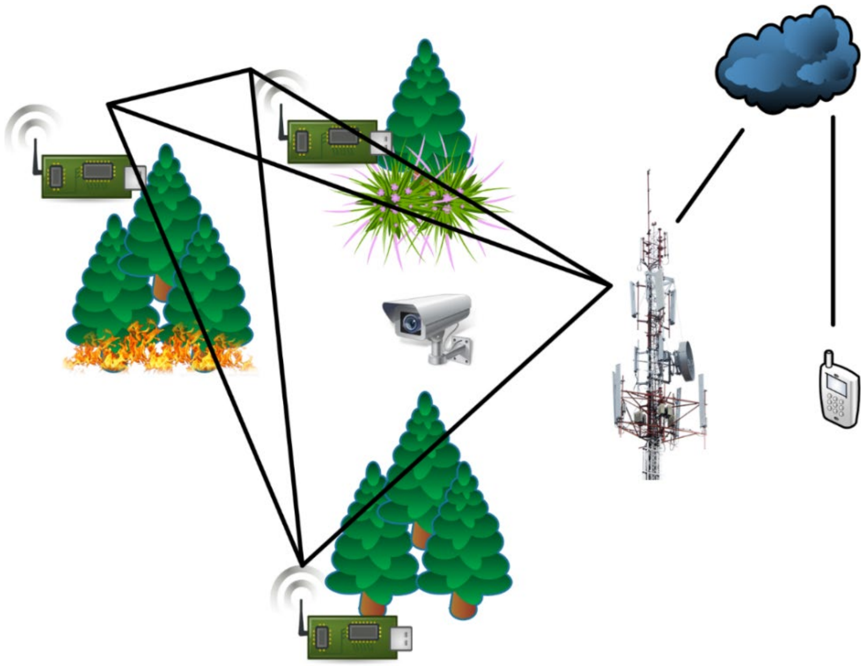


Figure 2-18 Early forest fire detection methodology

The other example of IoT technology is massive sensing in the real world. For example, air quality sensing throughout the city where numerous sensors measure various air quality properties and upload them to the cloud-based systems for further use and/or analysis. There can be thousands of sensors deployed that need to conserve energy for a long period of time, since those sensors can be scattered and disposable. As mentioned before, sending the data over any kind of technology is often more power-consuming than sensing itself. Therefore, there are a couple of methods to conserve energy while maintaining full sensing efficiency.

One of the most commonly used methods is to aggregate data and propagate it among the devices, using a network, all the way to the gateway that is connected to the Internet and has a reliable source of power (Figure 2-19), while the other method includes sensing the data and only informing the other devices if the next measured value is different than the previous.

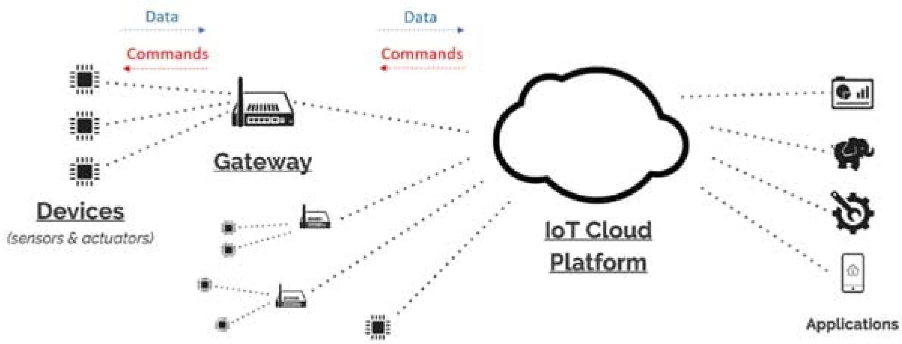


Figure 2-19 IoT ecosystem layers (retrieved from [72])

Internet of Things is the concept that will become ever more important now since there are more than 20 billion devices connected to the Internet, and the forecast is that by the year 2026, there will be more than 30 billion “things”, as depicted in Figure 2-20 [73].

	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	16	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	10%

Figure 2-20 Connected devices in billions (retrieved from [73])

Crowdsensing ecosystem as a middleware for the IoT

Researchers from the University of Zagreb have designed and implemented IoT middleware for *Mobile Crowd Sensing* (MCS). The main idea behinds MCS is that sensors and mobile devices jointly collect and share data while covering a large geographical area. The ecosystem for mobile crowdsensing relies on a cloud-based publish-subscribe middleware (CUPUS) to acquire data from the devices, as well as to process data streams in real-time. What separates this innovative solution from the rest, is the capability to manage mobile resources within the cloud, support for filtering and aggregation of data before transmission, and real-time data push to user devices. This solution was used to assess the quality of air in the city of Zagreb; multiple participants walked all over the town with specific sensors for monitoring the air quality. Data from those sensors was aggregated in the cloud, and the developed Web application in nearly real-time presented the air quality [74].

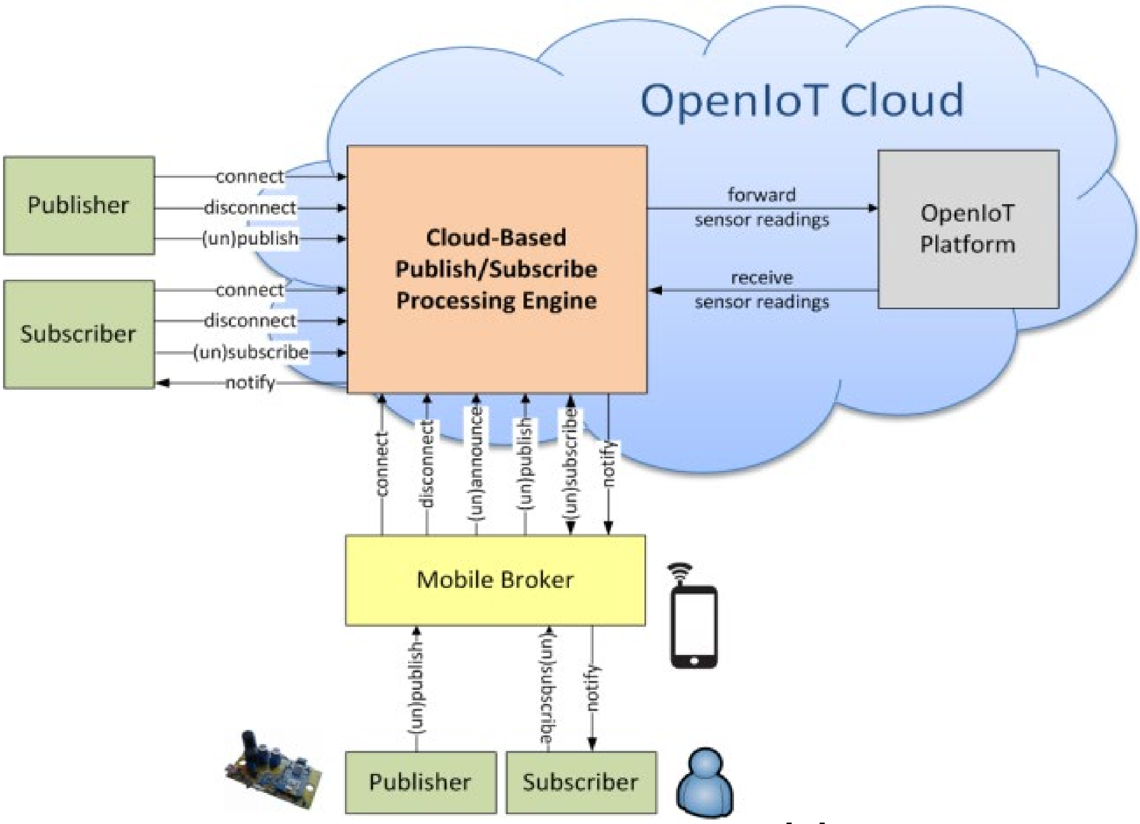


Figure 2-21 CUPUS high level architecture [75]

Remote room management

Another interesting IoT use case is remote room management. Authors of this idea developed a framework for remote classrooms management on a college campus.

There are two critical devices in this system, the receiver/transmitter device, and the near field communication (NFC) card. The receiver device receives the data from the NFC, i.e., when a student enters the classroom, he/she uses the NFC card to log their presence in the classroom, and transmits that data to the cloud so that various applications, e.g. monitoring the classroom capacity or monitoring who entered the room, can use that data. In this study, a map of a college campus in Spain, generated on the Web application, is marked with the information about the classroom availability. This data is also connected with social network services using its API, e.g., Twitter, Google Maps, or Facebook [76].

Figure 2-22 Map of the campus with classroom availability info [76]

Smart parking system

Nowadays, *smart cities* have gained increased interest from the perspective of both research community, as well as the industry. Smart cities are cities equipped with a lot of IoT devices that gather all kinds of data, and actuators that can perform various actions based on the data analysis, e.g., turning the streetlamps on and off.

One of the interesting concepts of smart cities is smart parking lots and smart parking garages. Researchers [77] have developed a framework based on the IoT concept for managing one of those parking lots. Each parking space is equipped with a sensor that detects if space is occupied or not. Each user can also state, using a mobile application, how long he/she intends to stay on the parking lot, as well as reserve an available spot in advance. High-level overview of the system is depicted in Figure 2-23. This system can significantly lower the congestion on parking lots and in parking garages around the city and provide easier access to free parking spaces.

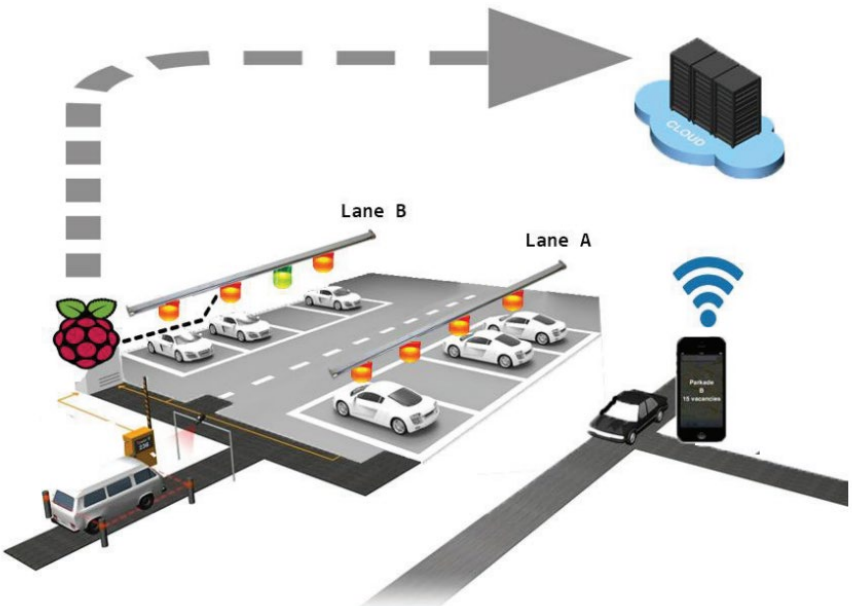


Figure 2-23 Smart parking lot high-level architecture [77]

2.6 5G networks

History and 5G network deployment

Even though mobile technology itself is not an emerging one, by considering the latest developments in the mobile network industry, it seems it will become a disruptive force with a potentially great impact.

To begin with, a public mobile network is a radio network distributed over land through cells. Each cell has fixed-location transceiver, known as the base station, and each cell uses a set of frequencies different from the neighbouring cells to avoid interference [78]. Together, these cells provide radio coverage over larger geographical areas so that the user equipment (UE), such as mobile phones, can communicate even if the UE is moving through cells during transmission.

Early mobile telephony was far off from the pocket-sized devices in use today. During the 1950's it was synonymous with car phones or voice communication over a mobile radio in a car. Interestingly, this mobile telephony radio equipment weighed more than 40 kg and was designed only with installation in the trunk of a vehicle in mind [79].

Later, the first commercially automated mobile network (1G, Japan, 1979) was designed to provide voice services only, however, being unreliable and having low capacity 1G networks were soon replaced with second generation (2G) networks (Finland, 1991) [78], [80]. Unlike 1G networks, 2G employed all-digital transmission technologies for both control signalling[5] and data traffic providing the grounds for the world's first text message to be sent on the 3rd of December, 1992 [82]. The Short Message Service (SMS), simply reading "Merry Christmas", was sent from a computer to a mobile phone [83]. Digital transmission brought a series of important features such as: a more secure communication thanks to support for advanced source and channel coding, more efficient spectrum utilization and a higher degree of resistance against interference and channel fading [82].

With the establishment of the Third Generation Partnership Project (3GPP) in 1998, a step forward has been made to utilize mobile networks as a *global* standard from 3G and beyond. The adoption of 3G networks (Japan, 2001) allowed operators to offer services like video calls, wide-area wireless voice telephone and sending/acquiring information and data via wireless access [80], [84]. Unlike 2G networks, 3G networks allowed UE to authenticate the network it is attaching to so that the user can be sure the network is not an impersonator. Furthermore, it provided a high Quality of Service[6] (especially voice quality) and low-cost devices thanks to global standards [84].

3G networks were soon outshined by 4G (Finland, 2009) ensuring faster Internet connection and lower latency. 4G networks focus on integrating existing wireless technologies and developing new standards and hardware. They provide mobile ultra-broadband Internet access, for example to laptops, wireless modem, smartphones and to other mobile devices. Possible applications include gaming services, high-definition mobile TV, video conferencing and 3D TV [80]. Evolution of mobile networks from the first to the fourth generation is shown in Figure 2-24.

[5] Signaling process of transferring control information such as address, call supervision, or other connection information between communication equipment and other equipment or systems [81].

[6] Quality of Service (QoS) in mobile networks is defined as the capability of the mobile service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications etc. [84].

Figure 2-24 The first generation mobile network (1G) was all about voice. 2G was about voice and texting; 3G was about voice, texting, and data; 4G was everything in 3G but faster (source: https://www.pinterest.com/pin/120541727502717698/).

In 2016 the European Commission launched the 5G Action Plan to boost EU efforts for the deployment of 5G infrastructures and services. At mid-September 2018 European operators were heavily involved with 114 trials reported in EU-28[7] countries. In June 2018 first commercially available 5G network was launched in Finland (Tampere) and Estonia (Tallin) [85].

5G is a very hot topic worldwide, in May 2018, Qatar claimed to be the first world player to launch 5G nationally with 50 sites registered in July 2018 and 50 additional base stations to be added in August 2018 [86]. On the 1st October 2018, 5G Home service was launched in limited areas of four US cities. The launch of the first commercial standard-based mobile 5G network in the US was announced on the 21st December 2018 [86]. In February 2018, using the Winter Olympics as a stage, South Korea displayed the 5G innovation offering a 4K streaming video service [86].

In December 2019, 181 5G trials were listed in the European Union. This number goes up to 222 trials if Russia, San Marino, Norway, Turkey and Switzerland are included [87]. A variety of experiments with 5G technology has been conducted. In Switzerland it was tested with VR, 360° live video and 4K video streams and recent tests in Finland have achieved the 1 Gbit/s rate [87].

According to the European 5G Observatory's Quarterly Report 7 (up to March 2020), ten EU Member States (and the UK) now enjoy 5G services: Austria, Finland, Germany, Hungary, Ireland, Italy, Latvia, Romania and Spain [88]. It is estimated there are close to 25 commercial 5G services worldwide. 5G devices were available quite early in 2019, and there are 199 devices available. Specific European cities announced their plans to become 5G Trial Cities. According to the report, it is estimated there are 147 5G enabled European cities (the list is available in the report) [88]. Figure 2-25 shows the 5G network releases worldwide (commercially available, limited availability and pre-releases).

[7] https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:EU_enlargements

Figure 2-25 The Ookla 5G map that track 5G rollouts in cities across the globe [89]

The exceptional circumstances caused by Covid-19 pandemic have forced some countries in Europe to postpone 5G auctions scheduled in the first months in 2020. Austria, France, Spain and Portugal had postponed it, while in Hungary the 5G spectrum auction was upheld and took place just one day before tight restrictions in activities and movements were imposed due to the pandemic [90].

2019 was the year of the first 5G launches in advanced mobile markets (Australia, Austria, Finland, Italy, Qatar, South Korea, Spain, Switzerland, UK, USA, and more to come). 2020 will also see quite a few 5G launches. Figure 2-26 shows estimates for 2020-2025. In order to understand Figure 2-26, one should now that full 5G System includes:

- eMBB (enhanced Mobile Broadband)
- URLLC (Ultra Reliable Low Latency Communications)
- mMTC (massive Machine Type Communications)

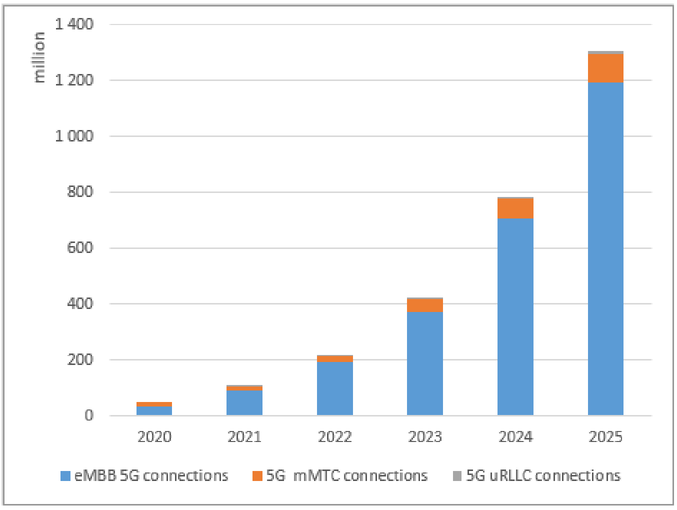


Figure 2-26 Estimates for 5G network, 2020-2025

5G adoption

At the end of 2019 most extensive 5G population coverage was in the US, China, South Korea and Switzerland and the global coverage was around 5%. Early 5G networks were deployed in dense urban areas, in larger cities. Until June 2020, there have been more than 75 5G commercial launches across the world and this number is expected to increase to 200 by the end of 2020 making it the fastest-growing generation of wireless mobile technology [91], [92]. It is predicted that in 2025, 5G networks will carry nearly half of the total mobile connections in Developed Asia in 2025 (Figure 2-27) [93].

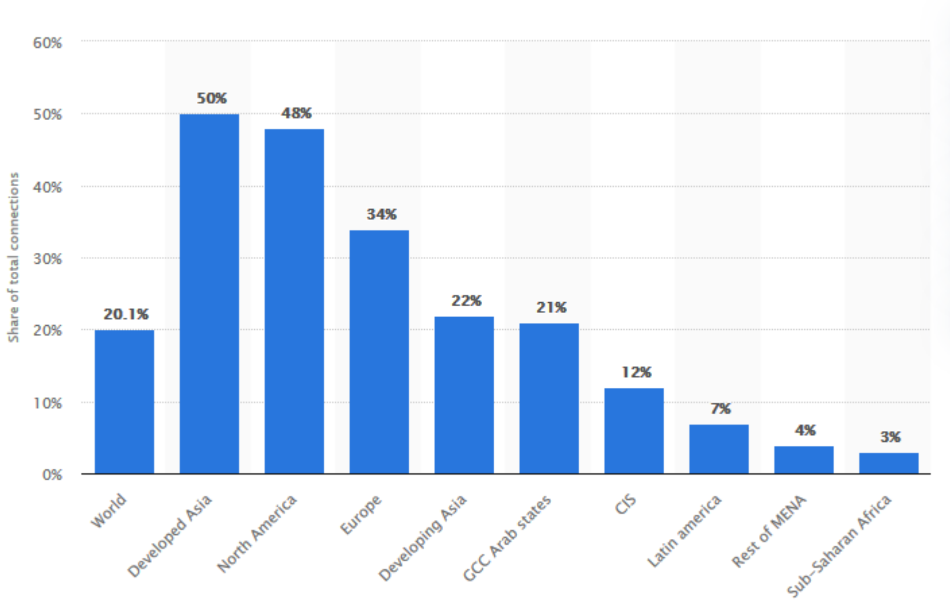


Figure 2-27 Forecast 5G share of total mobile connections in 2025, by region [93]

5G specifications

The emerging fifth generation networks (5G) are expected to outperform current technology by providing data at a speed of several hundred gigabits per second. From a peak speed perspective, 5G is 20 times faster than 4G which means that one could download close to ten applications using 5G network before 4G could deliver even just the first half of one [94].

Fifth generation networks are also supposed to answer the demand for low latency and high reliability, thus enhancing traditional mobile broadband while serving applications having demanding requirements [95]. Figure 2-288 shows some of the possible applications of the 5G network. When considering low latency, 5G brings latency to only 5 milliseconds which, comparing to previous 20 milliseconds latency, makes a difference of 15 milliseconds – or a time it takes a hummingbird to beat its wings. To understand how big of a difference this makes, consider the following: it takes at least 20 milliseconds before your brain registers something you see on the screen, but it takes, even more, to understand and decide how to react. The benefits of lower latency are obvious in many areas for example for autonomous vehicles where reaction time is crucial for the safety of people in traffic, in manufacturing low-latency edge computing could be used to transmit supply and demand data in milliseconds to control production enabling cost-efficient scaling and even for the gaming industry in online multiplayer games [94].

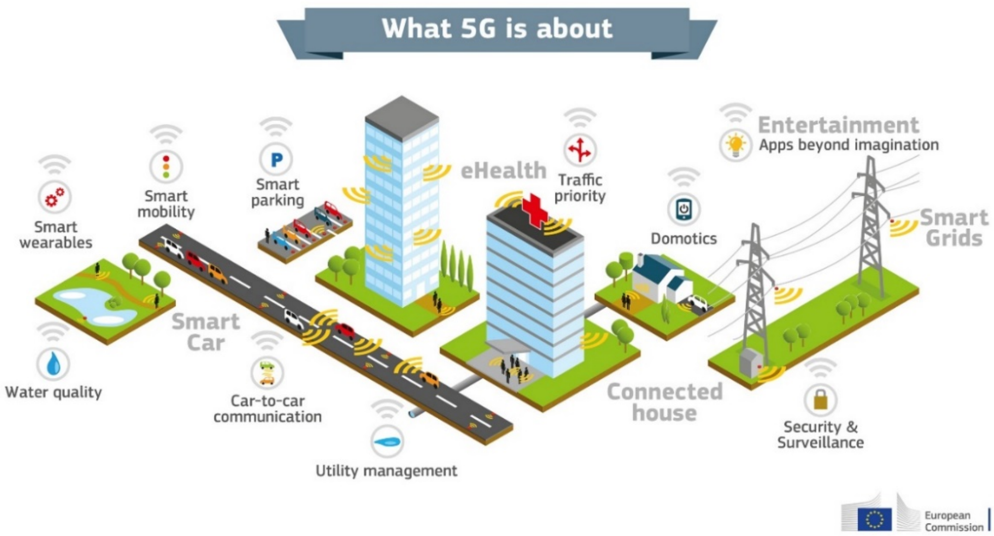


Figure 2-28 Possible application of 5G network in a Smart city [96]

Furthermore, 5G networks are expected to provide support for a heterogeneous set of integrated interfaces from the evolutions of previous generations as well as for new business models such as fixed wireless access (FWA), private networks, and network slicing over public networks which could be adapted to meet the requirements of various industries: manufacturing and financial services (thanks to low latency), automotive industry (thanks to wide-area coverage) and massive IoT (thanks to cost-efficiency) but also be essential for the next generation AR/VR experiences [97], [98]. In a broader sense, 5G will play a significant role in enabling fourth industrial revolution blurring the boundaries between the digital and the physical worlds.

There are eight criteria for a connection to qualify for 5G and they are related to the following: connectivity speeds, round trip delay, minimum bandwidth per unit, scalability and battery life of connected devices, coverage, availability and reduction of the network energy usage [97]. These characteristics, shown in Figure 2-299, could, for example, allow connected devices to operate for months without human interaction or provide real-time interactivity for services using the cloud [99]. Various potential use cases are presented in Figure 2-3030 [99].

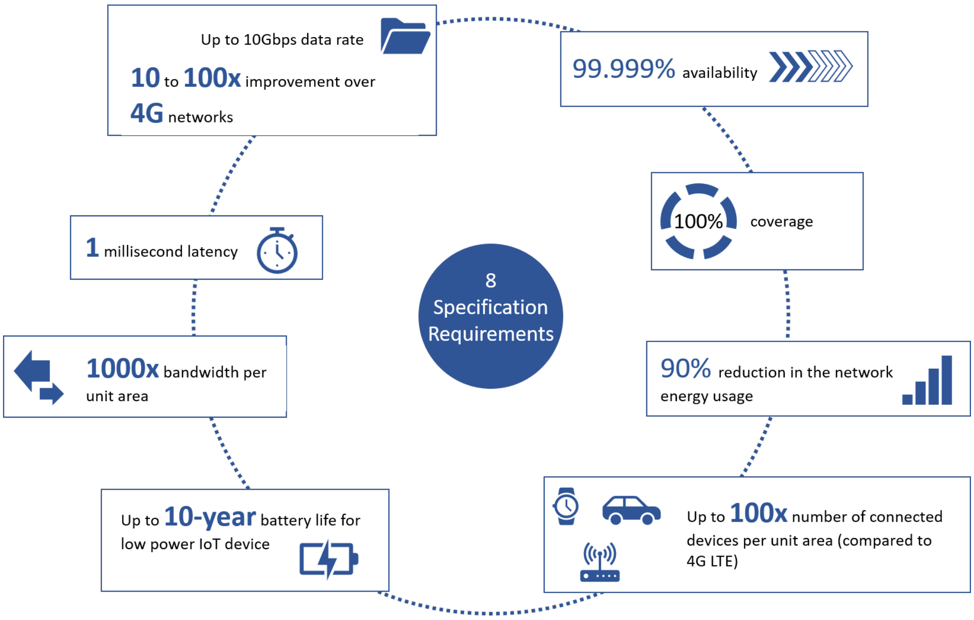


Figure 2-29 Quality criteria for 5G

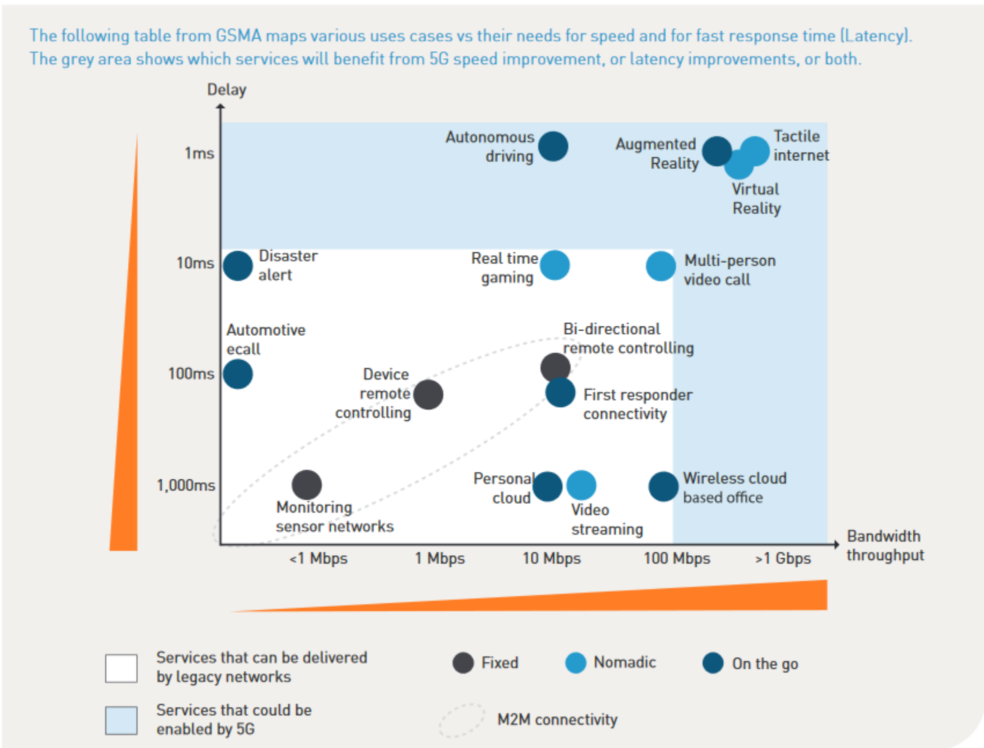


Figure 2-30 Various use cases vs. their needs for speed and fast response time (latency) [99]

5G use cases

According to some sources, "IoT cannot thrive without effective and affordable wireless connectivity, interoperability and common standards. We believe 5G has the potential to make a ground-breaking impact on the way in which future IoT ecosystems are designed, especially in the areas of scalability, latency, reliability, security and the level of individual control on connectivity parameters." [100].

For example, transportation history was made in Sweden, with the world's first 5G-enabled driverless busses (Figure 2-311). Each bus was automated and used 5G technology components to deliver a live camera feed and positional data to a remote-control centre through a 5G test network. The 5G-enabled driverless busses were part of a demonstration on the future of transport, and the general public was invited to climb aboard for a test ride [101].

Figure 2-31 First self-driving bus [102]

Furthermore, there are multiple use cases involving 5G technology, among communication applications which are critical. Since it is expected that 5G will be an ultra-reliable decision-making system, it could be used in a wide range of industrial and citizen services, some of which are:

- sensors to actuators real-time communication for industrial applications
- healthcare monitoring systems
- driverless cars navigation
- drones/robotics applications [99].

Consider the following example regarding driverless cars navigation and latency. A car driving 100 kilometres per hour moves 27.6 metres every second i.e. 2.7 centimetres every millisecond. At this speed, equal to or less than one-millisecond network latency, which 5G provides, means that the information will reach the car from the cloud in a time frame that is equal to or less than one-meter motion. This allows not only improving road safety but also reduces the barrier to access in terms of providing new ways of transportation for people who were not able to drive due to certain disabilities [99].

Another real-life example, showing 5G networks potential, is Lufthansa Technik that has set up two private, standalone 5G networks in aircraft hangars allowing for remote engine inspection and maintenance. This means off-site engineers can see real-time images and live video of the on-site mechanics creating new job opportunities, especially for engineers who have disabilities stopping them from accessing remote hangars [103] .

Innovative solution for increasing specialist medical resources in remote regions is in development. The world's first tele-operated robotic surgery using 5G network has demonstrated the significance of this technology and showed great potential in saving more patients' lives as well as removing health barriers such as lack of resources across regions [104].

Thanks to 5G, the world's first smart harbour is in development at the Port of Qingdao, China, one of the busiest ports worldwide. Some of the key findings show that 70% of labour costs can be saved using 5G automation upgrade. Data traffic from more than 30 high-definition cameras and control data for a programmable logic controller (PLC) were part of an established 5G connection [105].

All these use cases are proof of different possibilities and confirm the feasibility of 5G applications. Along the path of 5G adoption many more will arise enhancing countless industries and improving people's lives in untold ways.

VR, AR and MR applications' goal is to create a highly realistic experience of interacting with virtual elements in real-world setting or inhabiting a world that is completely artificial. However, combining and synchronizing the real world, and the users' motions with the virtual world requires a massive amount of graphical rendering power. Due to this demanding requirements, especially when rendering a full 360° scene (2,5 billion pixels) with refresh rate for dynamic applications (60 fps or above), on-device processes are augmented by splitting the workloads between the VR,AR or MR device and the edge cloud [98], [106]. When the rendering is done in the cloud, low latency, high reliability and high bandwidth are extremely important to create a truly immersive experience for the user. With 5G providing fast and reliable connection, some of the processing power can live in the cloud allowing VR/AR headsets to be set free from cords, game graphics to be seamless and higher resolution than ever before [94].

5G and exposure to radio frequencies

5G will extend into higher frequencies than the previous network generations (3.5 GHz and up to a few tens of GHz). The exact frequencies are country specific and are presented in the Table 2-1 for the partner countries of the INNOSID project. Some of the frequencies in Table 2-1 have already been utilized while others are earmarked for the future.

Table 2-1 5G spectrum for EU countries [107]

Country	5G spectrum consultation	700 MHz	3.4-3.6 GHz	3.6-3.8 GHz	>24 GHz	Other frequencies
Croatia	Done; March 2019	Allocation procedure scheduled	Allocation procedure scheduled; Partially 230 MHz	Allocation procedure scheduled; Partially 100 MHz	Allocation procedure scheduled	2.5-2.69 GHz, 1500 MHz
Spain	Done; 2017	Allocation procedure scheduled; 2020	Done; 2016	Done; 2018	Earmarked	-
Hungary	Done; 2017	Done; 5 lots of 2x5 MHz	Done; 80 MHz in 2016	Done; 310MHz March 2020	-	Done; 2.1 GHz/2.6 GHz (no bids)
Portugal	Done; 2017	Allocation procedure scheduled; 2020	Allocation procedure scheduled; 2020	Allocation procedure scheduled; 2020	Allocation procedure scheduled;	Earmarked; 450 MHz/900 MHz/1500 MHz/1800 MHz/2100 MHz/2.6 GHz
France	Done; 2018	Done; 2015	Allocation procedure scheduled; 2020	Allocation procedure scheduled; 2020	Earmarked	Allocation procedure scheduled; 1.5 GHz, 2.6 GHz TDD (earmarked)

These frequencies are commonly used in other applications, such as point-to-point radio links and body scanners for security checks. Furthermore, 5G networks will use a greater number of base stations and employ beam-forming antennas to focus signals more efficiently towards the device in use. The main mechanism of interaction between radiofrequency fields and the human body is tissue heating, so exposure levels from current technologies result in slight temperature rise [108]. With the increase in frequency, there is less penetration into the body tissue, and absorption of energy becomes confined to the surface (skin and eye) [108]. Two international bodies give out the exposure guidelines on electromagnetic fields:

- The International Commission on Non-Ionizing Radiation Protection, and
- The Institute of Electrical and Electronics Engineers, through the International Committee on Electromagnetic Safety.

The guidelines they provide are not technology-specific and cover radio frequencies up to 300 GHz (including the frequencies under discussion for 5G). However, the extent of any change in exposure to radiofrequency fields is still under investigation. World Health Organization (WHO) is conducting a health risk assessment from exposure to radio frequencies, covering the entire radio frequency range, including 5G, to be published by 2022 [108]. From the research WHO conducted so far there are no adverse short- or long-term health effects have occurred from the RF signals produced by base stations. Furthermore, WHO made official radio frequency limits by country public and they are available online[8].

COVID-19 effects

Considering the COVID-19 outbreak, everyone's lives have changed in a way that keeping a social distance while remaining connected has become a primary concern. In trying to keep our professional and personal lives as normal as possible, significant demands have been put on the network infrastructure and have highlighted its importance. Staying at home, working from home and continuing education online, due to the virus outbreak, has resulted in a geographical shift in traffic loads form cities to suburban residential areas [91]. Additionally, the lockdown has created a peak in hours of usage during daytime [91]. Avoiding service quality degradation during these hours requires support with a sufficient level of network performance, thus giving 5G adoption a greater priority. Some of the observations on the impact of lockdown restrictions on fixed and mobile networks are presented in Figure 2-32.

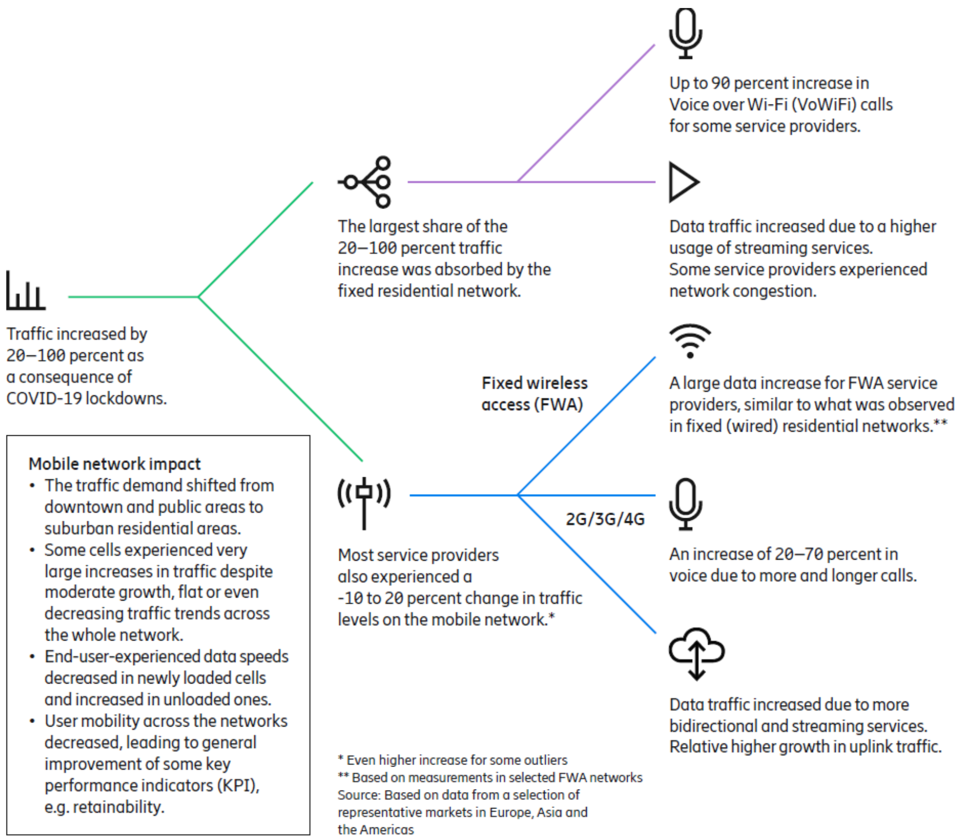


Figure 2-32 The lockdown restrictions impact on fixed and mobile networks [91]

Due to the pandemic, there has been an increase in the use of conversational and bidirectional applications, such as video calling, that requires at least 1Mbps download/uplink throughput and an increase in media consumption, such as video streaming, that could require up to 20 Mbps downlink throughput for a good quality service [91]. 5G satisfies all the beforementioned requirements and shows potential in dealing with other pressing issues, i.e. the COVID-19 pandemic. It can help in dealing with the virus containment and treatment. For example, material flow through the supply chain could be optimized, virtual patient monitoring enabled,

[8] https://apps.who.int/gho/data/node.main-eu.EMFLIMITSPUBLICRADIOFREQUENCY?lang=en

remote diagnosis, treatment, testing or consultations enabled, etc. [103]. Therefore, 5G networks adoption could be fast-forwarded as its benefits utilization is more important than ever.

2.7 Artificial Intelligence (AI)

As mentioned in the introduction of this chapter, Artificial Intelligence (AI) refers to “systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications).” [34]. Before analysing applications regarding the AI, let us define what Artificial Intelligence really is.

AI is a term made up of two words: artificial and intelligence. The word artificial is defined as something made or produced by humans, as opposed to natural, imitated, a copy of something natural [109]. While the word intelligence is defined as the capacity for learning, reasoning, understanding, and similar forms of mental activity [110]. **Artificial Intelligence** can be considered as any theory, method or technique that helps with intelligent computer data processing. This means that it attempts to analyse, simulate, exploit, and explore the human thinking process and behaviour so that computers can perform tasks that only a human is able to [111].

AI is divided into three levels (Figure 2-33) [112]:

- Artificial Narrow Intelligence (ANI) – the first level that is good at performing a single, goal-oriented task. It outperforms humans in some very narrowly defined ways.
- Artificial General Intelligence (AGI) – the level of AI that has the ability to understand, plan, solve problems, and reason its environment, similarly as a human would do.
- Artificial Super Intelligence (ASI) – an intellect that is smarter than the best human brain in every field from social skills to scientific creativity.

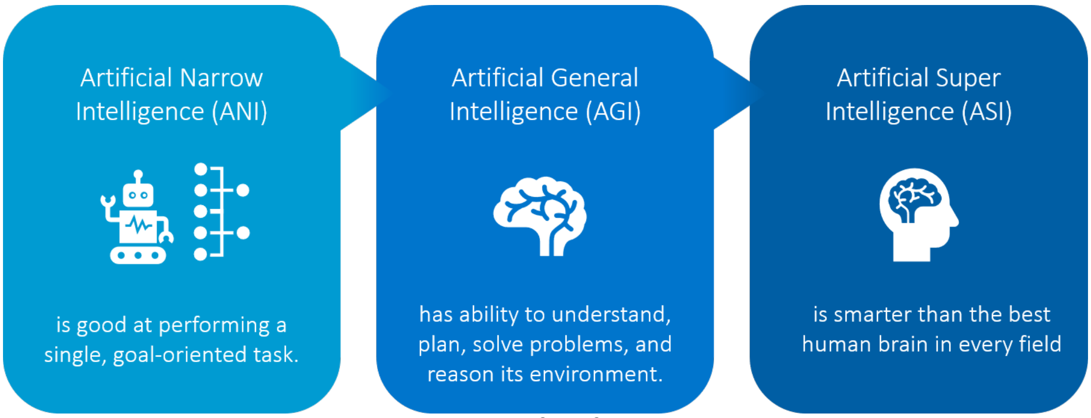


Figure 2-33 Levels of Artificial Intelligence

ANI, also known as narrow or weak AI, is the only type of AI that we have successfully realized to data. Therefore, in the literature, the term AI is generally referred to as narrow AI.

AI is the fastest growing activity in software development. According to Statista, the value of the AI software market in Europe will grow from 3,27 to 26,54 billion U.S. dollars from 2019 to 2025 [113].

The AI field has many branches; the most active of them are shown in Figure 2-34. All of them have many significant connections and commonalities among each other [114]. The most frequent term related to the notion of AI is probably **Machine Learning** (ML). ML focuses on the design of algorithms to optimize a performance criterion based on empirical data. According to data and their important parameters, the model, that describes the data, needs to be made. By executing that model and by using the training data or past experience, the computer program learns how to optimize the parameters of the model [115]. The model may be predictive (can make predictions) or descriptive (can gain knowledge), or both [115]. There are several types of learning algorithms. In supervised learning, the goal is to learn a mapping from input to the output data, where correct values are provided by a supervisor. While in unsupervised learning, the other type of ML, we have only input data, and there is no supervisor. In this type of learning, the idea is to organize data into similarity groups called clusters and to find regularities between them [115]. Deep learning is a branch of ML-based on neural networks where data is represented with a high level of abstraction. The aim is to learn from data and achieve their representation by a sequence of transformations with a minimum human contribution [115]. AI is widely used in different fields and industrialization projects, which brings innovations and development trends. The broad access datasets and more computer power encourage achievements in fields of AI and especially knowledge in the fields of natural language processing (NLP), predictive analysis, image processing, robotics, etc. has matured [111].

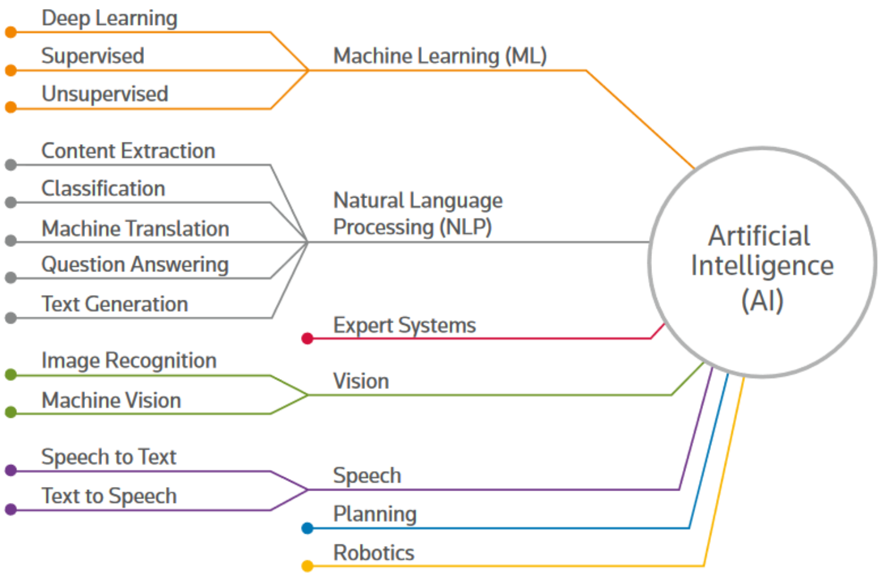


Figure 2-34 Branches of Artificial Intelligence [114]

AI has been developing for more than 60 years, notably since 2012 people's views on AI capabilities have changed. Information availability, hardware enhancement, and algorithm improvements are most responsible for advancing AI [116]. It has become multidisciplinary and interdisciplinary from natural to social science [111]. AI has found applications in health, medicine, education, automotive industry, bioinformatics, finance, recommender systems and much more [116].

Smartphone has become an integral part of our daily life. A lot of applications that smartphones run use AI in their implementation. We can say that Artificial Intelligence represents a big feature of modern smartphones and mobile applications.

The first example is Duolingo (Figure 2-35), a platform for learning languages [117]. It has a large collection of language-learning data and more than 300 million learners [118]. Good practice of this platform is a commitment to share data and publications which are accessible on their research web page [118]. In [119], they have presented a method for developing language proficiency assessments. Developed computer-adaptive language tests are driven by machine learning and natural language processing. They use that to induce proficiency scales based on given standard, after what they use linguistic models to estimate item difficulty [119]. With this, they are avoiding discourage users from dropping out of the course, because the learning materials are too simple. They have implemented AI in the Duolingo system to optimize and personalize lessons [118].

This is an example of AI application in the field of education, while Spotify (Figure 2-36) presents AI application in recommender systems. Spotify is a digital music service with millions of songs, from old singles to the latest hits [120]. Recommender system suggests items (in this case, songs or artists) to a user based on collected preferences of its user(s). Spotify uses ML for engagement and research-based recommendations. More precisely, they are using a framework that balances exploitation and exploration [121]. Exploitation means to create a personalized content experience (based on previous music or podcasts selections), while an exploration is a research tool based on user engagement and it is used to learn how people interact with suggested content [121]. With this framework, besides the user's favourite content, they recommend new tracks and artists.

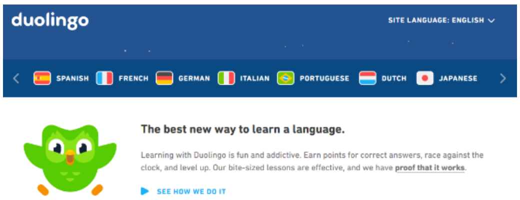


Figure 2-35 Screenshot of the web page of Duolingo platform [117]

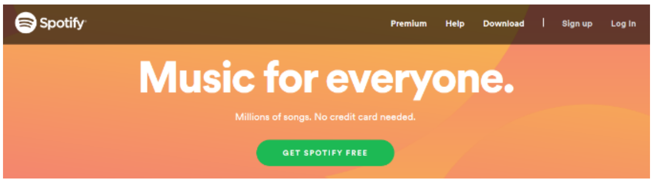


Figure 2-36 Screenshot of the web page of Spotify platform [120]

Netflix, a streaming service for watch TV shows, movies, documentaries and more, also uses AI [122]. Netflix counts more than 100 million members that enjoy hundreds of millions of hours of content per day [123]. They use ML for recommending content and in video studio for movies and TV shows production. Netflix applied ML for choosing the best bitrate selection for Internet traffic and for optimization in audio and video encoding [123].

The next example is Google [124], the most commonly used web search engine (Figure 2-37). Google RankBrain is an ML algorithm that is used to sort the search result [125]. The RankBrain works based on understanding search queries (keywords) and measuring user interaction with the results (user satisfaction). It understands keywords by doing keyword-matching and turning search terms into a concept. From a known concept, RankBrain finds pages that cover that concept [125]. After showing a set of results, RankBrain learns if results are good or not based on user satisfaction. Moreover, Google company has a website and a blog dedicated to AI [126][127]. The main purpose of pages is to publish their research, provide open source tools and systems (like TensorFlow[9]), and post the latest news from Google AI. There can be found a lot of AI applications.

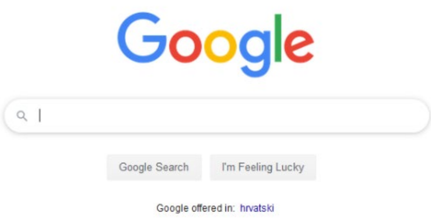


Figure 2-37 Screenshot of Google search [124]

Artificial Intelligence is also present in the medicine. Research has been done from an interdisciplinary perspective, theory, and practice in different domains in medicine, medicine-oriented human biology, and health care [128]. In [129], explainable AI for breast cancer is presented as an approach where analogical reasoning is used. Aim of analogical reasoning is to give solutions for the query. In the case of breast cancer, the query is the patient, and the solution is the classification of the patient in a class of diagnostic or therapy. As a trained data set, previously known cases with their solutions were used [129]. AI is also used in lung sound classification [130]. Doctors evaluate and diagnose patients with pulmonary conditions by using a stethoscope. In some cases, they can make the wrong decisions and compromise the patient's condition. To overcome this problem method for clinical diagnosis, a solution based on neural networks is developed. It uses an electronic stethoscope with pattern recognition [130]. AI is also applied to predict seizures for people with epilepsy. In this case, a prediction is very important because seizures are unexpected and can make serious brain damages [131]. If a seizure is predicted person has enough time to do necessary things, to reduce the seizure or its impact,

[9]TensorFlow is an open source platform for machine learning. It has tools and libraries that help developers for easy build and deploy ML applications (https://www.tensorflow.org).

and to improve his/her life quality. Resources found this challenging because there is no universal brain pattern, moreover each person has its unique one. They apply deep learning, a large neural network, for developing a model that uses an algorithm that analyses spatial-temporal features of the person's brain activity [131]. The developed model needs to be trained for each person in order to reach high efficiency. It was tested and applied for 22 patients and shows 99.6% accuracy.

Artificial Intelligence has also found its application in the battle against COVID-19 pandemic. COVID-19 disease, also known as coronavirus, was declared as a global pandemic in March 2020 by the World Health Organization[10]. Some areas where AI can contribute are prediction and early warning, data visualization, diagnosis and care, social control, and more [132]. One example is Blue Dot, the product of the Canadian company, which predicts the new epidemic focal point [133]. Besides this, AI can be used for predicting how seasonality can affect COVID-19. This prediction can be helpful and contribute to financial stabilization [133]. Early detection of coronavirus can suppress the spread of disease and that can save lives. Several studies use AI for developing a trained AI model that diagnoses the disease based on chest radiography images [132]. Resources apply AI for developing treatments and vaccines against coronavirus and for testing the potential impact of existing drugs on COVID-19 [132]. Data availability and accuracy, information sharing, openness and collaboration between multidisciplinary sides are very important for improvement in areas where AI is applied, especially in the fight against the COVID-19 pandemic [132].

2.8 Robotics

The robot is defined as an automatically operated machine that replaces human effort. By extension, robotics is the engineering discipline dealing with the design, construction, and operation of robots [134]. The scope of what is considered robotics progresses with the progress of technology. The first generation of modern robots starts in the 1950s with so-called manipulators, sensorless robots with simple control algorithms.

This encompasses first mechanical arms used in the automotive industry which were capable of picking up and moving objects. The integration of sensors marked the second generation of robots. These robots had rudimentary awareness of their surroundings, and they were also used in the automotive industry to boost production. In the 1970s, billions of dollars were invested by companies into production automation, and this started the generation of industrial robots [135]. One such robot was FAMULUS, developed by KUKA, the first industrial robot with the now-standard setup of six electric motor-driven axes (Figure 2-38). New programming languages for robot control and reprogrammable robots were also introduced.

Figure 2-38 FAMULUS industrial robot [136]

The turn of the millennium marked the start of the fourth generation of robots called intelligent robots, capable of logical reasoning, learning and working with data. This also resulted in broader usage of robots. Robots are used in agriculture for crop monitoring, harvesting and even herding [137]. Surgical robots, such as the da Vinci Surgical System (Figure 2-39), are used for cardiac valve repair and gynaecologic surgical procedures [138]. Military uses robots for various tasks like reconnaissance, surveillance and mine detection [139]. Robots can also be used for educational purposes. Robotics provides an effective way for children to learn about science, technology and mathematics, and it encourages children to use their imagination and be innovative in design

[10] World health organization (WHO) is an organization that coordinates international public health within the United Nations system. (https://www.who.int/)

[140]. Robotics can significantly impact the nature of engineering and science education across all levels, from kindergarten to graduate school [141].

Artificial intelligence is increasingly relevant in the field of robotics, as the robots are being equipped with more sophisticated sensors and have the much greater processing power. This brings us to the future generation of collaborative and personal robots, which are expected to enhance and help humans with everyday activities. One such robot present in many homes worldwide is Roomba (Figure 2-40) – the first vacuum cleaner domestic robot. In the future, personal robots are predicted not only to assist people with house cleaning, lawn mowing, pool cleaning and providing reminders but to even drive people autonomously [143].

Figure 2-39 daVinci Surgical System [142]

Figure 2-40 Roomba Robot Vacuum (retrieved from: https://www.irobot.com/roomba/600-series)

Although industrial robots led the growth of robotics since its beginnings, latest trends such as transitioning from mass manufacturing to mass customization show that new generations of professional and consumer robots could soon take over (Figure 2-41).

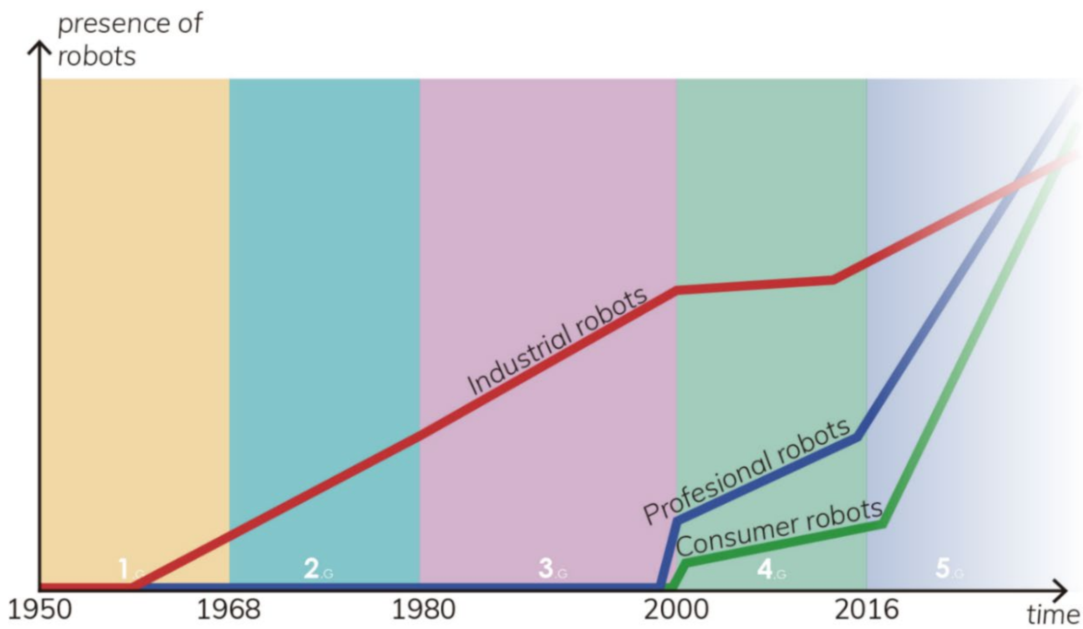


Figure 2-41 Trends in the distribution of robots in the world through five generations [135]

2.9 3D printing

Three-dimensional printing (3DP) is a process of creating 3D objects by fusing one layer on another, rather than removing or carving out material, such as in traditional machining. The basic principle behind every 3D printer is to build physical objects layer-by-layer according to information generated by slicing a 3D model with special pre-processing software. A single slice (layer) of the model can be considered as a horizontal section of the object in 2D, thus it can be built by the printer during a single-phase (Figure 2-42). The third dimension is created by superimposing the sections on top of each other [144].

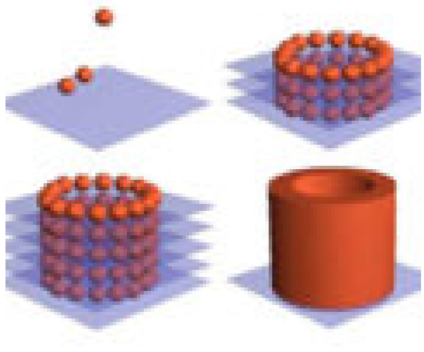


Figure 2-42 Main principle of 3D printing [145]

The simplest implementation of 3D printing is based on a technology called Fused Deposition Modelling (FDM), which is cost-effective and requires only a basic, relatively cheap desktop printer. It builds objects from plastic filaments rolled to a spool and led to the nozzle, where it is liquefied by heating. As soon as the thermoplastic material is placed on the required location, it immediately hardens again, ensuring a stable surface for the next layer (Figure 2-43). There are several other technologies available, but their presentation is beyond our scope, since most of the users, including school children and university students, will definitely meet a desktop FDM printer first [146].

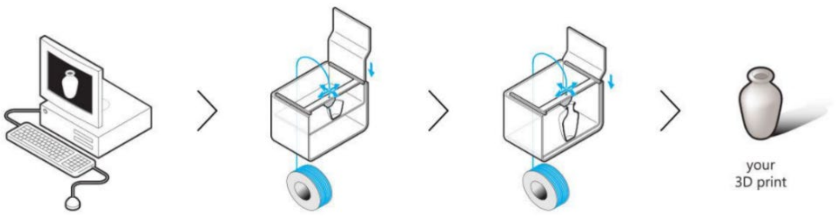


Figure 2-43 Fused Deposition Modelling [147]

One of the most difficult tasks in designing 3D printable models is to meet the conditions required for successful printing. The necessary properties depend on the technology, for example, in the case of FDM too thin parts, overhangs or very curvy shapes are usually not printable and complex inner structures must be very mindfully created. Still, even the cheapest FDM printers can produce print-in-place (PIP) models that are named after their unique property: right after printing the object has movable parts. Various types of joints, and hinges ensure that there is no need of assembling parts to make the movement possible (Figure 2-44).

Figure 2-44 Print-in-Place (PIP) designed robots [148]

Innovations in 3D printing are welcomed in many fields. There are countless examples of how 3DP helped to achieve goals that were either not feasible or were hardly feasible without applying this amazing technology. Next section demonstrates some interesting and exciting use cases.

3D chocolate printer

The basic principle of FDM printing can be applied with some modifications in order to use a unique raw material such as chocolate (Figure 2-45). It is known that chocolate cannot be wound into a hard filament and is too soft to extrude with gear and motor. However, melted chocolate can be stored in a cartridge and extruded with a syringe. The chocolate does not harden as easily at room temperature as plastic does, so the printing is slower, but the resulting chocolate shapes are very attractive and preferred by master confectioners as well as by children. Most chocolate 3D printers can use the same kind of design files as a normal 3D printer, once converted to machine code [149].

Figure 2-45 ZMorph VX chocolate printer [149]

3D printed jet engine from GE Additive

Using 3D printed plastic parts in aircraft is not surprising nowadays, but it can seem unbelievable that metal components are also 3D printed. A350 XWB aircraft of the Airbus has more than 1000 3D printed plastic part, and a massive metal component for its jet engine as well. In 2016 Airbus received the very first production LEAP-1A engines from General Electrics, marking the historical moment in which a critical 3D-printed part was integrated into a commercial aircraft (Figure 2-46). The 3D-printed fuel nozzle in the LEAP-1A engine brings new efficiency to the functioning of a jet engine, both in terms of design and fuel savings [150].

Figure 2-46 3D printed fuel nozzle, and the LEAP 1A engine [150]

Office building in Dubai

In 2016 Dubai announced its 3D Printing Strategy which aims to 3D print 25 per cent of the city's buildings by 2030. An office building called "Office of the Future" was created as the first step towards this goal. The 3D-printed frame of the building is a concoction of cement and a special building material produced in the United Arab Emirates and the United States of America. According to the Government of Dubai Media Office, this material has passed a variety of tests in China and the United Kingdom to confirm its reliability. The building was printed off-site in only 17 days then brought to its final location, where it was assembled in two days (Figure 2-47). Only one staff member was required to control the printer, seven people installed the individual office components on-site and 10 electricians and specialists oversaw the engineering as the building was assembled. At the construction site, mobile 3D printers were implemented to finalize the building's assembly. According to the Government of Dubai, labour costs were reduced by more than 50 per cent, compared to traditional construction techniques [151].

Figure 2-47 Office of the future outside and inside [151]

3

Social inclusion of people with disabilities

There are many terms which are frequently used in everyday conversations and that are somehow intuitive even though their exact definitions are likely not known by people engaged in discussions. However, few of them are as abstract as the term "social inclusion". This is perhaps not surprising as social inclusion is an umbrella term which encodes one of the most ambitious and, arguably, one of the most important challenges our society face today. Given the importance of social inclusion for this chapter, it makes sense to give at least a light introduction to the basic concept by asking the following questions:

WHAT, HOW and FOR WHOM?

Having said so, the World Bank in the essential reading on social inclusion [152] does a very good job of defining social inclusion in two ways. The basic version articulates social inclusion as

*"The process of **improving the terms** for individuals and groups to take part in **society**."*

This statement, although concise and abstract, informs that there seems to be a need to improve a position of certain individual and groups within society. In other words, it specifies the so-called "WHAT?" part of the definition. The second version is a bit more elaborate as it expresses the "HOW?" and "FOR WHOM?" can social inclusion be improved:

"*The process of **improving the ability, opportunity and dignity of people, disadvantaged on the basis of their identity**, to take part in **society**.*"

Given the above-mentioned, it is evident that social inclusion can be improved for people who are excluded based on their *identity*, i.e., based on "*the qualities of a person or group that make them different from others"* [153]. There are many identities, and it is important to mention that a person can have multiple identities, which can make her or his life much better or much worse, depending on how "compatible" those identities within the realm of other identities are. Social exclusion has plenty of negative effects as impacted people are likely to have a lower social standing, lower-income, employment and denied rights and opportunities we normally take for granted. Some of the most common identities which experience exclusion are gender, sexuality, race, caste, indigeneity, ethnicity, culture, religion, children and youth, old age, and disability [154]. This report will now focus on discussing the social inclusion of persons with disabilities (PWD) by touching upon some of the key insights from the *World Report on Disability*, the pioneering work from the World Health Organization which gives a global outlook of the situation of PWD, their needs, barriers they face and what can be done to help them [25]. Furthermore, discussion will contain case studies and examples from the countries which participate in the INNOSID project. Interested readers can find additional insights related to the INNOSID partner countries in the Appendix B part of the report, e.g. demographic information or some interesting facts.

3.1 Disability in general

Disability is an umbrella term which covers a wide spectrum of impairments, activity limitations and participation restrictions. According to the Merriam Webster dictionary [155], disability is

"*a physical, mental, cognitive, or developmental condition that **impairs**, **interferes** with, or **limits** a person's ability to **engage** in certain tasks or actions or **participate** in typical daily activities and interactions*".

Even though the majority of people do not have a reported disability, it is worth mentioning that over 1 billion people globally experience disability, of whom between 110-190 million experience significant difficulties [156]. To put this into perspective, about 1 in 7 people have some kind of disability which makes the persons with disability (PWD) a highly represented group, also called "the largest minority", in today's society. It is also observed that those numbers (including their proportions) increase with the growth of population.

Now, recall that the basic premise of social inclusion is to provide equal opportunities to all people regardless of their identity. However, due to many reasons, PWD face difficulties in achieving the same opportunities as persons without a disability which negatively impacts their social inclusion. For example, concerning general health care, **PWD are four times more likely to be treated inadequately** in the health care system as opposed to people without disabilities. Given their often-peculiar needs, about half of PWD cannot afford proper health care.

Next, PWD may face difficulties due to a physical environment that is not accessible (e.g. a person in a wheelchair not being able to access a building with stairs), lack of assistive technologies (assistive, adaptive and rehabilitative devices), negative attitudes towards PWD services and laws that do not include all people with a health condition, and many others.

3.2 People with disabilities as heterogeneous group

When talking about PWD, it is important to mention that every PWD is different in the sense that she or he may have one or more disabilities, each of which affect them differently. For example, children with hearing or visual impairments or intellectual disabilities tend to have lower grades than children with physical disabilities. Similarly, people with mental health problems or intellectual disabilities are likely to have more problems with employment as opposed to people with some other disabilities. Figure 3-1 illustrates one example where two persons have the same disability but are impacted differently.

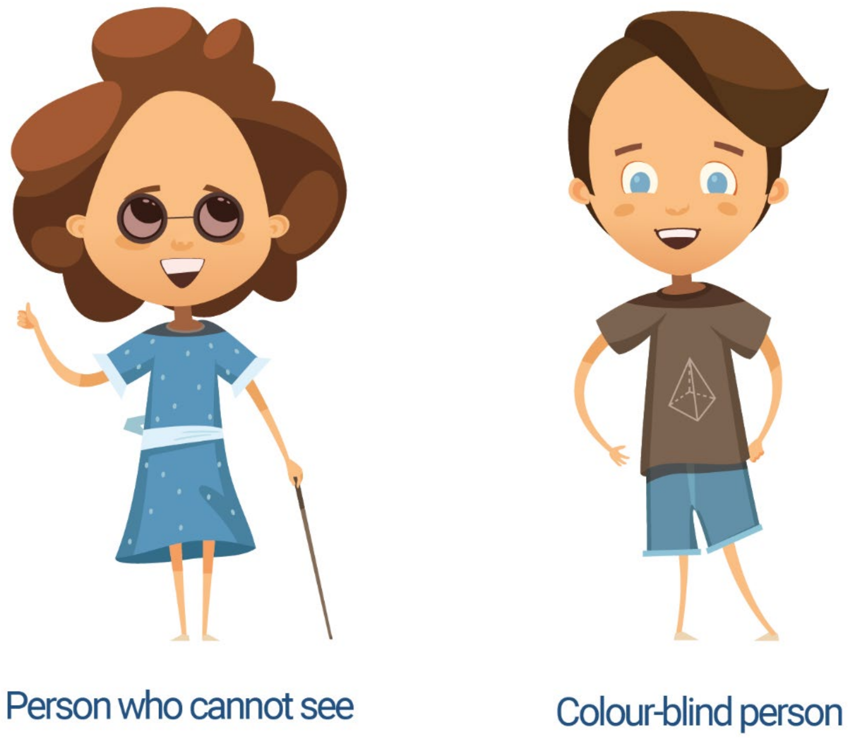


Figure 3-1 The same disability may have different outcomes in terms of person's functioning

Following the above examples, it is obvious that PWD are a highly **heterogeneous group of people**, suggesting that there is a necessity for a **holistic view** and **interdisciplinary collaboration** when designing solutions for their social inclusion. In that sense, the WHO, with its International Classification of Functioning, Disability, and Health (ICF), provides a framework for describing a person's individual functioning profile by using a common language, with the aim of a better understanding of the person's specific needs. Furthermore, the ICF defines steers away from focusing only on the **disability aspect** of individual and proposes the framework which considers both **functioning** and **disability** at the same time. Such an approach is beneficial as functioning and disability represent the positive and negative aspects of functioning from a biological, individual, and social perspective and they also reflect the interaction between health condition, environmental and personal factors [157]. Figure 3-2 shows the resulting ICF biopsychosocial model of functioning and disability.

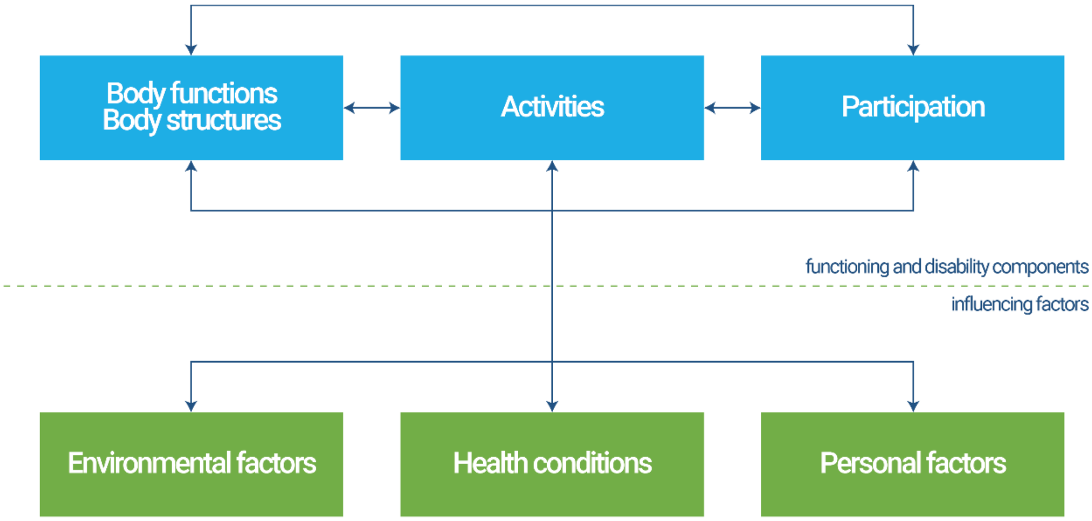


Figure 3-2 The ICF biopsychosocial model of functioning and disability, adapted from [158]

More details about the ICF model and its components are available as an open educational resource (OER) [158]. The above-mentioned discussion suggests that there are many internal and external factors apart from the health condition that affect functioning and disability of a PWD, which makes social inclusion of PWD intricately complex. Fortunately, there are some **general guiding principles** from the UN's Convention on the Rights of Persons with Disabilities (CRPD) [20], a legally binding policy instrument that advocates of all human rights and fundamental freedoms by all persons with disabilities:

1. Respect for inherent dignity, individual autonomy including the freedom to make one's own choices, and independence of persons
2. Non-discrimination
3. Full and effective participation and inclusion in society
4. Respect for difference and acceptance of persons with disabilities as part of human diversity and humanity
5. Equality of opportunity
6. Accessibility
7. Equality between men and women
8. Respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities.

3.3 Key areas for improving social inclusion of people with disabilities

The barriers that PWD encounter everyday are numerous and PWD are experiencing them in different aspects of their lives. Architectural, socio-cultural, legislative, or regulatory barriers are just some of the many barriers that PWDs must overcome in their day-to-day life to be able to enjoy a fully inclusive life. By following the general principles of the CRPD, society can be easily guided on how to overcome these barriers together in the right way.

The European Disability Strategy 2010-2020 adopted by the European Commission in November 2010, represents a fundamental policy instrument for persons with disabilities and their organizations in order to make a barrier-free Europe. The Strategy identifies eight main areas for action: accessibility, participation, equality, employment, education and training, social protection, health, and external action [159].

Children and people with disabilities should be able to attend different levels of education, considering their specific difficulties, and receive the corresponding support in the classroom, as well as during the transitions between different educational levels or into the work setting or employment. In an increasingly "digitized" society, people with disabilities should not be excluded from the use of commonly used ICT devices and services, such as computers, tablets, smartphones, social network, etc. On the contrary, all these should be used as tools that promote social interrelationships, help stimulate their cognitive, creative, and emotional processes, contributing greatly to their personal autonomy.

Different public and private instances, as well as regional and national state agencies, have recognized the necessity of carrying out the activities to reduce these barriers and improve social inclusion of PWD. Urban plans for universal accessibility, an adaptation of content and training cycles to ensure the inclusion of all students, specific courses for people with disabilities, mentoring and daily support through associations and volunteers are just some of the activities and initiatives helping overcome existing barriers that have contributed to the social exclusion of PWD. The importance of this topic is confirmed by the development of various legislations, e.g. the one that supports and stimulate professional development and entrepreneurship of PWD.

Everything mentioned above leads to the conclusion that there are many areas with room for improvement in the social inclusion of PWD. Key areas that are intertwined in this context, such as accessibility, education and employment, will be further elaborated.

3.3.1 Accessibility

The CRPD recognized "the importance of accessibility to the physical, social, economic and cultural environment, to health and education and to information and communication, in enabling persons with disabilities to fully enjoy all human rights and fundamental freedoms". Measures that need to be taken to ensure to PWD equal access to the physical environment, transportation, ICT and other services open to the public are well defined in Article 9 of the CRPD. These measures, besides buildings, roads, transportation and other indoor/outdoor facilities, should be applied to information, communication and other services, including electronic and emergency services [20].

Web accessibility

The web and the Internet are an increasingly important resource in many aspects of life, including education, employment, government, commerce, health care, recreation, and more. More than 45% of people in the world use the Internet actively via their computers, smartphones and television sets [160]. It is important to ensure access for PWD to new information and communication technology and systems, including the web and the Internet, to ensure equal access to information and opportunities mentioned technology gives. Accessible websites accessed via the Internet on computers or smartphones can help PWD participate more actively in the digital society.

The importance of web accessibility is confirmed by different laws and policies that include strict deadlines and rules for implementation of websites accessible for users with disabilities [161]. These laws and policies enacted all around the world also encouraged different initiatives and programmes, such as the one from ITU[11] intended for countries and governments who want to make their public websites accessible to all citizens without discrimination. The European Parliament and the Council of the European Union issued the Directive (EU) 2016/2102 on the accessibility of the websites and mobile applications of public sector bodies which obligates Member States to commit themselves to take appropriate measures to ensure access to PWD [162].

People with disabilities are not the only group who would benefit from accessible websites. The population is getting older in most regions of the world and will continue to experience growth in average age in the coming decades. Their independent participation in society can be improved by using different web services so, since

[11] https://www.itu.int/en/ITU-D/Digital-Inclusion/Persons-with-Disabilities/Pages/Internet-for-@ll.aspx

the number of elderly increases, they are considered the fastest-growing segment of Internet users. Functional capabilities and communication features of older people which are substantially determined with numerous physical, psychophysical, biological and social changes that are a part of the normal ageing process should not be the reason why elderly people cannot access Internet and different web services [163]. That is, all web solutions must be in accordance with the *Universal Design* principle and accessible by all people. The principle of "Universal design" means that "the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [20].

Web accessibility is an inclusive practice whose goal is to allow all users to access and use web content. The issue of ensuring equal access is very important, as 15% of the world's population has some type of disability [164]. Although PWD have assistive technologies such as text-to-speech software, screen readers, alternative mice, affordable keyboards, and computer-based view management systems, they often encounter problems using the web. These technologies can only function properly if the websites' content and design are in accordance with accessibility guidelines. A significant number of countries have recognized the importance of web accessibility, and some of them even legislated how public content must be designed in order to be accessible to everyone. Examples of government regulations on web accessibility are listed in [161]. There is no universal solution for all issues related to accessibility, but there are many recommendations and guidelines to help make websites more accessible [165]–[170]. Although there is no universal methodology for developing or evaluating an accessible website, there is one very important factor: include end-users (PWD) in the development and evaluation process of an accessible website. This is very important since PWD are a heterogeneous group of users whose needs are specific considering different disabilities, but also it is not rare that two persons with diagnosed sane disability have different needs and requirements.

Accessible website prototype

The research of the most visited websites' accessibility within the Croatian catalogue of websites conducted in 2014 has indicated that websites' design is still not accessible and is not tailored to the needs of specific categories of users [171]. It has been concluded that the greatest responsibility lies in the development of accessible design or new services that will be able to interpret the content of individual websites and automatically make adjustments according to the users' needs [172].

Another research conducted in 2017 by Croatian Regulatory Authority for Network Industries (HAKOM) and the Laboratory for Assistive Technology and Alternative and Augmentative Communication (ICT-AAC Lab) at the Faculty of Electrical Engineering and Computing, University of Zagreb has shown that for some PWD modern technology and the Internet are the only way they can connect with the world and be included in different aspects of the community. Therefore, ICT products and services must always be available and accessible to them. Another finding from the research is that PWD have difficulties finding information of interest on the websites of telecom operators. So, it was concluded that it would be useful to gather information about offers and services from different telecom operators in one place [173].

These findings as well as the act issued by Croatian Parliament which regulates public sector bodies to ensure the accessibility of their websites and mobile applications for people with disabilities [174] (which is in line the Directive issued by the European Parliament and the Council [162]) motivated the development of a prototype of an accessible website as a place that will contain information about special offers from telecom operators for PWD[12], but also will serve as a model for all stakeholders who are interested in the implementation of accessible websites. The web prototype is designed in line with Web Content Accessibility Guidelines (WCAG) guidelines and users' requirements based on the needs and preferences previously collected from PWD or their representatives. The web prototype has implemented accessibility options that are defined as must-have

[12] *Accessible window into the world of telecom operator information*, http://usluge.ict-aac.hr/pristupacni-web-2

options on an accessible website. To be in accordance with users' requirements, the following needs to be kept in mind: careful selection of colours, fonts, images, way of presenting content (e.g. grouping and highlighting), the layout of graphic elements etc. The Accessible Website for Persons with Disabilities project, within which this web prototype is developed, is a product of years of research and multidisciplinary cooperation between the academia and state regulatory agency for telecommunications [175].

Figure 3-3 Home page of the Accessible Web Prototype

Implementation of accessible solutions

It is very important to keep in mind the principles of accessibility when designing different products to be able to offer it to a diverse range of people, regardless their abilities, language, location, hardware or software they are using, etc. Also, choosing the right technology with which that can be accomplished is one of the important factors that need to be carefully considered before accessible solution development starts.

Plug-ins are software add-ons that allow customization of applications, web browsers and website's content. Accessibility plug-ins could be add-ons that make the software's environment more accessible. Most of today's content management systems (CMS) have accessible plug-ins that improve the accessibility of the website. For example, WordPress has its own accessibility team that works on the improvement of accessibility on its core of the system. Therefore, WordPress guarantees that their new or updated software complies with Web Content Accessibility Guidelines (WCAG) 2.0 at the AA level, which is the level of conformance between the lowest (A) and the highest (AAA) level meaning that the Web page satisfies all the Level A and Level AA Success Criteria, or a Level AA conforming alternate version is provided[13]. Websites that are developed from scratch should follow the recommendations and previously mentioned guidelines ([161], [165]–[169]).

Buying and installing a plug-in is the easiest and the fastest approach to implementing accessibility, especially if it meets all the needs of the end-users. This option is the most common for websites developed using CMS such as WordPress, but a developer needs to be prepared to a number of challenges. For example, if it is needed to accommodate the existing code because plug-in's functionality does not match users' needs of some website, then the code needs to be modified. For example, if you modify a WordPress plug-in, the plug-in can no longer be updated because the newly written code would be deleted and overwritten by the update. Creating a solution from scratch, on the other hand, is more demanding, and it takes more time; however, the end-product is much safer and better software solution than the plug-in.

[13] https://www.w3.org/WAI/WCAG21/Understanding/conformance#levels

Plug-ins and add-ons can significantly slow the websites down. Website speed is important for creating an enjoyable end-user experience. Fortunately, most web accessibility services require just a few additional lines of code in the website's backend in order to upgrade them. This code has very little impact on the overall website speed. However, if many plug-ins for accessibility are added, the website may be slowed down. The solution could come with the implementation of 5G networks because faster Internet will allow faster communication with servers and therefore faster download of the entire website and its plug-ins.

Most of the basic accessibility features are easy to implement on websites, either by using existing solutions or creating your own. Accessibility optimization overlaps with other good practices such as mobile web design, device independence, usability, design for elderly users and search engine optimization. It leads to cleaner interfaces, simpler navigation and other elements that improve overall user experience. As a result, accessible websites have better search rank and extended market reach.

3.3.2 Education

Education is central to individual evolution and must be a right for all. It provides each person with the possibility to fully participate in society, to access the labour market and to develop one's potential. In some EU Member States, children and young persons with disabilities can benefit from the mainstream education system. In other countries, the situation is very different and, in some cases, pupils with disabilities are completely excluded from schools and universities [176].

Education is an area where there are still many problems that prevent a fully inclusive education for ones who need it the most, i.e. children with disabilities and/or special education needs (SEN). There are still children with disabilities that are placed in segregated institutions or in mainstream settings alongside their peers but with inadequate support. Also, children with SEN frequently leave school with few or no qualifications, subsequently moving into specialist post-school training. This limits them in the labour market, and they are much more likely to be unemployed or economically inactive than non-disabled people [177].

Article 24 of the UN Convention on the Rights of Persons with Disabilities affirms the right to education as a fundamental one. Despite the limited competences of the European Union in this field, the European Disability Forum believes that the right to education should be considered and protected by the EU, as being part of the fundamental values and principles and a universal human right [178].

The European Disability Strategy 2010-2020 aims at reducing the rate of school drops-out to less than 10% and to increase the share of persons having completed tertiary or equivalent education to at least 40%. Early school leavers rates are higher for pupils with disabilities due to existing barriers (architectural, legal, attitudinal) that hamper their access to education, especially for children in need of high-level support with everyday tasks. The European Disability Forum (EDF) works to make sure that education quality and freedom of choice becomes a reality for all persons with disabilities in Europe [179].

In particular, EDF campaigns for:

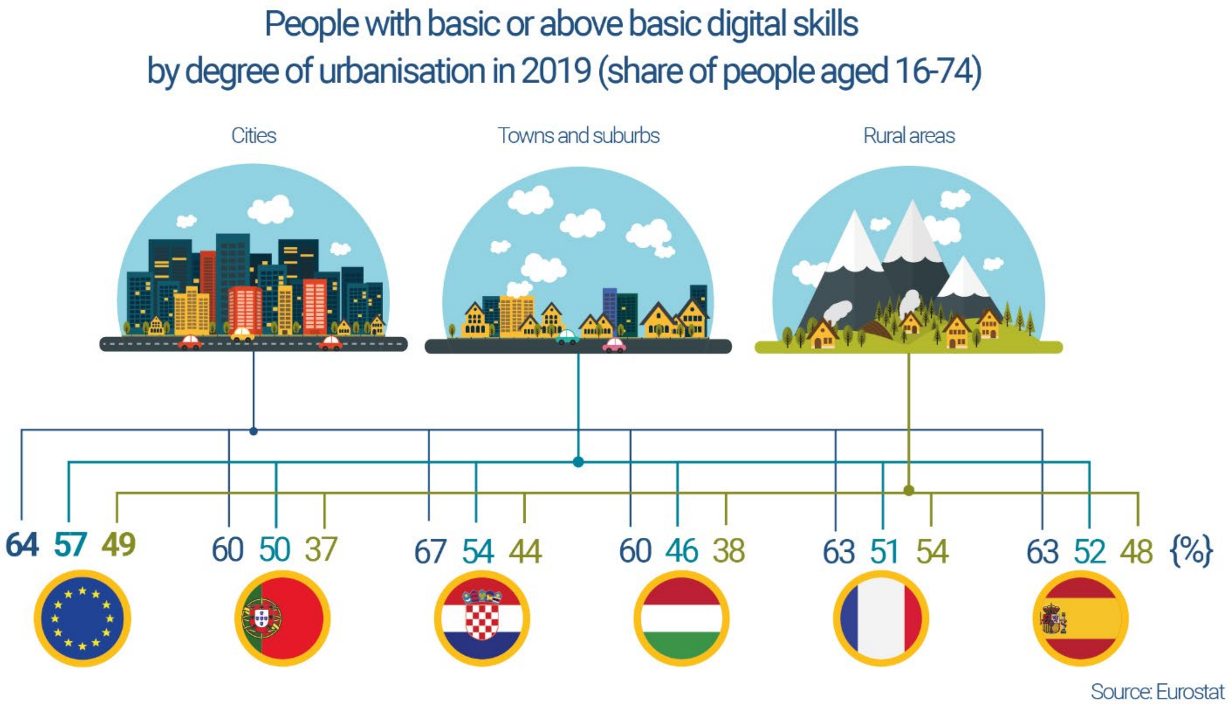
- The right for persons with disabilities to access education and to choose the education system they want to follow.
- Persons with disabilities' right to benefit on equal basis with others from EU exchange schemes and opportunities to study and learn abroad.
- The right to learn throughout life.
- Accessible educational content and accessible Information and Communication Technologies
- Accessible school and university curricula (i.e. exams, etc.) [180].

The European Agency for Special Needs and Inclusive Education (EASNIE)[14] is defining **inclusive education** as "the provision of high-quality education in schools that value the rights, equality, access and participation of all learners". The research from [181] indicates that inclusive education increases the opportunities for peer interactions and for close friendships between learners with and without disabilities. This finding is very encouraging since, unfortunately, there are still children who did not have opportunity to meet with children/people with disabilities in person, so they do not know how to behave around them. Having the opportunity to live and socialize with them from a young age can have a positive impact on social interactions and friendships with people with disabilities in general. Further findings are that learners with disabilities educated in inclusive settings may perform academically and socially better than learners educated in segregated settings, as well as that inclusive education setting can positively affect the likelihood of enrolling in higher education [181]. All of these are of great importance for PWD's further education and employment.

Digital literacy

According to UNESCO, **digital literacy** can be defined as the digital skills and competencies required to participate in an information society and knowledge economy [182]. In addition, UNESCO also emphasizes that the term digital literacy has become far more relevant than the ability to handle computers since it comprises a set of basic skills which include the use and production of digital media, information processing and retrieval, participation in social networking for creation and sharing of knowledge, and a wide range of professional computing skills [182]. Being defined like that, it is obvious that the term 'digital literacy' is closely related to Information and Communication Technology (ICT).

The current situation regarding digital literacy and people with disabilities is, no more, an unknown fact for society in general. There are several initiatives that cover this issue and tend to promote effective strategies that fight the lack of basic digital competencies which specific groups, such as people with disabilities, have been showing as a need that still needs to be addressed. In this sense, according to EASNIE's report [183], it is possible to understand that ICT is now part of many people's daily lives. It has an impact on many aspects of society, including education, training, and employment, and is a particularly valuable tool for people with disabilities and special needs. The potential of ICT to improve the quality of life, reduce social exclusion and increase participation is internationally recognized, as are the social, economic, and political barriers that inaccessible ICT can create [183].



[14] https://www.european-agency.org/

Besides understanding that, when used effectively, ICT can facilitate inclusive education, within and between schools, support for schools as learning communities, and strengthen respect for diversity as a step towards cross-cutting learning for entire communities, the report [183] highlights the importance that skills in the field of digital literacy have in the social and professional inclusion of people with disabilities. That dimension that digital literacy can bring with it allows us to respond to the digital exclusion factor. This is a complex issue, with an impact on the educational and social experiences of many more people than those with disabilities and/or special educational needs. Access to the use of accessible, common and specialised support technologies that reduce digital divide requires a systemic approach at policy and practice level, involving all stakeholders [183].

In addition, it is also stated that within today's information and knowledge society, students with disabilities and special educational needs are among the groups most likely to face barriers to accessing and using ICT. As one can recall, this is a key argument of the United Nations Convention on the Rights of Persons with Disabilities which obliges signatories to "... promote access for people with disabilities to new information and communication technology systems, including the Internet" [20].

However, demonstrating numbers or statistical data that backs up this type of information remains a difficult task to perform. Firstly, given the specificity of the theme of "digital literacy" and the target audience itself, which is called, in this case, people with disabilities. Despite the extensive information available through the official portals and frameworks, in particular, those that are part of the European Commission and which relate to the fundamental objectives of the European Disability Strategy 2010-2020[15], there remains a "general ignorance" of quantifiable data assessing the performance of the disabled population in general and its relationship with learning digital literacy skills. This remains one of the major challenges for a more direct and clear understanding of state of the art, as well as of the very positioning and knowledge that people with disabilities have or lack basic digital skills. Information, which is generally known, remains, for the most part, qualitative and self-critical, not presenting numbers, statistical data or other quantitative relationships that allow us to perform a reliable interpretation of data.

Thus, although the data are scarce, an effort will be made to try to present some quantitative elements that make it possible to understand the current situation vis-a-vis digital literacy and people with disabilities. In this sense, according to the *Flash Eurobarometer 345* survey on *"Accessibility"* from 2012 [184] whose purpose was to identify accessibility issues for disabled citizens, it is possible to realize that:

- In total, 25 516 interviews were recorded for persons with disabilities over the age of 15 through the 27 members of the European Union.
- Of these 25 516 respondents, 26% indicate that there have experienced difficulties using a computer or phone.
- It is possible to verify that 24% of the same number of respondents (25,516) demonstrate difficulties in buying a product or service they needed (online purchasing included).
- 19% of them have difficulties in using official authorities' websites, and 17% have difficulties in using commercial websites.

These indicators allow us to understand that efforts are still needed to ensure the acquisition of digital literacy skills for citizens with disabilities. Although the focus is on accessibility, the importance of this target audience having sufficient knowledge in digital literacy for an autonomous use of the tools is understood.

[15] https://ec.europa.eu/social/main.jsp?catId=1484&langId=en

Good practice example

High figures on accessibility issues in terms of digital literacy for Portuguese citizens [184], such as difficulties using a computer or telephone, difficulties in buying a product or service they needed, and difficulties in using official and commercial websites, have been a concern ever since. Having that in mind, some good practices related to the improvement of digital literacy parameters and quality of life of this target audience in Portugal are worth mentioning. A pilot experience that has been taking place since 2007, focusing on the learning of digital skills for young students with disabilities, has achieved the following results[16]:

- More than 5,000 teachers, tutors and pedagogical agents involved.
- More than 400 technical therapists involved.
- More than 200 volunteers and auxiliary staff.
- More than 2,500 students with disabilities involved.
- And more than 275 families covered.

This pilot project was supported by the Ministry of Education and all ICT Resource Centres for young people with disabilities in the country. This initiative, therefore, remains one of the best practices in terms of digital literacy, which has been implemented considering guidelines and strategies for promoting digital inclusion at national and European level.

Training of PWD for the labour market

There are different means that can be used to promote the social inclusion of PWD. Some of them include the strategic modernization of some fields of action of civil society itself. In terms of training, there are specific courses adapted to the learning of young people with disabilities. In particular, the unique and pioneering course in Portugal named *Digital Literacy for the Labour Market*[17] started a higher education program for 11 students with Intellectual and Developmental Disabilities (IDDs) in 2018. Each year a new selection of young people with different kinds of difficulties or disabilities is made in order to integrate them into the labour market. More about the training and its implementation can be read in the description of an Escape room project.

Escape room project

Project description

This project translates into the planning, design and development of a *Space*, where "immersive experiences" can be implemented to train young people with intellectual and developmental disabilities (IDD) equal to or greater than 60%, in themes related to social inclusion, employability and entrepreneurship.

[16] https://www.european-agency.org/country-information/reports?country%5B207%5D=207
[17] *Digital Literacy for the Labour Market* , http://w3.ese.ipsantarem.pt/literaciadigital/

This *Space*, both physical and conceptual/pedagogical, translates into the implementation of an "Escape Room" in the IPSantarém ESES[18], and comes to support, in a first phase, the first edition of digital literacy training for the labour market, particularly with regard to the development of critical behavioural skills for employability.

Framing and description of the project

This project has its framework and is directly linked to a non-conferring degree training in "Digital Literacy for the Labour Market", carried out by ESES.

As mentioned above, training is aimed at young people with intellectual and developmental difficulties (IDD) with a disability level of 60% or more. It is an innovative, supportive, and pioneering program, the most relevant particularity of which is the first model of inclusive education training in the context of higher education for intellectual disabilities. This makes it a model of reference and training for other experiences, being the main characteristic of personal development, well-being, and social and labour inclusion from the higher education environment of the ESES. It presents itself as a replica of the model that has been operating for 12 years at the Autonomous University of Madrid, and with very good results in the market, having been naturally adapted to the Portuguese reality.

It is important to highlight that the students of this training originate in several regions besides the Region of Santarém, such as those from the Region of Lisbon or Évora.

The need to implement such a program in Portugal is associated with one of the greatest difficulties today, which is to guide young people, with IDD, with the lack of adapted vocational training response, preparing them, depending on their capacities, to be able to integrate into the labour market, allowing their partial independence. It is also important with the new legal framework, in force since January 2019 [185], which requires the hiring of people with disabilities in entities with more than 75 employees.

Having said that, we believe that the commitment to the implementation of this training is so important and is fundamental for the construction of a more inclusive society, to the extent that it is directly directed towards employability, enhancing, improving and facilitating the construction of the professional profile of each student.

This said, the specific training here abovementioned started in October 2018 and lasted until June of 2020, resulting in a two-year training program in Higher Education for young students with disabilities. It aims to promote and facilitate the social, labour and employability inclusion of these young people, through their training and development of specific skills in digital literacy tailored to the needs of the labour market in this with a view to building an adjusted professional profile.

It is intended, in this way, to promote the adjustment of the skills profile of young students to the specific needs of the market, and of companies and partner entities of training in "Digital Literacy for the Labour Market".

For the pursuit of this objective, several pedagogical approaches, members of the Study Plan, compete, highlighting here the Curricular Unit for Inclusion and Employability, which integrates various related contents and pedagogies, with the following specific objectives:

- Identify potential work contexts for internships and future employment opportunities.
- Promote interaction with partner entities to identify the needs of work contexts and their characterization.
- Develop continuous, self-directed, and autonomous learning, enabling the development of skills appropriate to work contexts.

It is in this context that the concept of Escape Room and Escape Game arises for this target audience. It is a training space where a game methodology will be put into practice, an exercise that combines a playful

[18] Instituto Politécnico de Santarém Escola Superior de Educação de Santarém

immersive experience and at the same time a very strong pedagogical purpose, specifically designed for this purpose and for this type of target audience.

Designed for small teams, it consists of experiencing immersive scenarios where the way some key behaviours are manifested under pressure or in more adverse contexts, and in a group, the environment is explored.

When entering a room, participants are confronted with the pressure of time and a goal to be achieved, reinforced by a countdown, placing them in an amplified situation of the key moments for their inclusion in the labour market, such as the interview, their first days of internship, or even their professional day-to-day life, where the time is invariably short and the environment different from the usual, and as a consequence, does not always allow us to make the best decisions.

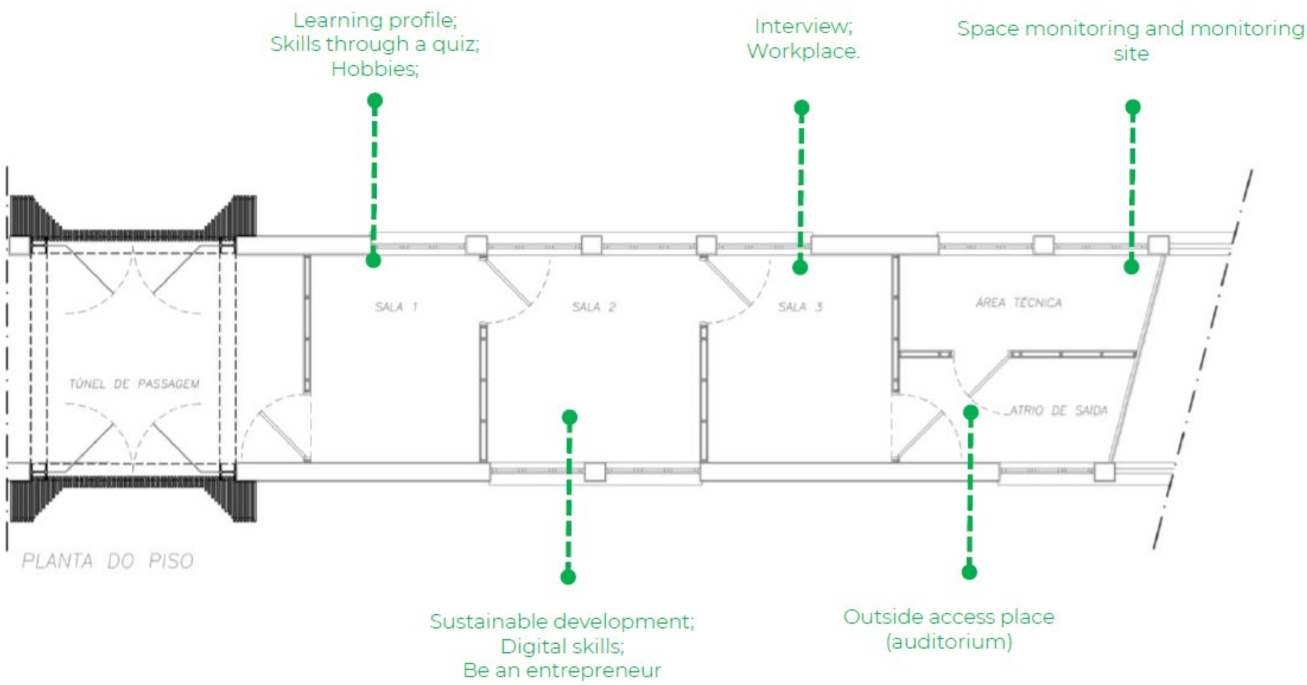


Figure 3-4 The Escape room plan

This "game" will be played in the premises of the ESES of IPSantarém, where it is intended to provide a room of technical means and materials to support the "game", but always prepared for a maximum of 20 people, divided, in the case of this Training, into teams of 2 or 3 elements each.

It is intended, and in the context of the aforementioned Training Course, to use and develop escape games (in "escape rooms") as immersive scenarios for the classroom, as part of a series of assessment activities, as a successful playful alternative to conventional study sessions and as projects to teach employability skills. With the creation of this Escape Room, it is intended to provide a methodology of learning, practical and playful, which can serve as a basis for the practical development of the skills object of work in the various curricular units for these young students.

A game example could potentially be:

Right to work - Universal

- It starts in room 1 and takes place in room 1
- As soon as they enter in room 1, they see the first clue sent to their mobile phones:
- Clue 1 - "We all have rights and duties. A fundamental document for humanity. But to do that, you need new worlds. And the article you have to send us is the 23º."

- People enter the room and settle, noticing the existing objects.
- The clues to opening the safe with padlocks are hidden in the photos and calendar. The key to opening the safe is hidden behind the photo of the coin, and 1948 is the code that opens the safe that has inside several objects and a photo with the Universal Declaration of Human Rights.
- After achieving this initial task, then they will have to look for the text of the statement on the tablet, identify Article 23 and text it to receive the next clue.

Thus, and specifically, the following objectives were built for this Escape Room and Escape Games project:

- Provide an experience that amplifies the natural behaviours of participants allowing observers a more accurate record of the reactions to the proposed challenges.
- Facilitate and accelerate the development of skills for the employability and inclusion of young people with IDD
- Provide a differentiating experience to participants in the context of behavioural training and assessment, among other exercises of analysis and development of competencies.
- Create another differentiating element of training for digital literacy for the labour market, enhancing the predisposition to carry out integrated projects, with other Higher and Polytechnic schools, as well as stimulate participation in new challenges, such as the creation of an Escape Room Challenge.

This project will last for 12 months (starting in the last months of 2019 and ending in the mid-term years of 2020) coinciding with the preparation of student traineeships for the labour market.

In short, the intention of this project is to improve and consolidate this pioneering model of Inclusive Training, which can be replicated nationally and internationally, in accordance with the principles recommended for an Inclusive Society, both in terms of technology, social, economic and employability, and based on the strategic lines of "Digital Skills for Jobs" [186].

What is it for?

This dynamic of Escape Room can, in one or two hours, highlight the natural behaviours of each person: allowing to identify personality traits, attitudes and commitment to the group; on the other hand, it allows evaluating the functioning of the team: to observe group dynamics and collective strategies more or less effective to achieve the objectives set.

After the game, conclusions are drawn from the functioning of the team and each of its elements through a powerful debrief, conducted by a teacher/trainer of the Digital Literacy Course for the job market.

Characterization and quantification of their beneficiaries

The target audience of this project are: Young adults over 18 years of age with an intellectual and developmental deficit (IDD) equal to or greater than 60%. Given its particular characteristics, it is a very special target, with specific needs and potentialities of social and labour integration, and that properly "worked", overcome intellectual, emotional and functional difficulties in favour of the construction of a professional profile of competencies adjusted to the labour market. In the first phase, the 11 participants of the Digital Literacy Course for the labour market will be used, and then be able to be applied and used to this general population.

3.3.3 Employment

Access to quality education for children is a concern of every parent, especially parents of children with disabilities and/or special education needs because they are less likely to obtain high-level academic qualifications, and thus face greater barriers for entering and remaining in the labour market [187]. Although disabled people who obtain higher education qualifications still experience labour market penalties, they are much more likely to be employed than less qualified disabled people. This proves that access to higher education is of vital importance for disabled people [177].

As it is a well-known fact, having a job is an important factor for the wellbeing of every adult. It is important because, among other reasons, it gives a person a purpose, helps to structure their life and make plans or build a social life, as well as make money. Moreover, employment is an essential element to guarantee equal opportunities for all people and contribute decisively to the full participation of citizens in economic, cultural, and social life, as well as to their personal development. Since people with disabilities, especially those with severe disabilities, form a group with high levels of unemployment (Figure 3-5), the employment is an area where there is a lot of open questions related to the integration of PWD into the ordinary work system or, if not possible, their incorporation into the productive system through the special formula of protected work. Solutions related to these open questions are the basic objectives of the employment policy for workers with disabilities [188].

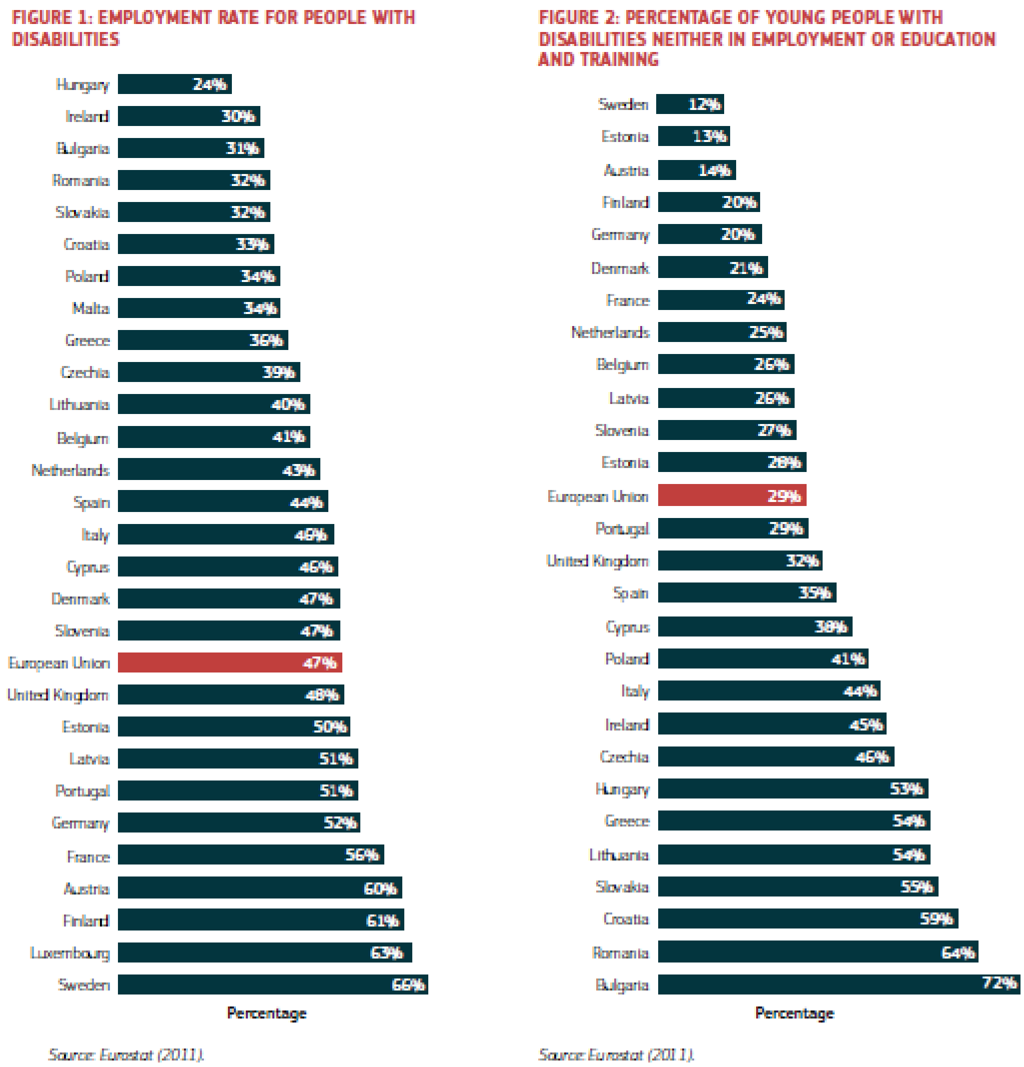


Figure 3-5 Employment rate for PWD (left) and percentage of young PWD neither in employment or education and training right) [164]

For the fulfilment of this objective, different regulations, plans of action, strategies, and laws are needed in order to contemplate different measures that promote the employment of workers with disabilities. One of the key disability initiatives in this area is the EU Directive 2000/78/EC which established a general framework for equal treatment in employment and occupation [189]. The principles of equal treatment apply not only to the equal treatment regarding employment, vocational training, and promotion but also working conditions. This means that employers shall take appropriate measures, i.e. effective and practical measures to adapt the workplace to the disability, for example adapting premises and equipment, patterns of working time, the distribution of tasks or the provision of training or integration resource etc. [189].

Today, significant progress has been made in understanding disabilities, and hopefully this positive development will continue. This is a very complex process, where appropriate and safe working conditions must be created for PWD according to their rights for employment. Their work also needs social utility, not to mention that their salaries and other benefits must not fall behind their peers without disabilities. In addition, society should help as much as possible in their independent living. In the 21st century, they cannot be hidden, and their inclusion will be exemplary for the growing generations. The European Union has made an extraordinary advance on social inclusion and the rights of people with disabilities since its foundation. New technologies and ICT will give us new tools to improve their quality of life and provide better opportunities for employment. The social role of multinational companies is exemplary. European Association of Service providers for Persons with Disabilities (EASPD) and the European Union of Supported Employment (EUSE) regularly overview the best practices for employing PWD in Europe [190], [191].

Being socially inclusive for an enterprise is all about including people from any type of background, ethnicity, gender, social status and with or without disabilities. However, in this case, the enterprise must define its own and unique culture, which can bring an advantageable scenario for their own employees despite their personal profile. Specifically, people with disabilities who wish to have the same opportunities as other employees have.

Open Market Supported Employment[19], Adaptation of Jobs and Elimination of Architectural Barriers, and Inclusive Employer Brand, which aims to recognise and distinguish open and inclusive management practices developed by employers in relation to persons with disabilities [192], are just some of the good examples of the inclusive employability mechanisms.

Many European countries are also trying to get companies to employ people with disabilities through positive incentives, wage subsidies or contributions.

Below are described some good practice examples from some INNOSID countries.

Good practice example

In Spain, the regulation considers measures such as the establishment of a system of labour intermediation, employment with support, labour enclaves, or the regulation of positive action measures in active employment policies (job reservation, hiring subsidies, bonuses in Social Security contributions, tax relief, etc.) [188]. The Spanish Ministry of Health, Consumption and Social has different types of initiatives aimed at promoting the employment of PWD. These initiatives are grouped as they are intended to facilitate the incorporation into ordinary employment, or into protected employment. There are other measures, such as occupational centres, which are not properly an employment modality, but an assistance activity [193].

ICT workshops from Spain

As mentioned, Occupational Centres in Spain are types of measures for the integration of PWD in the employment system, which are not exactly an employment modality, but an assistance activity. They are defined as "establishments of occupational therapy services and personal and social adjustment for disabled when at

[19] The definition of 'supported employment' is "providing support to people with disabilities or other disadvantaged groups to secure and maintain paid employment in the open labour market" (European Union of Supported Employment 2005).

the degree of their disability cannot be integrated into a company or a special employment centre. Its aim is the personal development of people with disabilities." [194].

Polytechnic University of Valencia (UPV) has been organizing various workshops related to ICT since 2012, in close collaboration with the Occupational Centre for people with disabilities "La Torre" in Valencia. The main objective of these workshops has been to increase personal autonomy, which leads to a parallel increase in the self-esteem and well-being of the person [195], [196]. Figure 3-6 shows several users of the Occupational Centre for people with disabilities "La Torre" in Valencia participating in various workshops related to Radio, Information Technology and Social Networks.

It is of great importance to emphasize that in all these workshops, not only people with disabilities learn and develop new skills and abilities. Professionals, volunteers, support people and supervisors who assist them every day also benefit from new forms of psychomotor stimulation, communication, establishing social links, etc. These workshops present a 360º process where all participants learn what the added value of these workshops is.

Figure 3-6 Workshops at the Occupational Centre "La Torre"

Another example of a workshop organized by UPV and Occupational Centre is related to an emerging technology known as 3D printing. In this workshop, various articles of use and consumption are being produced whose sale constitutes an important source of income for its normal functioning, the knowledge and mastery of 3D printing techniques.



Figure 3-7 Users from the Occupational Centre "La Torre" attending the 3D Printing Workshop at the UPV, Valencia

Social, digital, and labour inclusion of PWD

Regarding different initiatives and strategies that promote the social, digital, and labour inclusion of people with disabilities in Portugal, the following can be highlighted:

a) *Digital citizenship* – The Portuguese government considered digital accessibility as one of the priorities for PWD. In this sense, some tools and mechanisms (mostly online portals) were developed that would facilitate access to digital information were developed [192]. These strategies are in line with the EU Directive on web accessibility [162].
b) *Quota system for PWD* – It is a system of employment quotas covering PWD with a degree of disability equal to or greater than 60%, which aims at their hiring by private sector employers and public sector bodies [192].
c) *Changes in social protection area* – the recent introduction of new benefits and social responses, more in line with the perspective of human rights, was positively registered, such as *Social Services for Inclusion and the Support Model for Independent Living*. However, more conventional social responses such as *Occupational Activity Centres* and *Residential Homes* registered growth trends, both in terms of the number of equipment and the number of vacancies [197].

Initiatives and strategies implemented to help families, and wider communities of PWD in their social inclusion, are some of the factors that affected the Portuguese inclusive scenario and its evolution over the years. Now, for example, there is the National Institute for Rehabilitation responsible for boosting training activities and development of all resources and practices related to PWD. This social body has been collaborating with other entities to respond to the needs of families that include people with disabilities.

Good practices for employment strategies for PWD

Hungary has a regulation in place from the 1st of January 2019 where any company can employ disabled people or people with disabilities without a contribution if the salary is less than twice the minimum wage [198]. The International Conference on Creating Value ÉRTÉKPLACC has recently been held related to this topic on 17-18th of January 2020, in Castle Garden Bazaar, Budapest. The main goal of the conference was to present good practices in the employment of PWDs through examples of Hungarian and international companies [199].

Here are some Hungarian good practices related to employment strategies for PWD:

Regional Association of Visually Impaired

The management, staff and volunteers of Regional Association of Visually Impaired consider it important to develop a positive attitude towards visually impaired people at all levels of society; therefore, they place special emphasis on sensitizing and informing the people without disabilities. Through their programs, they try to bring the participants closer to the blind and partially sighted people, providing them with different experiences. Their programs consist of multiple groups depending on the participant's age. The target groups are companies that already employ or plan to employ a disabled worker, educators, bank, health or tourism employees [200].

Salva Vita Foundation

Salva Vita Foundation was established in 1993 with the mission to foster the social inclusion of disabled people and to build a more diverse society. Three years later, the Work Experience Program was developed to help students with learning disabilities to prepare for work and give them the opportunity to gain some real work experience during school years. In the program, they have the opportunity to complete practical training periods at various companies. In small groups and accompanied by a mentor, participants can get familiar with several workplaces and jobs; they learn to meet the workplace expectations and get to experience diverse company cultures. It helps them decide on their choice of career and gives them some very useful work experience before they start looking for a job. The scope of consultant and mentor activities is limited to the capital. The methodology of Supported Employment was tailored to the Hungary and remodelled in accordance with the special needs of people with various disabilities. Supported Employment (developed in the U.S.) is a highly personalized methodology that provides tailored support for both the employers and those looking for a job [201].

The Disability-friendly Workplace Recognition

Salva Vita, the Ministry of Human Resources, Hungarian Association for Excellence and American Chamber of Commerce in Hungary founded the award titled The Disability-friendly Workplace Recognition. It is given to companies that demonstrate an outstanding commitment to employing disabled people. The Award raises the reputation of the company recognizing it as a responsible employer. The Employers' Award (The Disability-friendly Workplace Recognition) has dual aims. Using the Award Logo, it supports bringing together the disabled job seekers and employers who are ready to employ them. On the other hand, it rewards employers who are committed to best practices regarding disability in the workplace. Receiving the award, the employer becomes entitled to use the Award Logo for 2 years. In recent years, besides the multinational companies (e. g. Spar, Auchan, Tesco, Morgan Stanley, IBM, Rossmann, Telecom), smaller family businesses have also been placed among the winners [202], [203].

The Baltazar Theatre

The Baltazar Theatre, founded in January 1998, is the one and only professional theatre company in Hungary whose members are mentally challenged actors and actresses. The Baltazar Theatre Foundation, which runs the theatre company, breaks new ground by putting actors' disabilities aside while emphasizing their talent.

Figure 3-8 The promotion of performance Pitypang/Por by Baltazar Theatre, its premier was 12th December 2019 [205]

They create the conditions for disabled people to earn a living from their talent. Their work is based on the ambition that their performances should not be prepared and presented as social exclusion and should not be judged by a relative standard but by their own values. The company, through its operation, would like to establish a culture that offers disabled people the possibility for social integration. Its aim is to ensure that social discrimination of disabled people disappears. The company wants to attract the widest audience possible. Besides regular theatregoers, they would like to involve people who do not go to the theatre but whose social sensitivity is aroused by the performances of the Baltazar Theatre [204].

Figure 3-9 A scene of the performance on Theatre's night in 2019 [205]

Its education programme was launched in 1999, taking a completely new approach. Further training for people with special needs is still unresolved. It is not possible to choose between professions or educational institutions. Apart from art therapy, there was no high standard of art education. [204].

The Baltazar Theatre Foundation feels it has a duty to develop a notion about the disabled society free from prejudices. People can be strongly affected by feelings – by art [205].

Hungarian individuals' examples for the employment of PWD

Kockacsoki

There is an example where a family starts a business that can also employ a family member with a disability. Chocolate manufacturing business Kockacsoki [206] offers high-quality handmade chocolate products and chocolate-making workshops, but they are more than an average business. The owners also have personal experience in dealing with a disabled person, as their older son has autism, so the main goal was to start a business that helps people with autism. They have been very careful to provide a quality, marketable product regardless of the added value [207].

Figure 3-10 the professional products of the Kockacsoki's business using Belgian chocolate [206]

Never Give up

Café and restaurant Never Give up is the first catering service founded by people with disabilities in Budapest. Besides hospitality, they show responsibility in organizing community programs (exhibitions, literary evenings, concerts) as well.

Most of their staff are PWDs or people with reduced working capacity. They are proud that many taboos have been broken. They believe it is important to have a bridge between people with and without disabilities, and they do exactly that by establishing a direct encounter and a connection between the two worlds [208].

The initiative is supported by the European Social Fund and Government of Hungary.

Figure 3-11 The staff of restaurant Never Give up [208]

There are some similar initiatives in larger rural cities, e.g. Hatpöttyös Restaurant in Székesfehérvár [209].

3.3.4 Independent living

Support for independent living is also important for both elderly and people with disabilities as this increases the self-esteem of persons affected.

Hungarian example of the living situation of PWD

An example of an online material that can help people with disabilities to cook independently is *Easy Cook Book*, the first easy to read online cookbook published. This cookbook contains many recipes of Hungarian meals with detailed description and picture of every recipe step.

Figure 3-12 Cover of the first easy-to-read cookbook [210]

But not all persons with disabilities are capable of independent living. Those who required support in their living, the best solution is subsidized housing, where 8-12 persons are living together. The Fény Felé Foundation (in English: Towards Light) has a wide range of activities, they maintain a house in the Debrecen suburbs, and they have started to build a new one named as a Treasure chest.

Figure 3-13 The Building of House Treasure chest has been completed thanks to sufficient financial support [211]

Figure 3-14 The Lavender bags are brick tickets for House Treasure chest. Buying them can support the building process. Lavender was grown in the courtyard of the Foundation's Day-care centre, and the watering, harvesting, drying and processing was made by persons under care. The needlework on bags was also made by them with great care [212].

Foundation's Creative studio engage in craft activities, such as weaving, knitting, crocheting, tailoring, sewing, preparing materials according to the ability of the persons under care. They do so on a commercial basis to reach earnings. The Foundation operates a gift shop in the centre of Debrecen, and a web shop as well [212].

3.4 Raising awareness about the needs and rights of people with disabilities

As it is highlighted in the UN's Convention on the Rights of Persons with Disabilities [20], despite various instruments and undertakings, people with disabilities continue to face barriers in equal participation in society, and their rights are still violated across the globe. The promotion and protection of PWD's rights are also recognized and highlighted as a very important factor in this fight for basic human rights and is still needed. The society still needs to be concerned about the difficult conditions related to multiple or aggravated forms of discrimination based on race, colour, sex, language, religion, political or other opinions, etc. [20]. Sometimes it seems that people are not aware of the situations happening around them enough to think or want to do something about it (or stop doing what they may be doing wrong), which could make the world a better place for everyone. CRPD's Article 8 fits well into the abovementioned because it mentions the next measures to be adopted by the States Parties:

a) To raise awareness throughout society, including at the family level, regarding persons with disabilities, and to foster respect for the rights and dignity of persons with disabilities.

b) To combat stereotypes, prejudices and harmful practices relating to persons with disabilities, including those based on sex and age, in all areas of life.

c) To promote awareness of the capabilities and contributions of persons with disabilities.

3.4.1 Discrimination – main barrier towards full inclusion of people with disabilities

Over the years, there have been numerous challenges that people with disabilities and their families face. However, some of these challenges are more pronounced than others. One of the main problems that the disabled community faces is discrimination.

According to Great Britain's Equality and Human Rights Commission [213], disability discrimination is "when you are treated less well or put at a disadvantage for the reason that relates to your disability in one of the situations covered by the Equality Act[20]". According to the Equality Act, there are six main types of disability discrimination: *direct discrimination, indirect discrimination, failure to make reasonable adjustments, discrimination arising from disability, harassment,* and *victimisation*. The discrimination that people with disabilities and their families face arises in several ways, but there is a greater degree of focus on *social interaction scenarios*, *access to education* and *employment*. In addition to these challenges, other fears that families face is the fact that their families with disabilities are handed over to institutions, social activity centres, homes or other entities that do not always register the necessary conditions to provide a productive environment for this type of audience.

Connected with *social interaction scenarios*, there are numerous examples of people willing to help a person with a disability when they notice her/him, but in most cases they actually do not know what the right approach (even though they think they know) is. Because of that, it is not a rarity that both person willing to help and person with a disability, find themselves in an unpleasant situation. The best approach would be to, first, ask a person with a disability if she/he needs help at all, and if she/he answers yes, then the next step would be to ask HOW.

Serious games for raising awareness about people with disabilities

Serious games are games which, besides entertainment, have other primary purposes that focus on enhancing existing or acquiring new skills [214]. A, perhaps, unusual domain for serious games is social inclusion for people with disabilities. As it has been proven that serious games, having the entertainment element, intrigue the user and improve the learning process, it is only logical to use them for this purpose. Sensitization about people with disabilities can be achieved by raising awareness about them. The goal of increasing the engagement and motivation of people without disabilities could be achieved by developing a domain-specific serious game that would transfer knowledge on their disability, on barriers they face, on how to help them in various everyday situations etc. Although this area of serious games' application is relatively new, as the next few examples will illustrate, a number of them have already been developed and show promising results.

[20] https://www.legislation.gov.uk/ukpga/2010/15/contents

People with disabilities approach helper ("Susretnica" in Croatian)

People with disabilities approach helper is a serious game developed in Unity, making it suitable for multiple platforms. The name "Susretnica" refers to an encounter between a person with and without disabilities. The application serves as a social etiquette providing insight on how to behave in everyday situations that include people with disabilities. In our daily routines, we often come across a person with a disability, who is perhaps, in need of our help. The goal of the application is to teach the user how to behave in these situations. The application is being developed in cooperation with multiple associations and organizations of people with various disabilities who provided knowledge implemented in the application. It includes many different scenarios depicting interaction between the user's avatar and a person with a disability.

Figure 3-15 An example of a scenario when a person meets a blind person at the intersection with traffic lights

One example of a scenario is shown in Figure 3-15. The application gives advice on how to approach and how to act using animations and game-based elements. It presents two crucial questions used to establish communication between a person with and without disability: "Do you need help?" and "How can I help You?". Hopefully, after playing this application, people will be more open to helping those in need as well as more confident in approaching them, considering they acquired the knowledge on how to do that.

Susretnica is part of the *Accessibility of mobile applications and raising public awareness of the challenges people with disabilities face* project ("Pristupačnost mobilnih aplikacija i povećanje društvene svijesti o izazovima s kojima se susreću osobe s invaliditetom" in Croatian)[21] and is being developed as a result of cooperation between the University of Zagreb, Faculty of Electrical Engineering and Computing and Croatian Regulatory Authority for Network Industries (HAKOM).

Let's talk with pictures ("Pričajmo slikama" in Croatian)

We live in a world where we communicate intensively with speech, text and video messages. However, there are people who have difficulties in communicating by using classic communication channels due to different impairments in the production or comprehension of spoken or written language. To replace speech or writing communication devices, systems, strategies and tools known as augmentative and alternative communication have been used for quite some time now. The application Let's talk with pictures is a serious game that uses graphic symbols, which have been agreed upon to universally represent specific words, for communication. The fact that we use these symbols daily by, for example, adding emoticons into messages, may come as a surprise for some, but it proves that communication can be improved and made clearer when the visual stimulus is used.

[21] http://usluge.ict-aac.hr/pristupacni-web-2/o-projektu/

Let's talk with pictures enables the user to find and recognize a connection between a textual description and a visual representation using game-based elements. The user is presented with a house-ground plan and is required to move around and perform everyday tasks. The next level of the game puts the user in an every-day scenario in a store where customers that have complex communication needs ask for different help, and the user needs to help them by using symbols. The last level is a quiz through which the user can learn interesting facts about Augmentative and Alternative Communication (AAC). This serious game is one of the many applications developed within the work of ICT-AAC Competence network described in chapter 4.2 and is available online[22] on its official website.

Figure 3-16 Second level of the Let's talk with the picture serious game for raising awareness about AAC

HAKOM Quiz ("HAKOM Kviz" in Croatian)

Within the cooperation of the Croatian Regulatory Authority for Network Industries (HAKOM) and the University of Zagreb Faculty of Electrical Engineering and Computing (FER), the HAKOM Quiz application was developed in the form of an interactive quiz with questions about user rights in the electronic communications. While answering the quiz questions, the user can activate simulations of different motor, visual or cognitive impairments, and thereby gain a better understanding of how people with these impairments experience the web page. Besides the simulated impairment description, the website accessibility guidelines for designers are provided, encouraging them to follow them in their own work. Therefore, the awareness about accessibility on the Internet is being raised. The Quiz is available online on the next link: http://pristupacnost.hakom.hr.

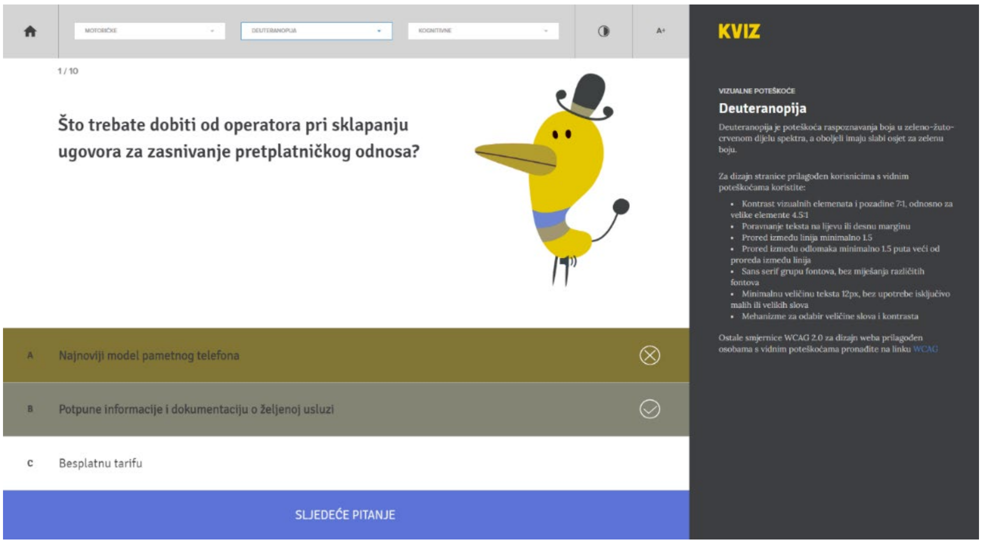


Figure 3-17 The screen of the Quiz with turned on simulation for deuteranopia which is a type of color blindness

[22] http://usluge.ict-aac.hr/pricajmo-slikama

In addition, when speaking or writing about people with disabilities, one should know that it is important to put the person first and not to use terms that could be disrespectful or even insulting. Some of the terms that are no longer in use are: *the handicapped*, *the disabled*, *cripple* etc. An appropriate term for all of these is a *disabled person* or *person with a disability*. The National Centre on Birth Defects and Developmental Disabilities[23], one of the entities within the Centres for Disease Control and Prevention[24] from the United States, brings an idea of using the "people-first language" to communicate appropriately and respectfully about PWD. Table 3-1 provides practical tips one can follow when communicating about PWD.

Table 3-1 Some general suggestions from the National Centre on Birth Defects and Developmental Disabilities for communicating about people with disabilities. More information can be found here: https://www.cdc.gov/ncbddd/disabilityandhealth/materials/factsheets/fs-communicating-with-people.html

Suggestions	Good examples	Bad examples
Emphasize abilities, not limitations	Person who uses a device to speak	Can't talk, mute
Do not suggest the lack of something	A person with a disability	Disabled, handicapped
Emphasize the need for accessibility	Accessible parking	Handicapped parking
Refrain from the use of offensive language	A person with a physical disability	Crippled, deformed, invalid
Avoid negative stereotypes	A person without a disability	Normal person, healthy person
Do not portray people with disabilities as inspirational only because of their disability	A person who is successful, productive	Has overcome his/her disability, is courageous

Discrimination complaints

According to report [215], there were 270 complaints related to discrimination on the basis of disability in 2017 in Portugal. The fields that got most complaints of discriminatory attitudes or behaviours towards PWD were:

- ACCESSIBILITY (a total of 70 complaints).
- EDUCATION (a total of 44 complaints).
- HEALTH (a record of 34 complaints).

Furthermore, it is possible to verify that 102 complaints of discrimination were made in the field "other limitations in the exercise of rights".

Thus, by conducting a deeper analysis of the nature of these data and according to the data collection from [216] it is possible to specify that discriminatory attitudes towards these groups at risk, including people with disabilities, go through the societal situation in which they are inserted, since 65% of the people surveyed in Portugal consider that they have been discriminated against on the basis of disability, which is above the EU average (50%) [216].

Many of the discriminatory attitudes lie, in terms of a basis, in the very disability that the person presents. In this way, they are hindering their opportunities for greater social inclusion, both in terms of access and opportunities.

However, on the topic of discrimination, between 2009-2018 Portugal recorded a 1937% increase in complaints about discrimination based on disability, from 41 to 835 complaints. This increase seems to reflect greater

[23] https://www.cdc.gov/ncbddd/index.html
[24] https://www.cdc.gov

awareness on the part of people with disabilities and their network about their rights and legal mechanisms at their disposal [197].

3.4.2 Importance of parents, families, and community engagement for inclusion

As it is stated in [217], UNICEF and other agencies and governments have recognized that there is still a negative attitude of parents towards inclusion which is probably influenced by **lack of awareness** of their children's rights. There are other reasons that can be identified as barriers towards their inclusion, such as fear of stigmatization and hostility from within their communities, lack of the awareness of the educational alternatives for their children, poverty motivating placement in special residential schools etc. This is why it is necessary to address concerns of families and help them in a way to provide the necessary training, support and empowerment so that they understand their children's rights and can be included in the decisions for inclusive dynamics in schools and communities [217].

A very important factor for the implementation of inclusive education for children with disabilities is to engage with parents, families, and community organizations in the process. Different approaches to engage with them can be used to support the inclusion and to make it effective and meaningful for all parties. The most frequent recommendations to engage parents and the community are the next ones [217]: providing support and regular training to parents, facilitating regular access to information and consultation, and creating a friendly institutional environment. Local communities should use the lifelong education in order to broaden the knowledge on the social inclusion of PWD so that the active citizenship is promoted, and equal opportunities ensured for all members of the community, including the PWD.

Other than obvious benefits for the children with disabilities if they are included in a school where they are welcomed and where there is a social and educational atmosphere, there are gains for other parties if they are engaged. For example, parents increase interaction with their children and become more sensitive to their needs and more confident in their parenting skills, teachers better understand families' culture and diversity as well as feel more comfortable at work, and as far as schools are concerned, by involving parents and the community, they tend to establish a better reputation in the community [217].

People with disabilities and their families have a crucial role in raising awareness about the needs of the PWD. They also can help each other and other families to get the support, information, and practical advice. It is not uncommon that the majority of organizations for PWD are led by the family members of PWD.

People with disabilities and their families can take part in various research, individually or via association like it is the case in the INNOSID project. PWD and their families will be one of the crucial stakeholders since all application developed as a part of the project are intended for them to use. Their input and evaluation of those applications are of great importance.

From parental engagement to social innovation

Twenty years ago, in Croatia, it was a rarity to have people (children) with disabilities involved in the kindergarten, and in regular primary and secondary school classes. Students with motor disabilities were involved in schools first, then deaf and hard of hearing students. They were followed by the inclusion of children with intellectual disabilities, Down syndrome, blind children, and children with autism spectrum disorder as well as children with multiple disabilities. Some highly active parents and professionals in non-governmental organizations (NGOs) have made great steps in several areas important for the inclusion of people with disabilities. Previously mentioned parents used experience from other EU countries and from the USA and tried to implement some good practices in Croatia. Books from those countries helped so much in everyday work, preparation for work and for educational materials. The examples of books are shown in the figure below.

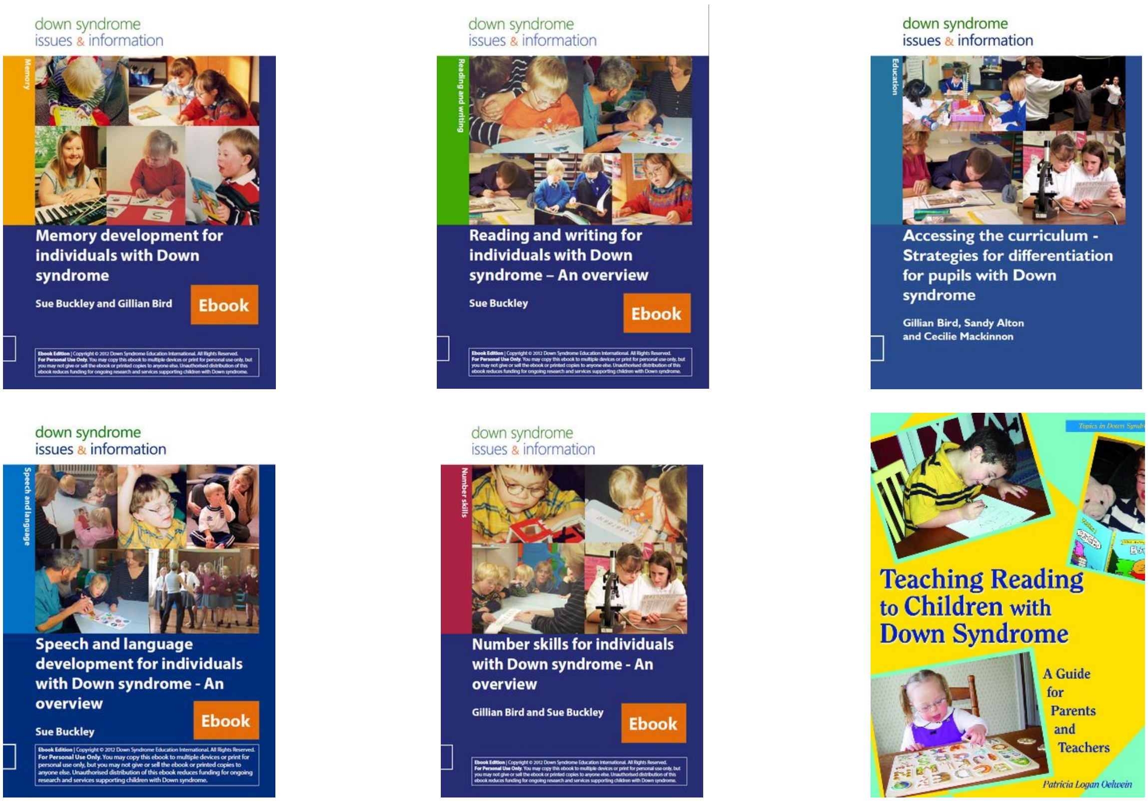
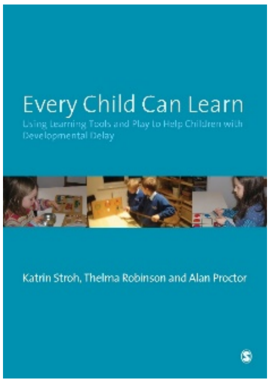


Figure 3-18 Examples of books that were very helpful to parents in Croatia [218]–[223]

Children with disabilities and their parents need support and help from the first year of a child's life. Active parents learned the most important steps for working with their children and prepared educational materials according to world literature and the experiences of experts from other countries. Several experts helped and guided the parents on how to work and learn with their children. Parents spent a lot of time preparing materials and adapting them to their children. Each material had to be prepared either by hand or on a computer, then printed, plasticized, and finally cut, folded, and then used only with own child. Examples of prepared materials are shown in Figure 3-19.

Figure 3-19 Examples of materials prepared for working with a child with a disability in different contexts



"Every child can learn" book [224] explains the way of learning and how to use learning tools in the method called "Functional learning" for the children with disabilities. That method helped many children with disabilities, even children with multiple difficulties. The principle of the learning tools was used in the requirements specification for the development of first mobile applications in Croatia. Learning tools include paring, matching, sorting, and sequencing, and these principles are today used in applications in a similar way as they were used when working with printed materials. The learning desk has been replaced by a tablet screen.

The educational material created for the child should be permanent because learning with a child with disabilities is often long-lasting, and the same material can be used in various situations during learning even for the school subjects. According to parents' reviews, one of the best tools for the preparation of educational materials is the Boardmaker[25] software from the USA. This software allows the creation of printed material such as communication boards, dictionary words, etc. with graphic symbols supported in 44 languages. Now about 44 000 symbols are ready for use in the preparation of educational material in printed form or on a computer screen.

The continuous challenges of learning with children have prompted a lot of new ideas in parents, as well as new ways of encouraging the child, looking for ways how to adapt work and educational materials. Information and communication technology (ICT) have made it much easier for the parents and professionals to improve and be creative in their activities, to create educational materials and design new ways of learning. Many ideas have translated into new applications for computers, tablets, and smartphones. One such example is shown in Figure 3-20.

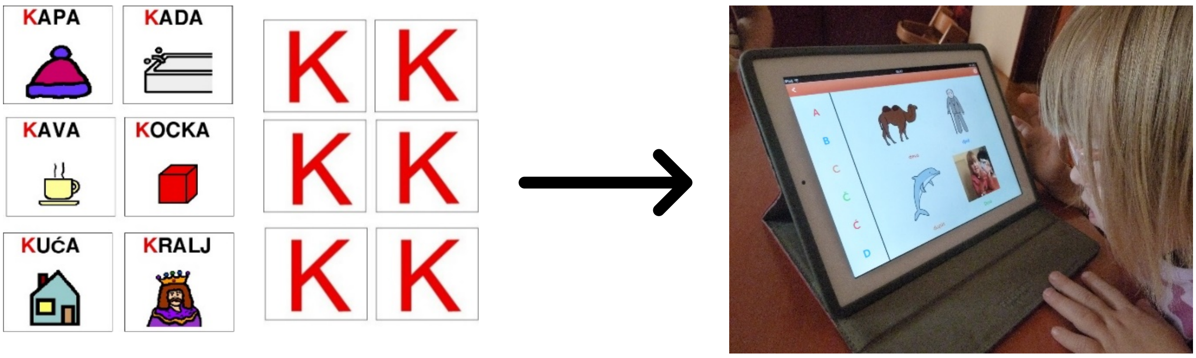


Figure 3-20 Example: from an idea to a mobile application

Following good practices and examples from other countries, one NGO from Croatia (Croatian Down Syndrome Association, CDSA) learned a lot. In addition, CDSA learned a lot from their own experiences. The experience and knowledge gathered in practice, the members of CDSA translated into u handbook for parents and professionals with the goal of improving the quality of life of people with Down syndrome [225].

[25] https://goboardmaker.com/

Hungarian examples

Teacher training

The social venues of sensitization are community spaces. These include educational institutions that require trained educators who give support to children with disabilities and their families as well. Here is an example of one such:

The Teacher Training Centre of the University of Debrecen (UD) pays special attention to the methodological training for educating teachers. To this end, they developed a curriculum entitled *Development of pupils with special educational needs* [226] and another one for regular teacher students entitled *Pedagogy of special treatment* [227]. All undergraduate students have access to an elective course that addresses common sensitization topics (such as Animal Assisted Therapy) but also introduces them with the basics of sign language communication [227].

In addition to teacher training, the UD also plays an important role in the education of the university community by establishing the Mental Health Centre in 2010, where various skills are developed, and sensitization training is conducted (self-awareness, communication skills, stress and conflict management, equal opportunities) [228]. In addition to various community-building events, they also organize a Mental Hygiene Film Club with discussions, Mental Café informal talks, and open university lectures on partner relationships.

Communicator

The National Association for the Advocacy of People with Intellectual Disabilities and their Helpers (ÉFOÉSZ) was established in 1981 on the initiative of parents. Their activities are nationwide, but they have member organizations in all countries. ÉFOÉSZ focuses on ICT accessibility and intellectual disabilities. Under the ÉFOÉSZ guidance, the first Hungarian free of charge mobile application was completed, and the organization's first IT training specifically for people with intellectual disabilities was launched. The application is particularly great because it was made with an easy-to-understand communication method thanks to representation of daily used terms by icons [229].

Figure 3-21 Some screenshots of mobile application: daily routine, request for help, shopping and paying [230]

ÉFOÉSZ is the only one in the country to provide easy-to-understand translations. They have created accessible and easy-to-understand websites and publications for many institutions and organizations, such as the Convention on the Rights of Persons with Disabilities [231].

3.4.3 Sensitization about people with disabilities

Sensitization can be defined as conscious or unconscious, planned, or spontaneous influencing, education that, through its attitude-forming effect, raises awareness, empathy, and acceptance of deviations from the "normal" and the ordinary. Thus, sensitization can lead to the acceptance of any physical or mental disorder or a permanent and unchangeable state of being, basically through an experiencing catharsis [180].

A negative attitude toward disability is one of the barriers for people with disabilities (PWD) in achieving social equality. Sensitization and education of persons without disabilities are necessary to make them understand the notion of discrimination, to become aware of its existence and of themselves as discriminators in certain situations. However, it is also important to provide PWD with relevant education and information about sensitization, to inform them timely about their rights, regulations, and changes in regulations in order to enable them to understand the mechanism of discrimination. And finally, society needs to be aware of the necessity and opportunity to actively fight exclusion [180].

The Disability Intergroup of the European Parliament is an informal grouping of people from all nationalities including political groups who are interested in promoting the disability policy in their work at the European Parliament as well as at the national level [179]. Since its foundation (1980) it endeavours to hold a serious and fruitful dialogue with all persons with disabilities and their representative organizations. The European Disability Forum (EDF), as the umbrella organization defending the interests of 80 million persons with disabilities in Europe, cooperates closely with the Disability Intergroup and acts as its Secretariat [159].

Sensitization in Hungary

The Convention on the Rights of Persons with Disabilities (CRPD) and its Optional Protocol was adopted in 2006 and was signed by Hungary in 2007 [232]. With this, Hungary, among other countries, has also undertaken all kinds of accessibility obligations besides respecting citizen human rights. A previous Act (No. XXVI. of 1998) states that a person with a disability has the right to a barrier-free and safe environment, this does not mean the actual removal of barriers, nor does the Constitution and anti-discrimination laws eradicate harmful stereotypes. For a person with a disability to truly have equal opportunities in his or her life, he or she must, in the broadest sense, be surrounded by a barrier-free world (both morally and physically) [233].

Basically, the above-mentioned regulations were formulated from the perspective of people with disabilities but failed to include the other segments of society. There is no uniform regulation in Hungary regarding the sensitization and training of a healthy society beyond basic rights. In general, employers may exercise such rights, but there is no obligation for them to do so. For certain occupations (e.g. adoptive parents, foster parents, trainers, health professionals), appropriate sensitization is a part of their training [234]. For companies who wish for disabled workers to apply, it is recommended but not required to participate in the sensitization programs [235].

Lifestyle workshops – a good example

As an example, the local organization in Győr offers lifestyle workshops for adults aged 18 and over who are mentally disabled and work in groups of 10-16 people under the guidance of professionals. Workshops mentioned above are structured around 8 topics: Leisure and Scheduling, Assisted Housing, Conflict Management, Relationships, Emergencies, Abuse and Coping Strategies, Rights and Interests, and Lifestyle [236]. The presence of a trainer, a workshop assistant and a mentor are mandatory, volunteers are optional. With regard to the volunteers here, it has to be emphasized that the matriculation requirement in Hungarian high schools is 50 hours of community work since 2016. The work can be related not only to PWD, but many young people had just come in close to them for the first time [237].

People with disabilities are often prevented from engaging in social events due to their environment and behavioural barriers and are often discriminated against and excluded from society. The basis for a barrier-free society exists with the aim to raise awareness about the existing discrimination. With this in mind, manifestations are organized and can include exhibits, performances, workshops or simple stands on fairs and events. People without disabilities can get more information, or offer their expertise, help or volunteer.

The following sections show some Hungarian initiatives that have proven to be successful in the process of social sensitization and have helped greatly with creating a bridge between the disabled and non-disabled people.

Hungarian initiatives for sensitization about people with disabilities

International Chromosome Carnival

In 2016, the International Chromosome Carnival was an outstanding event with the aim to raise awareness about individuals with Down syndrome and other disabilities, difficulties and living situation of their parents, as well as the power of cooperation and support. In addition to the charity procession, the event featured various free programs, including concerts, lectures, a creative workshop and counselling.

Figure 3-22 Parade in Budapest during the II. International Chromosome Carnival in 2016. Among the participants, there were young people with autism and their families, as well as some celebrities, actors and actresses [238].

The aim of the initiative was to highlight the importance of integrating children with disabilities and their families into the society and to strengthen cooperation between national and international organizations [238]. The event conveyed an important message that life cannot exclude those with any type of disability. In 2016, the initiative won the "Project of the Year" award established by Visegrád Fund [239].

These kinds of events are often backed up by foundations and professional organizations which are dedicated to helping PWD and their families. Furthermore, providing care to children with disabilities is particularly important, and adequate care should be widely available.

Csodavár

Csodavár is an inclusive development centre and playhouse in Hungary, where professionals develop, play and emphasize family involvement and support. Personalized therapies, inclusive and modern environments, and unique, innovative solutions all contribute to the success of the development of children with disabilities. The first development centre and playhouse were opened in Nyíregyháza, and a new institution was established in Budapest in 2017. They provide early development support for over one hundred children with special educational needs. The aim of this initiative is beyond the special therapies; they aim to integrate children with special education needs with groups of children without disabilities. Besides children, this affects their families and their immediate environment, helping to promote social acceptance.

Educational institutions and nurseries have a huge impact on the children's development, however, they are not always promoting inclusion [240]. A special, inclusive playground, the Csodavár-Űrbázis, will complement the complex development needs today. There was a public community fundraising with the focus on inclusiveness from early on in 2019 [241].

Figure 3-23 Integrated music therapy in Csodavár Budapest, March 2019 [240]

NEVER GIVE UP

NEVER GIVE UP (in Hungarian: Nem Adom Fel) is not just the name of an organization in Hungary, but a spirit, a new approach to the social field that pervades this term. They aim to make disadvantaged members of society (people with disabilities, people with learning disabilities, socially disadvantaged young people, the elderly, etc.) believe in themselves and discover their talents. The band NEVER GIVE UP grew out of the Down Foundation Art Workshop, where they have been making musical and theatrical appearances together with other professional performers for many years.

Figure 3-24 The band NEVER GIVE UP on the stage on 18th January 2020 during the ÉRTÉKPLACC International Conference on Creating Value [242]

In 2003, as part of the European Year of People with Disabilities, a series of street concerts were organized, performing at major hubs in Budapest. Nowadays, music and other arts (band, Creative-Therapeutic Workshops, Concert tours), as well as some other activities (Youth Development Houses, Employment Agency Services, Intensive Therapy Days, Educational training, Summer Camps, Cafeteria and restaurant etc.) are supported by the NEVER GIVE UP foundation [242].

Hold my Hand Foundation

The Hold my Hand Foundation (in Hungarian Fogd a kezem) has long planned to launch a sensitization program to alleviate segregation, but the specific idea was formulated in 2013. In the Ability Café programme, a person with a disability can be monitored while performing a specific task, job, example. In this programme, a conclusion was drawn that catering places are the most suitable for this kind of learning experiences. The foundation put development training for young people and assessed why people with disabilities want to work and what skills they have. Their Work and Therapy Centre (Day-care Centre) hosts the volunteers to support the activities of the disabled young people through five different workshops (candle, paper, creative, household and assembly type of hired labour). In addition to professional therapists, the work is done within the cooperation with the local volunteers. Thanks to those artistic activities and performances, they can enjoy very high publicity in Pécs and in Baranya County, thereby increasing social acceptance of PWD [243].

Figure 3-25 A workshop in integrated summer camp, 2018 [243]

Figure 3-26 Some products of Day-care Centre which are available in their web shop: textile bags for environmental awareness, scented candles, decor products made of ceramic, custom jewellery, seed-papers (handmade paper products with flower seeds inside) [243]

Pet therapy helping people with disabilities in different contexts

Specialized therapies can bring society closer to PWD. Pet therapy (Animal-Assisted Therapy, shortly AAT) is a guided interaction between a person and a trained animal. The purpose of pet therapy is to help someone recover from or cope with a health problem or mental disorder. AAT is a useful supplementary treatment for individuals of nearly all ages and with many different conditions [244]. Dogs, horses and cats are most used in pet therapy that builds on the pre-existing human-animal bond. Interacting with a friendly pet can help with many physical and mental issues. It can help reduce blood pressure and improve overall cardiovascular health, also release endorphins that produce a calming effect. It can reduce stress, anxiety, and depression, and increase positivity and socialization.

For example, during the dog therapy for children diagnosed with ADHD or Asperger syndrome their symptoms were very much reduced and they have learnt to recognize their own basic feelings and to deal with emotions like anger, sadness, and fear [245]. The Foundation Csodakutya is one of the initiatives on AAT in Hungary since 2009. The volunteers with their own trained dogs participate in the foundation's activities. They namely hold regular therapeutic sessions for healthy, sick, injured, physically and mentally disabled, children with special needs and elderly people in Debrecen and Tiszaújváros. They participate in the life of the region, presenting their activities through contact experience in different events, thus promoting social acceptance of PWD [246].

Figure 3-27 The volunteer shows how to caress the therapy dog. Controlling limb spasms can be one of the goals of AAT [246]

Hungarian individuals' initiatives

Let us also remember individual initiatives, whereby someone takes on additional responsibilities because of his or her vocation, although this would not be mandatory for them.

Support for parents of children with disabilities

Virág Sárosdi is a speech therapist and special education teacher in Hungary, who is a mother of six children. In 2010, she launched her children's development blog in Hungarian to help those who would like to teach their children at home. Five years later, she continued the publication on her own website; now, the revamped site is SKILLO [247]. In addition to the free printable templates and descriptions available on the site, newsletter subscribers can access thematic and age-specific content. She regularly organizes online training and workshops. Posts with specific content are available for families with children with Down Syndrome, but also to everyone who has an interest in it, helping families not affected by Down Syndrome that can encounter similar situations during the upbringing [248].

Practices do not require any special tools; she usually uses things available in every household such as: caps, pencils, paper sheets, gravels, plastic bottles, buttons etc. In her work, she explains clearly the development methods, helping not only parents but also the rest of the family. She pays attention to fostering family relationships and accepting diversity. The headquarters of this enterprise is located in Veresegyház, but the workshops are in Budapest, and the other educational activities flow through the Internet. The online activity is highly effective, with more than 11,500 followers on different social platforms [249]–[251].

Figure 3-28 Printable schedule cards designed by Virág Sárodi. The pictograms help not only young children to develop routines, but also children with disabilities [247]

Sport therapy

Sport has repeatedly proven that it cannot only prolong a person's life but can also save it. Muay Thai Boxing Association (in Debrecen) is exemplary in providing support to sports facilities of PWD. A girl with Down syndrome started her sports activity based on a special, personalized workout plan several years ago. She is very happy to be a member of a team that treats her without prejudice about her disability. According to her trainer, the girl was carrying the load well, losing weight, her physical function was significantly improved, and Thai-boxing was mentally beneficial her. Thanks to her stamina, she defeated a serious infection. She has a place in society [252].

Figure 3-29 Erzsébet Nagy and her trainer during training in 2016 [249]

Music therapy

The sensitization and education of society are always based on committed individuals who have a great influence on the lives of smaller communities. Ágnes Kocsis as the harp teacher at the Kodály Zoltán Music High School and Music School of Debrecen, began working with two young girls with autism several years ago. Ágnes [253] graduated as a teacher of basic music studies, but she was not qualified to work with students with special needs. In her private life, she began to practice dog therapy and thus participated in several sensitization programs. She became committed to learning about autism and learnt about educational methods that could be adapted to music education helping with developing fine motor skills and creating links between written material and sound or music and spatial processing depending on neurological processes.

Figure 3-30 Petra Lövei is a young girl with autism on World Autism Day 2016 [256]. She is one of the students of Ágnes Kocsis, awarded with Special Prize of the V. National Harp Competition in 2015. Petra's developments can be followed on her YouTube channel [257].

For those who live with autism, these processes are partially inhibited, and they also have limitations in their development. The different neuroimaging techniques have been reinforcing the correlation between literacy and numeracy skills, spatial-temporal reasoning, and music education. Musical training as a complex multisensory and motor activity strengthens connections between regions of the brain. In music perception and production, for example, visual decoding, auditory perception, and fine motor systems are repeatedly activated [254]. The coloured music sheet method developed for autists was adapted to be played on a harp according to the colours of the chords of music instruments [255]. Only the C and F tones were to be coloured and parallelly a new system of hand signs was developed by Ágnes and her students. Through six years of working together, other fellow students and their families have become more receptive of people with disabilities. Despite autism, communication abilities have also evolved spectacularly, and they had been invited to several events and occasions as performers. The new teaching methods are partially built into Ágnes's regular music education programme for younger students.

In addition to the good practices detailed above, there are many other examples in Hungary that can help to support people with disabilities or to promote social acceptance of them. The authors did not intend to disadvantage other good initiatives by giving these examples.

4

Social inclusion and technology

Technology always included some sort of tools and inventions that empowered people to do and achieve more. Over the years, people who faced more challenges than others have often been the motivating factor behind innovative solutions and have always been the ultimate early adopters. Even before the first computer was presented, in 1800s Pallegrino Turri invented one of the first typewriters in order to help a blind friend communicate with the world [258].

The Internet era has given us the opportunity to feel connected and the ability to interact with one another no matter the time and place. The Internet is readily available to a significant, continuingly growing number of people including people with disabilities, as many of the Internet supporting devices and platforms have built-in accessibility features. They are providing people with disabilities the option to connect with others despite the fact that their disability has had a huge effect on their everyday lives.

"I know the positive side of the Internet seldom makes the news. They would rather focus on cyberbullying, cyberstalking, hacking, catfishing, etc. But the Internet can be a beautiful way to feel validated as a person with a disability. I believe the Internet has set people with disabilities free by connecting us with each other" [259].

In order to maintain the natural course of our everyday lives during the COVID-19 pandemic, many of our personal and professional activities have been relying on technology more than ever before. We have been constricted to our homes, and the only means of communication included the Internet. On the other hand, for some people with disabilities that include limited movement, the pandemic had little or no effect in terms of technology usage. Considering this, organizing online education courses due to restrictions regarding social distancing has proven that technology can make the learning process more accessible for everyone. For example, Croatian Ministry of Science and Education has organized virtual classrooms, distributed tablets and SIM cards to students who do not have fixed Internet access, enabled access to virtual content etc. thus reducing the barriers people with disabilities normally face [260].

"As hard as it was, I must admit that videotaped courses and digitalized textbooks, which I would normally have to find by myself, have made my situation a lot easier. Accessible content, online consultations with no waiting in lines and online courses which we could attend from the comfort of our homes have certainly had a positive impact on the lives of students with disabilities as well as everyone else's." – Croatian student with disability [261].

The benefits of mainstream technologies for people with disabilities are obvious, however technology is constantly progressing, and the effects of the so-called emerging technologies listed in chapter 2 are already starting to show.

In addition to that, as mentioned in the introduction of the report, since the United Nations Convention on the Rights of Persons with Disabilities is signed, all the States Parties are obligated "To undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies, mobility aids, devices and assistive technologies, suitable for persons with disabilities, giving priority to technologies at an affordable cost;" [20]. To recall, Assistive Technology (AT) covers an area of technological solutions dedicated to making lives of people with disabilities better. The WHO defines it as "an umbrella term covering the systems and services related to the delivery of assistive product and services". More precise definition is the one from ITU's model policy report where AT is defined as "any information and communications technology, product, device, equipment and related service used to maintain, increase, or improve the functional capabilities of individuals with specific needs or disabilities" [26].

Assistive technology solutions can be classified in various ways given the disability they refer to, or the degree of technology used (from low-tech to high-tech). In this chapter, more sophisticated AT solutions that are a result of recent technological advances, i.e. emerging technology-based (ET-based), will be described. Multiple innovative ideas and solutions involving virtual, augmented, and mixed reality have been provided in the previous text. Considering the psychomotor and intellectual stimulation they provide, experiencing this technology could have a positive impact on people with disabilities of all ages. They could also be used to enhance learning motivation in children with cognitive disabilities. Holograms could also be used in education to improve students' attention span. This technology's potential is yet to be revealed as it has only recently been utilized for this purpose. Furthermore, the Internet of Things combined with the 5G networks has a huge potential in making an impact on the lives of persons with disabilities. Smart homes and smart cities could become even smarter, allowing them to live independently. Artificial intelligence can be used in solutions like smart caption glasses offering a speech-to-text conversion for the deaf and the elderly as well as used in text-to-speech solutions for the visually impaired. These and other use cases will be described in the next chapters giving a vague idea of how big of an impact emerging technology can have on the lives of people with disabilities.

This chapter also brings an example of good practice from Croatia, that is in line with the abovementioned CRPD's obligation. The good practice relates to the good operation of the ICT-AAC Competence network[26] over the last decade and the development of the ICT-based services and solutions for Alternative and Augmentative Communication (AAC) that are used by caretakers and organizations for the inclusion of persons with complex communication needs. Examples of ICT-based AAC services include means for communication (constructing sentences/phrases, sending e-mails, surfing the web, participating in social networks), learning and entertainment. In addition to the description of the mentioned examples, it will be described which research and development activities ICT-AAC Competence network actively conducts for exploring the potential of emerging technologies for the social inclusion of PWD.

4.1 Examples of emerging technology-based solutions for social inclusion of people with disabilities

4.1.1 Virtual Reality (VR)

Out of-reach dreams come true

Depending on the type and rate of the disability, there can be just a few or many activities people with this disability cannot be involved in. There are physically disabled persons, for example, who cannot enjoy climbing a mountain, skateboarding or swimming in the sea. Virtual Reality can provide the illusion of performing these activities, which would be dangerous for them in reality (Figure 4-1).

Figure 4-1 Virtual flying with hot air balloon [262]

Virtual reality treatment for autism

VR can help gain an idea of what an environment – a busy road, for example - could be like prior to visiting it in order to prevent a person from feeling overwhelmed and anxious.

[26] http://www.ict-aac.hr/index.php/en

VR is used to help autists developing the skills necessary for independence which some take for granted. A specially designed virtual environment is perfect and safe for an autistic person to develop his skills before repeating the studied activities in reality. A team of researchers at The University of Haifa, Israel, developed a VR system to teach autistic children how to cross a road. The simulation represents a street with traffic lights and cars which the child interacts with. There are different scenarios, so the child can learn and practice how to cross the road safely without facing real danger or causing undue stress. After gaining enough virtual experience, the child can practice these skills in the real world [263].

Most autistic children struggle with social attention problems such as reading facial expressions, picking up visual cues or paying attention to others whilst they speak. To help maintain their attention, a system[27] was developed in the US equipped with a head-mounted display (HMD) which shows images from a virtual classroom with a set of 3D virtual people or avatars who deliver an individual presentation. Each of these avatars starts to fade if the child looks away or loses interest.

Turn sign language into speech

Sign language developed for deaf people enables communication, but besides them, not many understand it. This creates a barrier in their everyday life, which might soon be a thing of the past, as two undergraduates from the University of Washington have created a pair of gloves called Sign Aloud gloves that translate sign language into text or speech. Special sensors are applied to record the wearer's hand positions and movements. Recorded movements are sent via Bluetooth to a central computer, which checks whether the movements match an American Sign Language gesture. In the case of a hit, the word or phrase is spoken through a speaker. This invention can be embedded in a VR system that can offer a richer and easier adventure game experience for a deaf person [264].

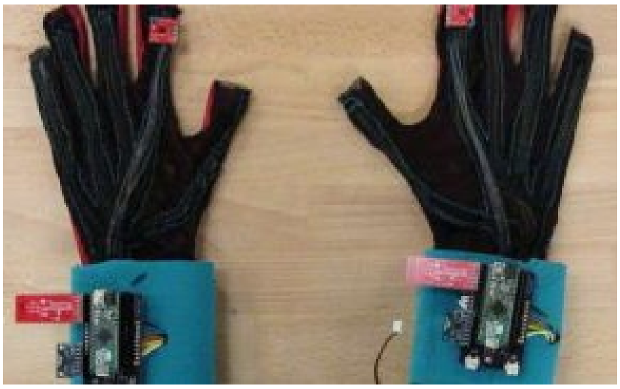


Figure 4-2 The special gloves designed to translate sign language into text or speech [264]

Augmented human beings

Not exactly an example of a VR solution, but the devices that are used in technology such as VR headsets represent the origins of the cyborg lens, an autonomous contact lens with a built-in flexible micro battery, which is developed by two teams from IMT Atlantique[28] (headed by Jean-Louis de Bougrenet[29]) and Mines Saint-Étienne[30] (headed by Thierry Djenizian[31]). This innovation illustrates a key function of augmented human beings (assisted vision) with a biosensory paradigm, as well as opening the door for scientists to develop other human-machine interfaces [265].

The innovation will allow them to "*take localized engineering to the next level*". The project has a wide range of potential uses, including helping visually impaired people. The scientists have paired up with the Institut de la Vision[32] with the aim of developing a device which can improve the sensory abilities of visually impaired people. As well as this, the cyborg lens could be used in VR headsets as a way of making visual commands [265].

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27 https://www.vrs.org.uk/virtual-reality-healthcare/autism-treatment.html
28 IMT Atlantique, https://www.imt-atlantique.fr/en
29 Jean-Louis de Bougrenet, https://blogrecherche.wp.imt.fr/en/?s=Jean-Louis+de+Bougrenet
30 Mines Saint-Étienne, https://www.mines-stetienne.fr/en/
31 Thierry Djenizian, https://blogrecherche.wp.imt.fr/en/2017/10/10/thierry-djenizian/
32 Institut de la Vision, http://www.institut-vision.org/en/on

4.1.2 Augmented Reality (AR)

Improve the independence of wheelchair users

A person who is confined to a wheelchair may not be able to reach items placed beyond an arm's reach, which limits independence in everyday activities like shopping or visiting libraries. A team of researchers has developed a system based on AR and Radio Frequency Identification (RFID) that enables the wheelchair users to interact with these unreachable items. The application runs on different interfaces and allows the user to digitally interact with the physical items on the shelf, thanks to an updated inventory provided by an RFID system. Fourteen PWD with different degrees of impairment have participated in the study, development and evaluation of the system and reported that the resulting experience was close to being able to browse a shelf on their own. They simply had to only look for AR markers on the shelf, navigate and click on items to obtain more information about the products.

Figure 4-3 shows a hand-held device pointing at the smart shelf equipped with the AR marker, and a close-up view of the hand-held screen showing the superimposed item information. This system definitely provides greater autonomy for people confined to a wheelchair in their everyday activities [266].

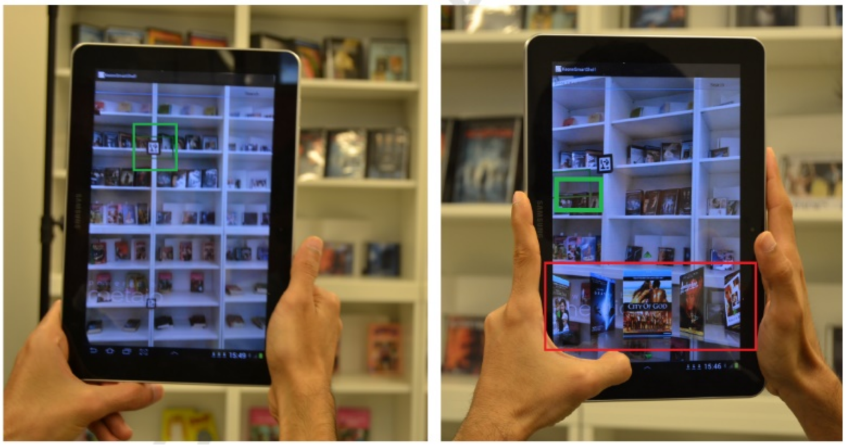


Figure 4-3 Acquiring more information via AR app [266]

AR-based teaching for children

A Taiwanese researcher team has developed a free mobile application to facilitate learning geometry for children with disabilities and to prove that the use of AR technology could enhance learning motivation and frustration tolerance in children with special education needs. The teaching material involves two games, the traditional Chinese tangram puzzle and a square puzzle game. The team developed an Aurasma AR app to provide help in solving the tasks. Children could scan the trigger image placed on a poster with a mobile device to view videos, animations or data that supported them to complete the task (Figure 4-4). The study demonstrates that AR can support intuitive and interesting learning processes for children with disabilities and/or special education needs by combining the real and virtual worlds [267].

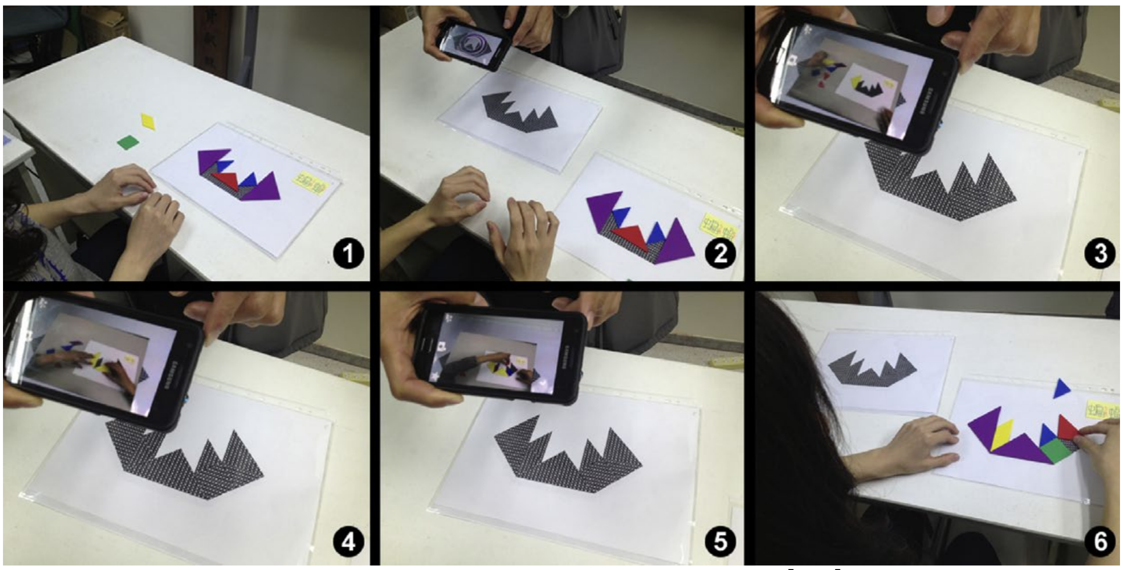


Figure 4-4 Asking for help with the application [267]

4.1.3 Mixed Reality (MR)

MR game for children with mixed abilities

Dutch researchers have designed a novel mixed reality computer game called pOwerball for children aged 8-14. The game was designed to bring together children with and without a physical or learning disability and to encourage social interactions surrounding the play. pOwerball is a tabletop tangible mixed reality flipper game for 2-4 players sitting around a table. The graphics of the game are projected on the table surface (Figure 4-5). Graphics and animations are associated with virtual artefacts but also with each physical element involved in the game. The challenge of the game is to liberate imprisoned creatures, not individually but cooperating with the other players [268].

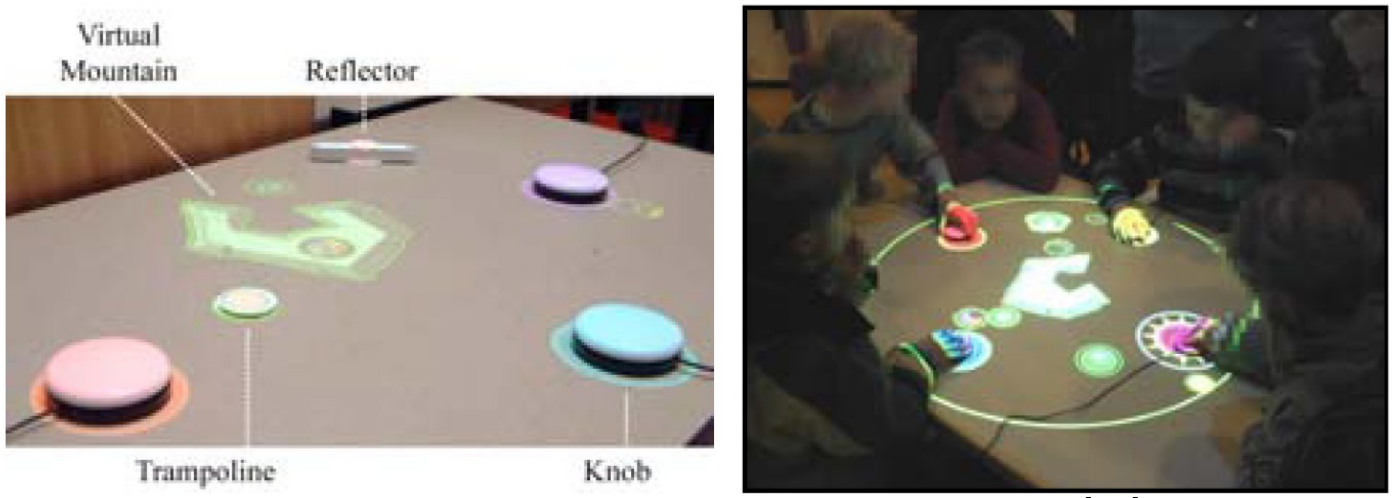


Figure 4-5 The projected tabletop of pOwerball and children playing the game [268]

Usage of emerging technologies for the stimulation of people with disabilities

The international scientific community, as well as the different professional fields related to people with disabilities, years ago, reaffirmed the need of stimulation from an early age of people affected by any type of physical or intellectual difficulty. According to professionals, it is vitally important to be able to define the type of disability that affects the person as soon as possible. This is because according to studies, the brain in the first stages of life is still in formation and an early stimulation according to the type of disability could help neural connections and counteract this disability.

This stimulation could cover the five senses through speech, various sounds, touch, etc. trying to capture the person's attention, increasing their relationship with their environment and their psychomotor processes. Likewise, the child with a disability should not be left out of participating in the activities and games traditionally performed by others. Whether in their family environment, place of residence, school, etc. And of course, in a current society where many games are electronic and/or based on the use of technologies, such as video games and consoles, they should be designed with an inclusive character.

For example, the use of video consoles can help visual and language stimulation, select those games that are appropriate to the child's cognitive level. On the other hand, ad hoc applications can be developed for this group considering its own characteristics. Virtual reality environments and applications that make use of augmented reality could be two ways of promoting this knowledge and better communication with the environment. To this end, there has been a use of emerging technologies in family and training environments since early childhood [269].

But what happens when these technologies and methodologies for stimulation are late for those who already exceed adolescence? What happens when these emerging technologies are not available to everyone? What happens to the language for its use? Who defines and how are the skills to be developed defined [270], [271]?

Spanish examples

Research applications for stimulation of people with disabilities

Since the academic year 2012-2013, Polytechnic University of Valencia (UPV) has been collaborating on various projects with training entities of the Valencian Community with the aim of responding to the previous conditions.

Students in practice, preparation of Final Degree Projects, Master's and Doctoral Thesis, have been designing, implementing and testing various interfaces and applications ad hoc with the aim of contributing to the psychomotor and intellectual stimulation of people with disabilities, regardless of their age. For example, the application "Jig Saw!" is developed to be used by the students affected by autism at the Secondary School "La Cañada", Paterna, Valencia (Figure 4-6).

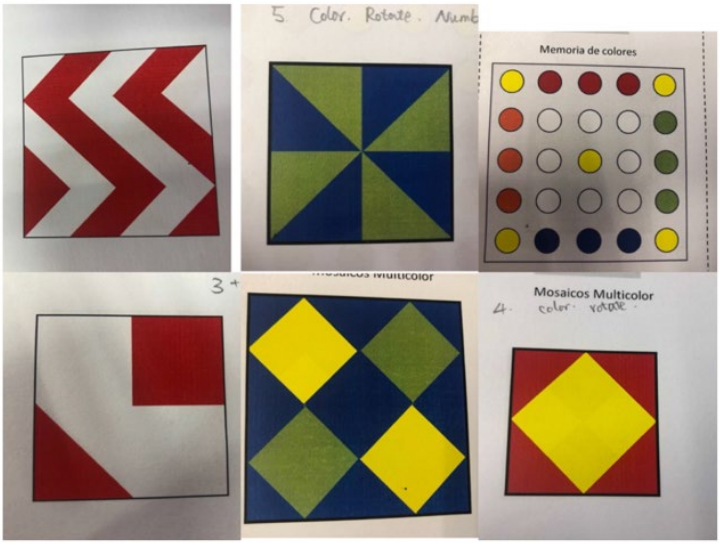


Figure 4-6 Puzzle for the ad hoc App "Jig Saw!" at the Secondary School "La Cañada", Paterna, Valencia

The application is designed according to the requirements established by the teachers who work with the students that are between 12 and 18 years of age. It has three difficulty levels that can be used according to the figure in question, the colours it may have, the time allowed the student to solve it, etc. The application has two modes: "Teacher" mode and "Student" mode (Figure 4-7). This allows the teacher (also a relative at home) to select the level, time, etc. as well as indicate the name of the student. At the end of the game, these parameters, as well as the date and the time, are recorded in order to know the results of the game and if they show progress after a certain number of game sessions.

Figure 4-7 Testing the ad hoc App "Jig Saw!" at the Secondary School "La Cañada", Paterna, Valencia

Spanish workshops for stimulation of people with intellectual disabilities

For people with disabilities, constant stimulation of the intellect is vital. Autonomy, creativity, abstract reasoning, etc., are closely related to this stimulation. That is why the emergence and popularization of products and equipment related to virtual and augmented reality are for this group an excellent way to expand in the field of stimulation [272].

Since the academic year 2012-2013, Polytechnic University of Valencia (UPV) has been participating in the organization of various workshops related to the use of virtual and augmented reality in order to contribute to the psychomotor and intellectual stimulation of people with disabilities, regardless of their age. In the example from Figure 4-8, people with intellectual disabilities from the Occupational Centre "La Torre" in Valencia visited an interactive exhibition at the UPV. Before the visit, they received an explanation about what an exhibition based on augmented reality consists of using smartphones and tablets. Also, considering their cognitive levels, the application has been downloaded for them, and its operating principles were showed to them. Technology is always something attractive and attention-grabbing. With this experience, a high stimulation of the intellect is achieved as well as social relations are favoured.

Figure 4-8 People from the Occupational Centre "La Torre" attending the Virtual & Augmented Reality Workshop at the UPV, Valencia

Also, for people coming from Occupational Centres, an ad hoc workshop has been designed in order for them to understand and use the Chroma Key techniques and the appropriate software in order to create an artistic product.

For people with intellectual disabilities, it is necessary that every day they participate in activities that stimulate their reasoning capacity, their level of abstraction and imagination. Considering the degree of disability, increasingly complex techniques such as those shown in Figure 4-9 can be used. In the case of this workshop, the Recording Studio at the Telecommunication School at the UPV was visited. Previously, the different elements used in a recording studio were explained, such as microphones, cameras, lights, mixing tables, wiring, control programs, etc., as well as the emphasizing in the Chroma Key. Examples of use were shown, such as the ones used in the cinema and its special effects, the weather forecast on TV, etc. This workshop's pioneering experience is shown in Figure 4-9.

Figure 4-9 People from the Occupational Centre "La Torre" attending the Chroma Key Workshop at the UPV, Valencia

4.1.4 Holography

Holograms represent an interesting group of technologies which have proven to be both attractive and useful. So far, no research has been conducted to show how this technology can help people with disabilities or how accessibility can be realized on holographic interfaces. Therefore, the applicability and potential of this technology for the purpose of improving the quality of life of people with disabilities is yet to be researched as well as the ways in which accessibility can be implemented into holograms.

4.1.5 Internet of Things (IoT)

Besides the wide use of IoT for various data collection and analysis leading to various applications and services, e.g., traffic-related, or climate-related, current results show that the IoT can be used to improve the social inclusion for the people with disabilities, as well as to help them with their day to day life [273]. One of the uses of IoT technology is in the concept known as the smart home. A smart home is a home equipped with the technology that can be controlled remotely, either by a human or a computer. The generalizes schematic of a smart home is depicted in Figure 4-10.

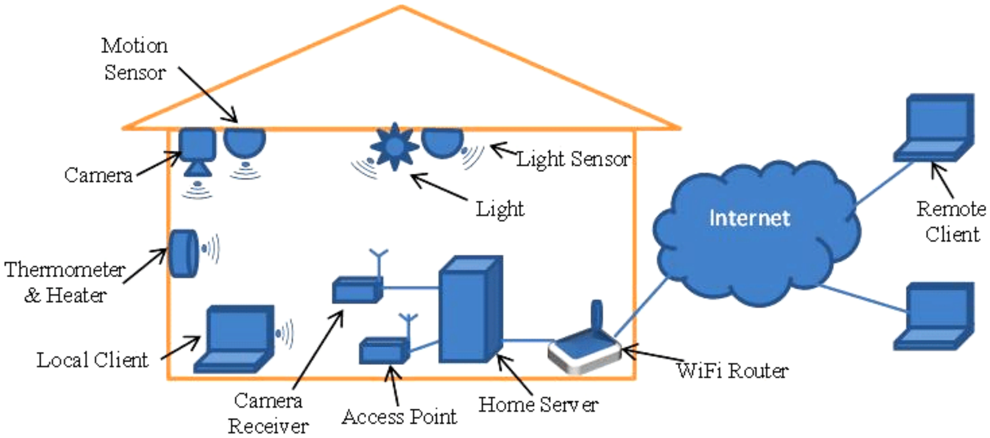


Figure 4-10 Smart home general architecture (taken from [274])

Smart homes are often suggested for elderly people, and people with disabilities since each home can be personalized to satisfy the specific needs of an individual. Most common features of smart homes are the light control, e.g., dimming the light, change in a light colour, or switching the light on/off, managing door locks, automation of curtains and blinds, security cameras, motion detectors, and CO sensors. When all the above is available, the next step is to figure out how can those technologies be used to help with the social inclusion of people with disabilities. Those concepts are known as Ambient Assisted Living (AAL).

Experiment'Haal platform

The Experiment'Haal (Human Ambient Assisted Living) platform[33] is a project which uses the cutting-edge Living Lab approach to develop, host and test experimental assistance devices before deployment in real-life situations.

Hosted on the Brest campus of IMT Atlantique the platform provides a smart apartment divided into 4 spaces: the apartment, equipped with a kitchen, bathroom, living room and dining room with connected furniture and blinds, a sensitive floor for fall detection, motion capture systems and smart lock; a 15 m² technical room, with servers and workstations, a 24 m² room, with a one-way mirror for user tests in conjunction with ergonomists and sociologists and a 34 m² robotics room.

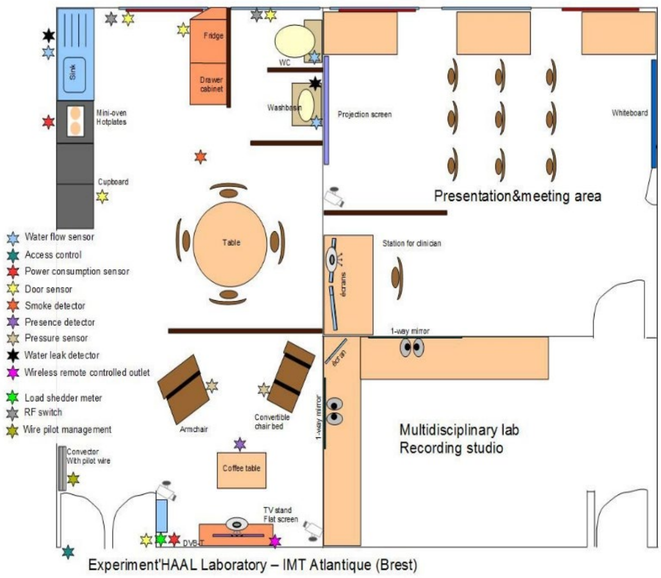


Figure 4-11 Plan of Experiment'HAAL (source: https://www.imt-atlantique.fr/fr/recherche-et-innovation/plateformes-de-recherche/experiment-haal)

[33] https://www.imt-atlantique.fr/fr/recherche-et-innovation/plateformes-de-recherche/experiment-haal

There are many wearable devices that measure different health parameters and emit all abnormalities to the communication devices in the home for the sole purpose of contacting the appropriate services.

Besides wearable devices, there are multiple motion detection sensors that can detect when a blind person or partially sighted person enters the room and then the speakers, as actuators, can notify them about the room they are in and what is currently happening around them, e.g., if the oven is on, or even adjust the room temperature for them [275]. There is a notable concept of smart home technologies to assist people that suffer from Alzheimer's disease to remain in their homes. Those smart homes depend on technologies that help with auditory, pictorial, video, or light prompts to assist people in completing their daily tasks [276].

One of the recent uses of IoT for improving social inclusion of people with disabilities is the ICC 2018 application [277] developed for Android devices by University of Zagreb Faculty of Electrical Engineering and Computing. ICC 2018 stands for International Camp on Communication and Computers 2018, which was held in Zadar, Croatia, and whose participants could learn how ICT and assistive technologies enrich the lives of blind and partially sighted people. The application's aim was to assist blind and partially sighted participants of ICC 2018 by helping them navigate through the unknown environment, i.e. by providing them with audio feedback on their current location within the camp [277]. The key concept is to use precise beacons, carefully distributed around the environment, e.g., doors, tables, chairs, or any other points of interest (PoIs). The mobile application is then used to warn the user about the proximity of specific PoI based on the beacon reading.

Considering the existing solutions in this domain, currently ongoing projects, and various initiatives, IoT is going to drastically revolutionize the world for everyone. However, IoT technology for people with disabilities, in a not too distant future, could possibly mean easier and more independent lifestyle [278].

4.1.6 5G networks

To fully grasp the benefits 5G could have for the society, it needs to be combined with other technologies some of which are analysed in this report. This can be particularly meaningful for people with disabilities as they rely on the current possibilities of technology in general.

Thanks to certain connectivity specifications 5G can offer automation and autonomy among cars on the road will be facilitated. If there would be an accessible version of an autonomous vehicle (AV) it could serve as a potential solution for those who cannot drive themselves. In the given context accessibility of an AV implies the ease with which people with disabilities enter, use and exit the vehicle, as well as use the communication interface, especially in emergency situations. The impact on PWD's lives, in case these requirements are fulfilled, could be huge as it will enable them to be mobile no matter the disability they have [32] [33]. Figure 4-12 shows Renault's EZ-GO autonomous concept taxi car that is accessible for passengers who use wheelchairs.

Figure 4-12 EZ-GO concept car by Renault [279]

Another example includes helping people with disabilities navigate independently. Blind people are often constrained to using nontechnological solutions for the purpose of getting from one point to another, for instance they use walking canes or service animals. A futuristic solution that has potential in solving this issue are 5G-connected smart glasses that would utilize the power of artificial intelligence to help navigate through, for example, a supermarket thus eliminating any need for assistance. Furthermore, people with visual impairments could easily follow bus and train routes if there are real-time audio feedback instructions and could be safer in doing so if these smart glasses would have a reliable facial recognition software to diverse a stranger from an acquaintance. In such cases there is no room for error as it could cause a serious injury or worse. This is where the importance 5G lies and it must be reliable (having low latency etc.) [35].

In March 2020, Envision announced plans to develop AI-powered smart glasses (Figure 4-13) that would extract information from images, detect and process any type of text from any surface, recognize faces, find object, detect colours and more. The information is meant to be read aloud so that the visually impaired and blind persons would be able to live their lives far more independently than before.

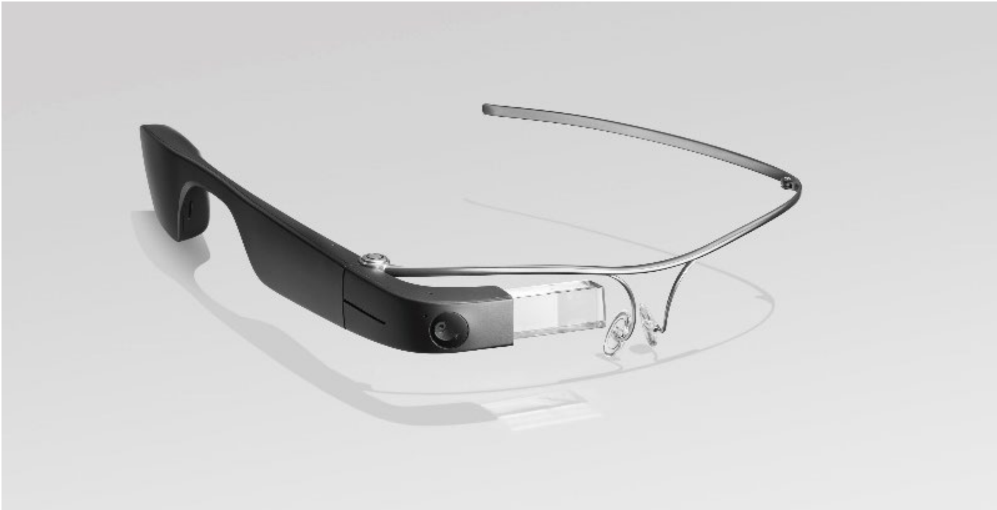


Figure 4-13 Envision smart glasses for the blind and visually impaired [280]

„As somebody living with a disability myself, I'm excited to see what it can do – from opening up new job possibilities to tackling mundane day-to-day tasks. For people who want to live independently in their homes, beyond just controlling the thermostat and the lights.“ – source: [35].

5G networks could also be used to help deaf people communicate seamlessly. Sing language is a visual language full of body gestures and facial expressions. Latency is a big problem when sign language is done remotely, and it can produce misunderstandings resulting in noneffective communication. This is where 5G can help by providing a low-latency communication channels and eliminate barriers for people who use sign language as their primary mean of communication [35] [37].

According to [38] 5G has the potential to revolutionize healthcare. To understand how, it is important to notice that the health-care system in use is not patient-centric meaning that the patient has to visit the doctor's office or a hospital no matter the severity of the illness he/she is suffering from. If this patient is also a person with disabilities and unable to live without assistance, this is inconvenient not only for the patient but for the patient's caregivers as well as they are the ones to take the patient to the clinic. The issues with the healthcare system are numerous, other examples include non-personalised care, inaccessible care, the lack of data-driven culture and so on. Thanks to 5G, combined with other technologies (AI, ML, big data analytics, IoT), the health care system can be restructured. Medical IoT is one way to address the problems listed above. In medical IoT all the connected devices are utilized by healthcare providers to collect relevant data, reduce time for remote health provision and improve the quality of care. These devices generate a large amount od data and 5G enables continuous monitoring of important information such as vital signs, blood pressure, body temperature, glucose, etc. Data collected can be used for either immediate reaction or to gain deep insights into various aspects of human life. The use of ML in remote diagnostics and surgery is another example of revolutionizing healthcare. Such systems that use probabilistic models can provide therapeutic recommendations, prognosis learning, personalized risk assessment, etc. Overall, 5G has the potential of reducing doctors' workloads and treatment costs [38].

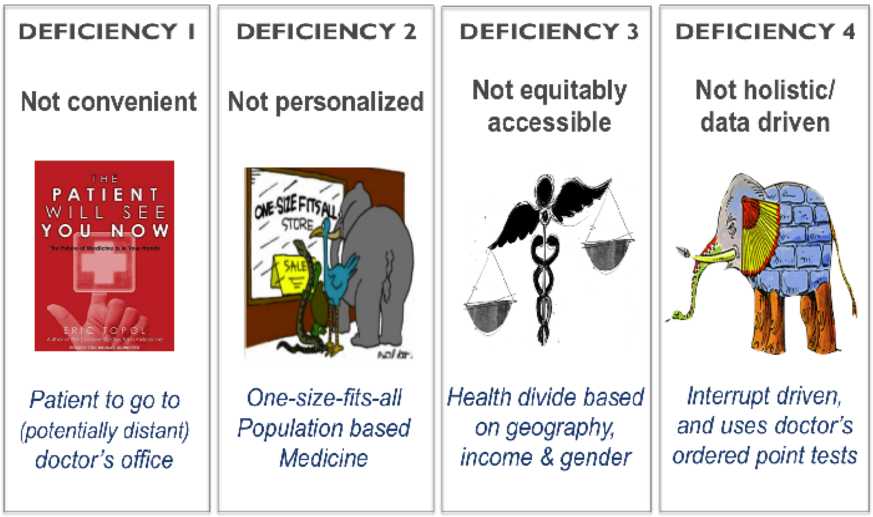


Figure 4-14 The four major deficiencies of the healthcare system

Furthermore, 5G network can be used for existing applications and systems enabling a better life in the context of health. The so-called caring home, a supportive environment that adapts to the needs of its user is meant to offer a range of services concerning the user's well-being.

One attempt in creating such an environment is the eWall project. The project's objective is to help people with chronic diseases or frailty lead a normal and safe life at home (Figure 4-15). eWall offers services such as the activity coach, video-based exercising, sleep qualification and a personalised guide. These services require a considerable bandwidth and other network specifications. For example, providing health advice during remote training requires a near real-time response and 5G, due to its capacities, could make this service impeccable. Additionally, with 5G new sensing methods that involve large amounts of data, such as mood changes detection using real-time video processing will be enabled [39].

Figure 4-15 eWall project[34]

4.1.7 Artificial Intelligence (AI)

Some applications of AI that target a wide range of users, such as voice recognition, speech-to-text and text-to-speech conversion, do not take into account the specific requirements of people with disabilities. As it was explained how Artificial Intelligence works in chapter 2.7., some training data is needed in order to learn something artificially. The training data does not usually include data that describes a scenario for people with disabilities [281]. Developers should take into consideration people with disabilities and the advantage of AI technology to improve social inclusion and to help them in solving problems they are facing.

However, there are also AI-based solutions that are especially important for people with disabilities. Some examples follow. Google provides automatic captioning of YouTube videos through voice recognition. This helps people that are deaf and hard of hearing, but also people that are not fluent in the spoken language [282].

34 https://ec.europa.eu/digital-single-market/en/news/ewall-smart-wall-make-life-easier

It is an example where AI handles the problem of speech-to-text conversion. A similar problem, but in the opposite direction, is tackled by Aipoly, an app for visually impaired people. Using AI, the app detects and recognizes all kinds of objects, and reads them afterwards [283]. The interesting approach of Facebook is computer vision technology that generates photo description. The developed system identifies faces, object, and other things from the photo and deploys alt-text that is used by screen readers [284]. A screen reader is a software application that reads the screen and helps people with different visual disabilities to use a computer.

The other interesting approach can be seen in an algorithm that Facebook uses in a search engine. Using AI, the algorithm predicts which person, page or group would fit a user and puts it high on a list in the search engine. It makes those predictions based on the user data, friends list, likes and some other private information that is provided [285]. For example, letting elderly people know about social activities in their neighbourhood may encourage them to go out and spend some quality time with other people, reducing social isolation. Sharing stories with health-promoting messages can entertain and subliminally provide education about healthier living. AI can suggest a healthier lifestyle – food and diet, exercise, some good living habits and much more [285].

Microsoft has a program named "AI for Accessibility" whose goal is to improve the inclusion of people with disabilities by using the power of AI [286]. One example is Zyrobotics, the tool intended to improve reading fluency [287]. The tool reads stories and asks interactive questions. With the help of AI, the received answer is analysed, and feedback with highlight mistakes is provided. Another product of the early mentioned Microsoft program is the InnerVoice tool [287]. Its purpose is to improve a child's social communication skills. The child types or asks questions or points the device at an object, and the tool explains it. After that, a child needs to pair facial expression with common phrases. The special facial expression is represented by the 3D avatar that resembles the user (child). Text-to-speech conversation, image recognition, and Q&A[35] services are AI technologies that are used in this product. The next interesting thing is the system recognizer for the emotional state of the users. Services and cognitive APIs, developed by Microsoft Azure, offer packages that can define the current moods of the user [282]. With the help of a camera and early mentioned APIs, developers can develop a system that will recognize user needs and adapt the computer interface. The adapted interface is especially good for people with behavioural disorders, such as autism and anxiety, because web accessibility is still not implemented in majority web sites [282].

An autonomous vehicle is a vehicle that can drive without driver involvement [288]. Autonomous mode required AI to process and integrate massive amounts of data collected from sensors. Autonomous vehicles can enable people with different disabilities (e.g. visual, physical) to drive a vehicle by themselves [288]. This example shows how AI can improve the lives of people with disabilities and accomplish things that were unimaginable in the past.

Altogether, the goal is to make one's life simpler and therefore better. This special need for AI in cases mentioned above and in other cases demands upgrades to already existing solutions that are not developed to be used by someone who is not an average user. That is why creative research and implementation is needed regarding AI solutions in this context in the future.

4.1.8 Robotics

Today, robots can assist people with a multitude of tasks, some of which were mentioned earlier. Robotics can also be used to help people with disabilities through physical and social interaction [289]. Rehabilitation robots are used in motor relearning and limb recovery. Such robots include the MIT-Manus [290], developed for shoulder and elbow training, Hesse's Gait Trainer I and Active AAFO [291] for lower limb rehabilitation and NAO robot for the rehabilitation of patients with hand fractures [292]. Wheelchair robots like the Raptor are another example of assistive robotics. The Raptor Wheelchair Robot System permits persons with severe disabilities to manipulate objects in their personal environment using a mechanical arm [293]. One more robot using a

[35] Q&A stands for "question and answer".

mechanical arm to assist people with disabilities is the Care-O-bot II [294]. It is a mobile service robot which has the capability to perform fetch and carry and various other supporting tasks in home environments.

Socially assistive robotics is a term used to describe robots that provide assistance to human users through social interaction. There is a multitude of important assistive tasks where social interaction rather than contact with the user is the central focus [295]. Robots can prove useful in several areas of learning by augmenting teachers, providing individualized or small group tutoring and performing tasks such as math problem practice or language learning. A commercial tutor robot called IROBI, designed to teach English was shown to enhance concentration on learning activities and academic performance compared with other teaching technology, such as audio material and web-based application [296]. Next, robots can be used for physical therapy, replacing a human therapist who, for example, coaches a stroke patient to repeatedly use the affected limb [297]. Cerebral palsy is another domain where robots performing repetitive exercises can play a key role in therapy [298]. A humanoid robot called MARKO [299] is one such example. It is used as a support tool for therapists with which they could conduct specific therapeutic exercises that involve both gross and fine motor function. Robots can also assist the elderly in daily life activities. In this case, robots can be used in the role of a companion. Pet-robots can help in assisted therapy, physically interacting with their users and stimulating their affection [300]. The most widely used robotic pet is PARO (Personal Assistant RObot) [301], a seal robot developed for therapy. This robot has been used at several facilities for the elderly and paediatric hospitals, resulting in an improvement of users' mood and in an increase of activity and communication with their caregivers and each other. Robots can also help the elderly with schedule planning. One such robot is Pearl [302]. It has two main functions: to remind elderly people of their daily activities such as eating, drinking and taking their medicine and to help elderly people navigate their environments. Finally, robots can be used to encourage emotional expression in situations where such expression may be challenging [295]. Robots have been used to help children with autism and children facing cardiac illness, by having the child and the robot create a story to act out together, expressing their feelings and concerns about the future [303].

KERAAL project

One of the current projects, in the field of rehabilitation robotics, is a state-of-the-art European Union funded project called KERAAL, part of the Echord++[36] project, led by Professor André Thépaut at IMT Atlantique in partnership with Génération Robot[37] and the Brest teaching hospital, CHRU de Brest[38]. The team has adapted an existing humanoid robot, called Poppy[39], capable of demonstrating physical therapy exercises to a patient suffering from lower back pain [304], and correcting the patient's errors in real-time.The researchers have used a co-design approach, working with physiotherapists, doctors and psychologists to define the most relevant exercises and the most specific gestures and verbal instructions to be given by the robot. An Intelligent Tutoring System (ITS) is used to provide immediate, customized feedback to patients [305]. Robots have also been shown to be effective social mediators for children with special needs [306], and the project is now being extended to accompany children on the autistic spectrum, with their parents and medical teams.

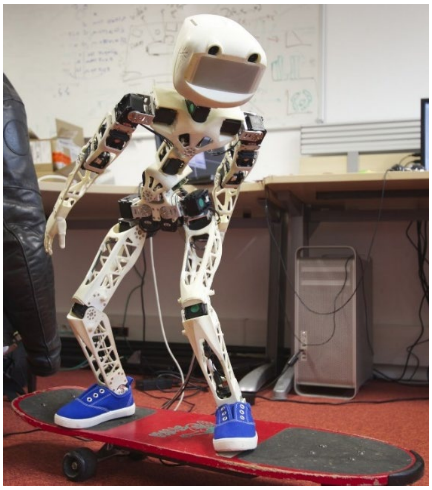


Figure 4-16 Poppy humanoid robot (source: https://www.poppy-project.org/en/robots/poppy-humanoid/)

[36] Echord++, http://echord.eu
[37] Génération Robot, https://www.generationrobots.com/en
[38] CHRU de Brest, https://www.chu-brest.fr/fr
[39] Poppy, https://www.poppy-project.org/en

4.1.9 3D printing

Prosthetic leg of the highest quality

Denise Schindler had already won several bicycle races and Paralympic medals when she started to prepare for the Olympic Games in Rio de Janeiro in 2016. Because of an accident, her right leg had to be amputated at the age of 2, so she needs a prosthetic device to be able to ride a bicycle.

For the Olympic Games, she wanted a new device of the highest quality, so she decided to look for a company that is ready to use the latest high-tech solutions (Figure 4-17). With Autodesk, her upper thigh was scanned and using advanced cloud design tool Fusion 360, and her measurements, a perfectly adapted prosthetic device was created. The whole process took only 5 days instead of 10 weeks like before. The prosthesis was 3D printed at Autodesk's Pier 9 manufacturing facility in San Francisco for a cost around a quarter of the usual price [307].

Figure 4-17 Denise Schindler with her prosthetic leg [307]

GLIFO: 3D-printed writing tools designed for disabled children

Although digital literacy is spreading intensively, children have to be taught the technics of handwriting and drawing. Usage of pencils and pens requires very precise movements and can be difficult to accomplish when facing challenges involving the central nervous system. This has motivated a group of European Designers to band together and develop a series of unique writing tools designed to help children with disabilities to master previously mentioned skills [I8]. Glifo tools are not only designed for the particular needs of children facing difficulties in using pens or pencils, but each tool can be tailor-made for a specific child thanks to the fact that 3D-printed parts can be easily manufactured individually (Figure 4-18). Glifo tools belong to the collection of UNICO – The Other Design that is a brand of objects co-designed with makers, therapists, children with disabilities and their families [308].

Figure 4-18 Glifo tools [309]

e-NABLE

The e-NABLE community is a group of individuals from all around the world that are using their 3D printers to make free and low-cost prosthetic upper limb devices for children and adults in need. According to the latest news, the community is made up of about 20,000 "Digital Humanitarian" volunteers in over 100 countries. They have delivered free prosthetic hands and arms to an estimated 8,000 recipients through collaboration and open-source design to help those who have little to no access to medical care.

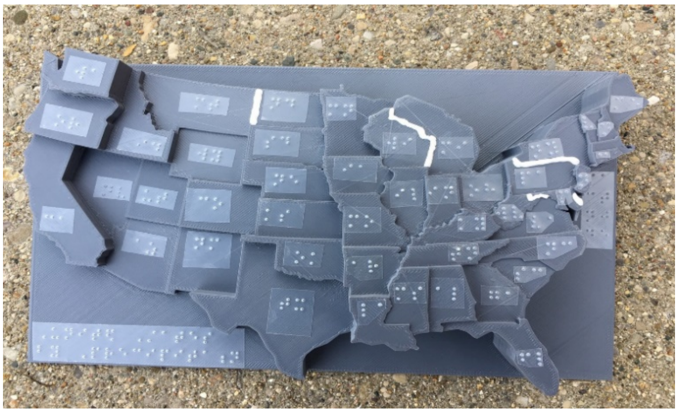
The open-source designs created by e-NABLE Volunteers help those who were born with fingers and hands not properly formed, and others who have lost them due to war, natural disaster, illness, or accidents. Children are especially affected since their upper limb assistive devices have to be 3D printed over and over until they grow up. The community is open for school or educational groups that would like to become an official e-NABLE Community School Groups or Chapters members. Joining this initiative improves the social sensitivity of the young generation and can be a great motivation to be involved in STEM/STEAM programs [310].

Figure 4-19 Liam from South Africa, who was the first child in the world to receive a 3D Printed mechanical hand in 2012 [311]

See3D

See3D is a project operated by volunteers that organize the printing and distribution of 3D printed models for blind people. Through touch, people who are blind can have a better understanding of what an object looks like. Besides blind or visually impaired people, anyone can benefit from this project because handling a tactile model can provide a complete visualization of the model which one cannot get from a picture or a text description. The most popular models that clients ask for are maps, buildings, snowflakes, molecules, animals and automobiles (Figure 4-20). Their mission is to build a bridge between blind and sighted people through 3D printing and spread awareness about the importance of accessible materials, including braille. This last one is the reason for including Braille labels and descriptions on our models rather frequently [312].

Basically, anyone can make a request for himself or for a person who is blind or has a visual impairment. See3D is ready to connect the requestor to people who have 3D printers who then create the model and send it by post to the requestor. For this project See3D is looking for support to create the models, as well as financial support for a fundraising campaign [313].



See3D
3D Printing
for the Blind

Figure 4-20 3D map of USA with Braille labels and the logo of the movement [287]

3D-Printed Book

Besides the traditional way of printing information on pages of a book, 3D printing provides an alternative, different opportunities to share information. One example is the 3D printed book form Tom Burtonwood called

Folium at the Art Institute of Chicago between January and August 2014 (Figure 4-21). The title Folium is derived from the Latin word for leaf and refers to the decorative leaves that allow each page to flex. Every page of the book represents a bas relief from the museum's collection spanning over two thousand years of human history. Pages of the Folium are printed based on 3D scans produced using Autodesk's 123D Catch and Recap photogrammetry applications. After some post-processing, for each of the scans, the positive and negative forms are printed on the same page, allowing people to use malleable materials to create copies of all the pieces inside Folium. The book is designed with braille translations of the front cover, and the list of works to aid recognition for the low sighted and visually impaired people [314]. The whole book design is available for free, so after downloading the pages, anybody can 3D print them [315].

Figure 4-21 The 3D printed book called Folium [314]

Simple but practical 3D-Printed Accessible Devices for People with Disabilities

3D printing has great potential in many fields of assistive living. It can be used to create small, but rather practical tools as well. A trivial, simple, daily movements, or activities that are easy for most of the people sometimes present a real challenge for people with disabilities. 3D printing has solved many accessibility challenges and can drastically bring down the cost to make them. The following figures represent some 3D printed practical devices that are already available, meaning that the models can be downloaded for free from an online resource (such as Thingiverse.com, or MyMinifactory.com) and 3D printed directly.

The pull ring can opener in Figure 4-22 was originally designed for people who have limited mobility with their hands, but others can find use in it as well (for example children).

Figure 4-22 Ring Pull Can Opener [316]

The idea of designing the 3D printable zippers could be the same as in the case of the pull ring can opener, but it can help many people who have problems with grabbing the small zippers that are on most bags and clothing. These 3D-printed zippers can be easily attached to a smaller zipper tab and make everyday life easier (Figure 4-23).

Figure 4-23 3D-printed zippers to be attached to a smaller zipper tab [316]

Figure 4-24 A single portable step ramp for going to inaccessible venues [316]

Furthermore, although many countries have laws stating that public buildings should be accessible for wheelchair users as well, there are still many where it is a real challenge to enter. This single, portable step ramp on Figure 4-24 is a great solution for making all venues accessible. Another example includes designing a 3D-printable cup holder that can be attached to a standard wheelchair but can be customized to each user's requirements (Figure 4-25) [316]. The possibility of customization is one of the greatest advantages of 3D printing.

Figure 4-25 Wheelchair cup holder with customizable ball socket joint [316]

Customized orthosis

A group of South-Korean researchers has worked out a scientific approach to designing a personalized assistive device that is optimized for the people living with brain injuries that cause difficulties in daily activities such as writing and eating. The team has conducted interviews and estimated disability status before designing the special device with the function of an orthosis. The users' needs included the ability to be able to type with both hands and to use the right hand for eating. The problem that often occurs is that the right-hand spasticity disturbed the ability to maintain these simple functions and evoked abnormal synergistic movements. The team developed and documented the precise process of manufacturing the assistive device from the 3D scanning to 3D printing (Figure 4-26) [317].

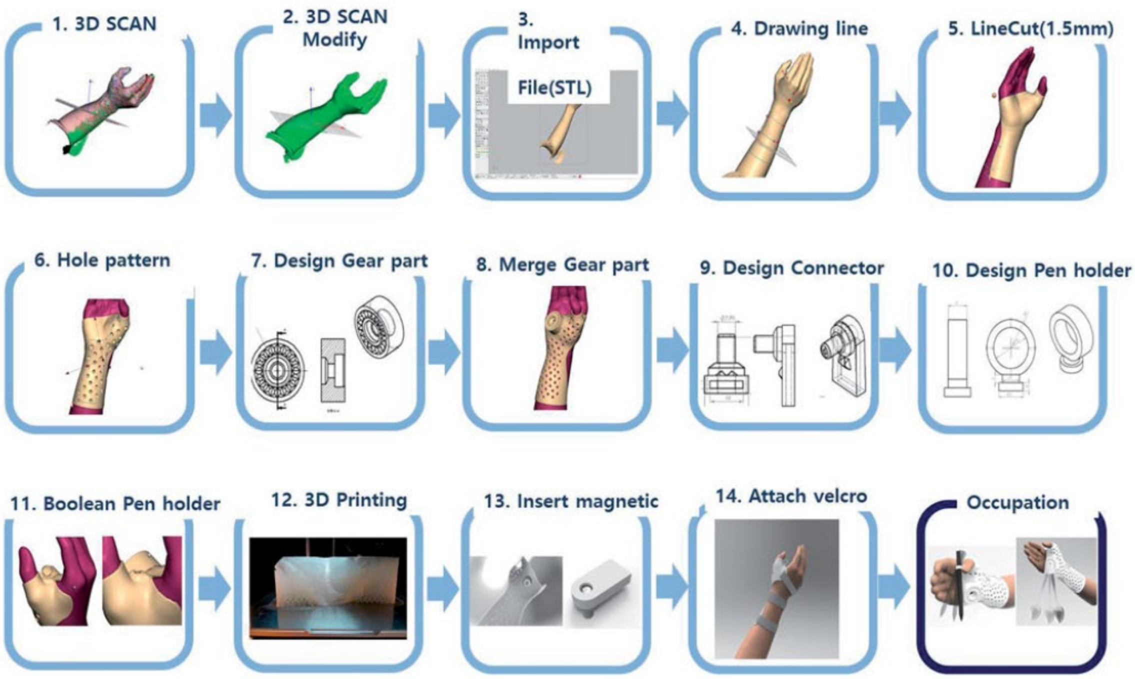


Figure 4-26 The whole process of manufacturing the assistive customized device [317]

4.2 Example of good practice from Croatia – ICT-AAC story

ICT-AAC Competence network[40] (hereinafter: ICT-AAC) implements activities of design, development and training in the area of ICT services for communication and education based on Alternative and Augmentative Communication (AAC). It brings together scientists and professionals from areas such as information and communication, computer science, education, rehabilitation, psychology, speech and language pathology and design, as well as representatives of persons with complex communication needs via parental NGOs and professionals in education, rehabilitation, speech and language pathology. Two faculties from University of Zagreb (the coordinator of the INNOSID project) form the core of the ICT-AAC: University of Zagreb Faculty of Electrical Engineering and Computing (UNIZG-FER) and University of Zagreb Faculty of Education and Rehabilitation (UNIZG-ERF).

The main vision of ICT-AAC is enhancing the social inclusion of PWD by developing free scientifically and professionally competent, recognized and approved solutions based on Information and Communication Technology (ICT) to enable effective communication, support education, and raise public awareness about needs and abilities of PWD. So far, there are more than 30 free solutions in the form of the mobile applications for Android and iOS devices, including several solutions for the web platform. The complete portfolio of the ICT-

[40] http://www.ict-aac.hr

AAC solutions can be found on the ICT-AAC official website[41], whereas the solutions are available for free via digital stores:

- Google Play store (Android solutions)[42],
- App Store (iOS solutions)[43].

Before publication, each solution is evaluated by end-users [318]. Furthermore, each application can be used for various purposes since there are built-in interface and content customization options to users' needs and teaching purposes.

Applications are divided into the following three main categories:

- education applications,
- applications for communication, and
- serious games for raising awareness of digital accessibility.

First, education applications are used in preschools and in different subjects and primary schools and in rehabilitation centres but also at homes for learning and training. By using these applications, users can increase their reading, writing and expression capacity. Applications can be used for learning:

a. visual symbols and colours,
b. time (hours, minutes), days of week, months, seasons,
c. new phonological forms (alphabet phonological awareness and other prerequisites for reading) - Figure 4-27 presents ICT-AAC Glaskalica as the showcase application,
d. new words by using the methodology aimed primarily for children with autism spectrum disorder and for children with cognitive impairment,
e. storytelling and for training complex sentence creation, memory and naming acts, events, people, and objects,
f. writing correctly capital graphemes,
g. basic mathematical skills (terms „amount" and „number" by using the principle of domino game; mathematical operation at the basic and advanced level; measurement and units).

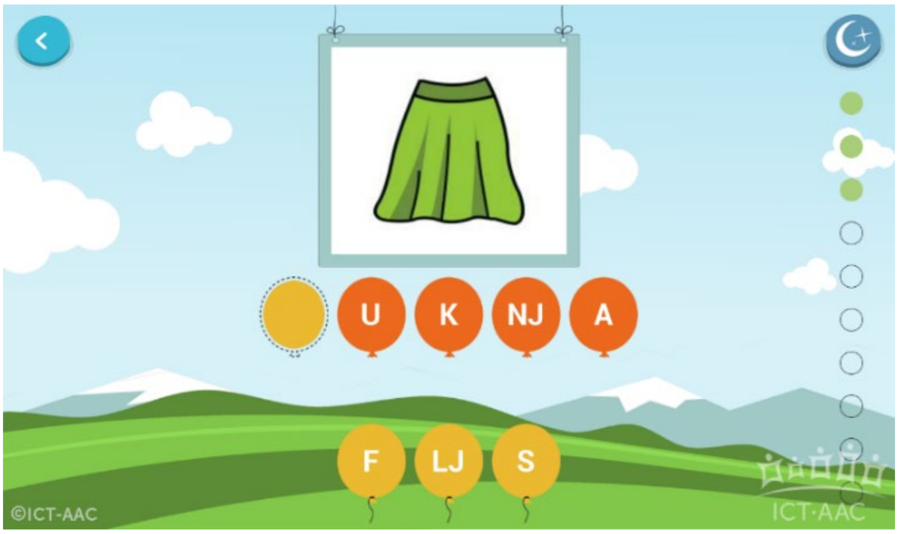


Figure 4-27 ICT-AAC Glaskalica, the education application for learning new phonological forms. Majority of ICT-AAC solutions rely on open source symbols such as ARASAAC[44] , Mulberry[45] and Sclera[46]

[41] http://www.ict-aac.hr/index.php/hr/aplikacije
[42] https://play.google.com/store/apps/developer?id=ICT-AAC
[43] https://apps.apple.com/developer/university-of-zagreb-fer/id596349037
[44] http://www.arasaac.org/
[45] https://mulberrysymbols.org/
[46] https://www.sclera.be/en/vzw/home

Second, **applications for communication** enable users to establish interaction with the environment. Each application produces audio output making this interaction more fluent. Figure 4-28 presents Komunikator+ as the showcase application. Such applications are aimed at:

- easier communication with the environment by using symbols to express their needs and feelings,
- complete communication with the environment with symbol-based phrases and corresponding voice reproduction.

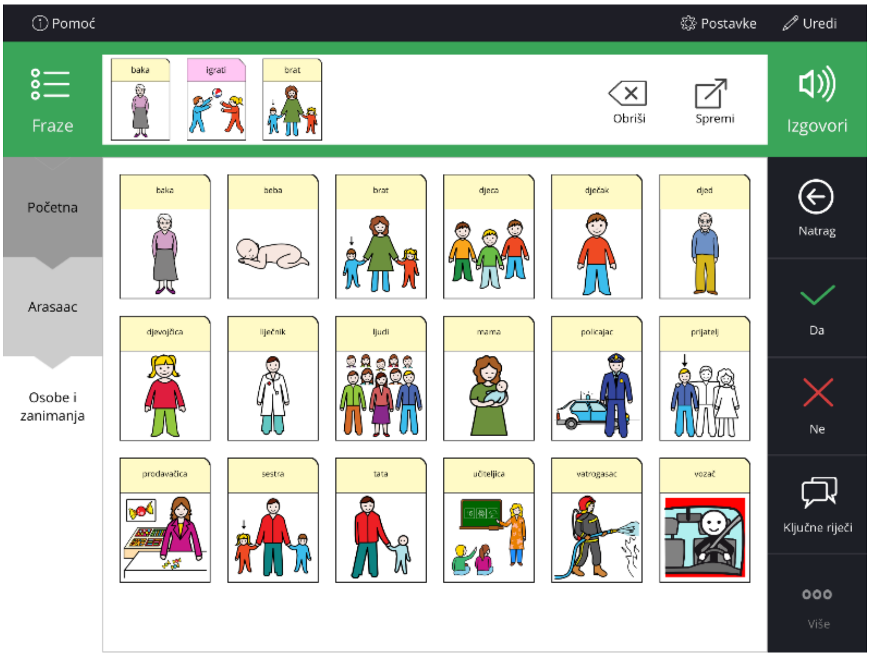


Figure 4-28 ICT-AAC Komunikator+, a showcase application which helps PWD in communication with the environment

Finally, third, **serious games for raising public awareness** and specifically awareness of ICT and graphic design students about digital accessibility and ways how it can be implemented, and particularly how they can personally contribute in building more inclusive society in their future careers. These applications aim is to remove the hardest barriers, those in people minds. Figure 4-29 presents Let's talk with pictures ("Pričajmo slikama" in Croatian) as the showcase application. Description of this and the other two serious games for raising awareness is provided in chapter 3.4.1.

Figure 4-29 *Pricajmo slikama, a showcase application for raising awareness about the needs of PWD*

From the descriptions above, one can identify that ICT-AAC's focus is on using the mainstream ICT technology devices such as smartphones, tablets, and computers to create software which improves the social inclusion of PWD. Before ICT-AAC solutions, Croatian users often relied on low-tech solutions such as printed cards or more advanced but limited solutions such as mechanical communicators. Figure 4-30 illustrates one example of how the ICT-AAC created a social innovation for AAC communication in the Croatian language through the implementation of the ICT-AAC Komunikator application. More details on how ICT-AAC uses social innovation to improve social inclusion of PWD can be found in chapter 5.3. (*ICT-AAC project – a successful social innovation story*).

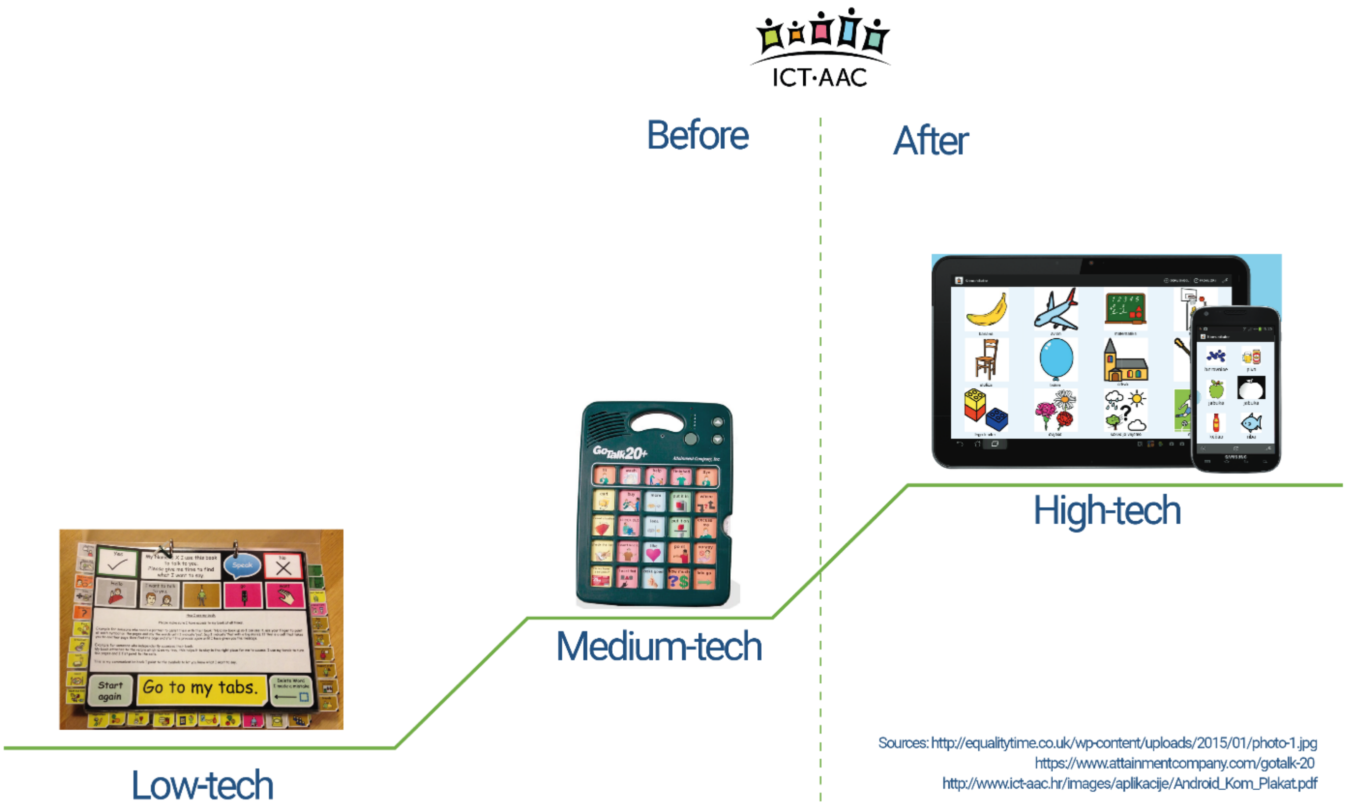


Figure 4-30 Social innovation in AAC: from physical to digital solutions

ICT-AAC research and development (R&D) applications for emerging technologies based AAC

The solutions based on the mainstream ICT technology devices proved to be highly impactful, given the fact that such devices are commonly available to users. Apart from this, ICT-AAC actively conducts research and development activities for studying how emerging technologies can support the social inclusion of PWDs. The following subsections present several case studies.

Application of virtual reality for learning mathematics

As already discussed, VR offers opportunities in many areas, including education. In research conducted by Zilak, Car and Jezic (2018) [319], ICT-AAC developed a prototype VR-based system for learning mathematical concepts. The approach was to use the content from one of the existing solutions for tablet devices, ICT-AAC Domino Brojalica, and to develop a VR-system comprising of a computer, a VR headset (Oclulus Rift) and a hand detection sensor (Leap Motion). The baseline application provides the children with developmental disabilities early experiences with the definition of quantity and numbers in an intuitive and fun way, enriched with sound and visual content. Figure 4-31 presents the side-by-side comparison of the baseline application and its VR counterpart.

It is worth noting that the research was conducted with people without disabilities to assess the potential of VR applications in education. The results have shown that there is good potential in combining VR elements with education as well as AAC technologies. Furthermore, the research identified that some VR-specific factors, such as the level of immersion in VR environments, unnatural behaviour of virtual hands, and the level of familiarity with the VR technology, need to be carefully considered in the follow-up studies concerning users with disabilities.

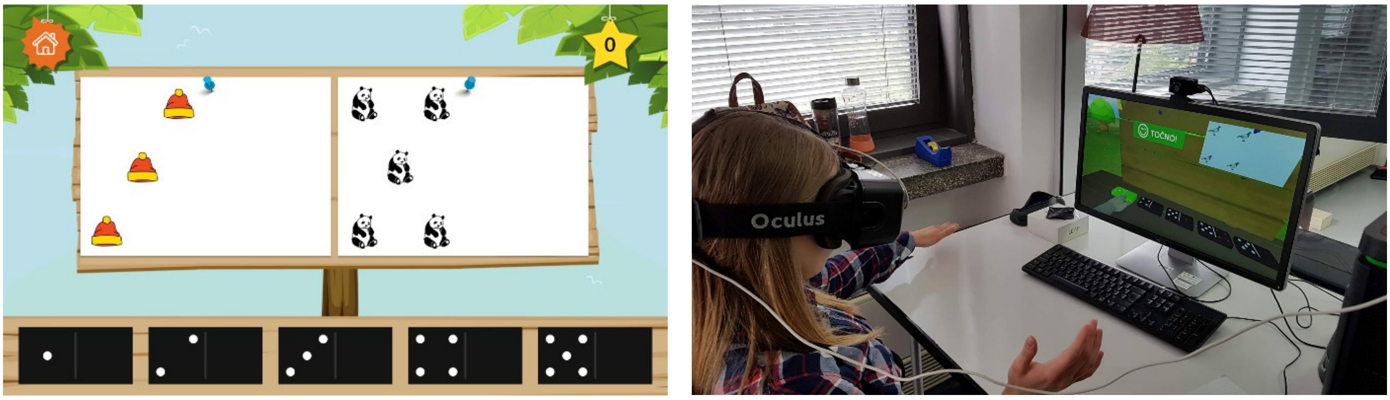


Figure 4-31 Side-by-side comparison of ICT-AAC Domino brojalica for tablet devices (left picture) and virtual reality system (right). Tablet version relies on point gestures, whereas the virtual reality version relies on hand and head movements.

Application of wearable technology as assistive technology

Wearable technologies such as smartwatch are getting increasing attention as in a consumer market. Through research conducted within Master Thesis (Kakša, 2015) [320], [320], ICT-AAC developed a prototype solution for smartwatches with the aim of facilitating AAC communication.

Figure 4-32 presents the developed prototype solution for smartwatches. Users can set up the contacts list in a way that each of the contacts is represented in terms of a symbol and vibration pattern. In that way, users that rely on AAC communication can make or receive a call with using symbols, whereas the visually impaired users can use vibration patterns to map a particular person from the contact list. Feedback from the testers suggests that smartwatches may have potential to be used for assistive technology applications.

Figure 4-32 Screenshots of the prototype solution for smartwatches

Application of eye-tracking for interaction with the environment

In award-winning research by Soko and Car (2014) [321], ICT-AAC developed and evaluated a prototype solution for communication between a user and its environment based on eye-tracking technology. The solution is primarily intended for PWD that have pronounced physical disabilities, are not able to speak, and have difficulties using the conventional user interfaces. As opposed to specific assistive technology devices which also enable human-computer interaction based on eye tracking, the proposed solution relies on web technologies so that the solution is available for computer devices which have a camera. In other words, the proposed solution is much more accessible to a big number of people as it does not need an expensive dedicated eye-tracking equipment.

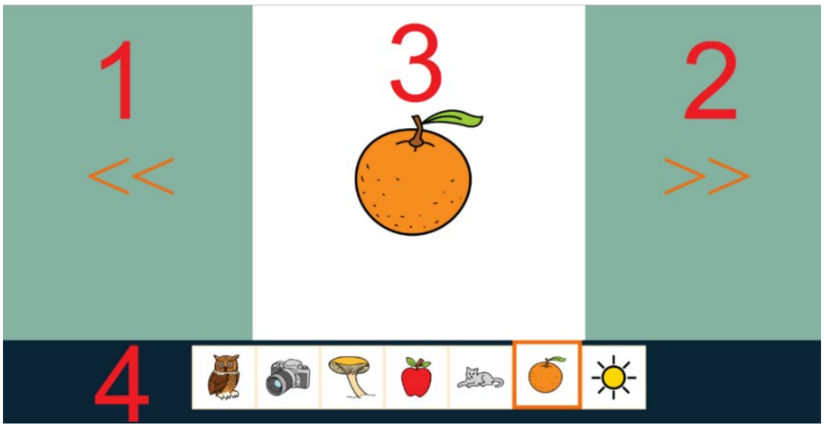


Figure 4-33 Solution based on eye tracking which helps PWD in communication

Figure 4-33 presents the developed prototype solution for communication and outlines the four key areas. Areas depicted with 1, 2 and 3 are the focus areas, whereas the area represented with 4 is the navigation bar. Focus areas react when a user's eye gazes towards them, and the interaction is graphically represented with the activation colour (i.e., animation with colour suggesting that the user wants to interact with the specific focus area).

Focus areas marked with 1 and 2 are for navigating among the available symbols with left and right, respectively. The focus area marked 3 is for reproducing the currently displayed symbol. Last, the navigation bar is used to list all the available symbols so that the user can navigate towards the wanted symbol.

5

Ecosystem for innovative solutions based on emerging technologies for improving social inclusion of people with disabilities

As it can be concluded from previous chapters and numerous examples provided there, the social inclusion of people with disabilities can be improved by creating various ICT solutions based on the needs of this target group. One of the goals of the INNOSID project is to develop innovative IT tools based on emerging technologies for improving the social inclusion of people with disabilities. Bearing in mind what the World Health Organization emphasizes, that only one in ten people have access to assistive technology, as well as the predictions about the number of people with disabilities, more precisely the increase in the number to two billion by 2050, it can be concluded that development of such innovative products can be one of the answers to this societal challenge and one of the ways to make the world more accessible and inclusive for people living with a disability. By addressing the needs of PWD in the right way, a positive impact can be achieved not only on the PWD but on their caretakers and families, as well as society. Having said that, these innovative solutions based on emerging technologies for improving the social inclusion of people with disabilities can be recognised as social innovations.

Talking about the creation of social innovation, one can imagine that it requires many entities to work together in order for it to have a proper impact. Thus, in this chapter, it will be described what else is considered social innovation, what are the entities and their roles in this “social innovation ecosystem”, and what is necessary to maintain successful relationships among them. These entities will be mapped to a conceptual framework which will define how one can develop a social innovation based on emerging technology (in general). After that, the key entities for the INNOSID project and their role will be described, after which they will be mapped to the generalized framework in order to propose the framework for social innovation based on emerging technology (ET) for improving the social inclusion of PWD.

5.1 Social innovation

Social innovation is the development of new ideas such as products, services and models with a goal of improving human well-being by answering social needs and creating different social relationships or collaborations [322]. It includes innovative responses to pressing social demands that affect social interactions. The main difference between social and technical innovations is that, in the case of social innovations, the innovation does not necessarily occur in the form of a technical artefact, but at the level of social practice [323]. Previously, societal challenges were tackled by traditional non-profit models, while today’s societal trends are increasingly perceived as opportunities for innovation. Trends in demography, community and social media, poverty, the environment, health and wellbeing, or ethical goods and services raise rapidly changing challenges which create a real excitement around new entrepreneurial answers and solutions.

There are many areas where social innovations can provide an effective solution for the imposed challenges. Social inclusion of people with different forms of disadvantages related to education, gender, age, physical status or ethnic background can benefit greatly from social innovations. I-Cane [324], a mobility solution for blind and visually impaired people is one such example. The I-Cane expands the functionality of the traditional white cane with features such as navigation, obstacle avoidance and orientation. These features contribute to improved mobility and higher social participation. Migration can also benefit from social innovations. For example, Portuguese public administration experienced difficulties of communicating with the immigrant population, while immigrants had to cope with the challenge of social integration. To respond to these challenges, Portugal opened National Immigrant Support Centres (CNAI), which increased the response time to problems faced by immigrants. Social innovation can also help with urban regeneration. In Germany, the government of North Rhine Westphalia organised urban regeneration in partnership with cities across the state to help turn around 80 neighbourhoods. The neighbourhoods worked with a wide range of stakeholders, understanding different perspectives and finding tailor-made solutions with a high level of acceptance. Microfinance tools were invented in developing countries to combat poverty. One such tool is the Kiútprogram [325] in Hungary, aiming to support Roma with starting up a business. To deal with an ageing population, new types of health and wellbeing services are being developed. The Living Lab on Wellbeing Services and Technology in Finland is an innovation platform that enables a new way of producing services for elderly people, with users actively participating in the welfare services and technologies product development, design and usability testing processes [326].

All these examples of social innovation show its potential to be an engine for new dynamics in society in areas neglected by traditional commercial innovations. Unlike profit-oriented entrepreneurs who shy away from areas where it is difficult to capture values, social entrepreneurs aim at value creation for society, not focusing on potential profits. This is why actors of social innovation do not act solely within the traditional commercial innovation ecosystem (inventors, R&D teams, patents, entrepreneurs, accelerators, business angels, venture capitalists), they can be committed individuals that develop and incubate their projects inside social economy organizations, within government units or local government entities, as well as in existing firms [327]. However, because of it not focusing on profits, social innovation requires financing, experimentation and scale – developing a plethora of projects and have a few of them grow to show high value and impact. For this reason, social innovation ecosystems are needed to create social innovations.

According to the SI-DRIVE comparative analysis of social innovation initiatives in seven major policy fields (education and lifelong learning, employment, environment and climate change, energy supply, transport and mobility, health and social care, and poverty reduction and sustainable development), it is clear that "Social innovation has become a ubiquitous concept." [328]. Just to name a few examples, social innovations impact the way we live together (shared housing), work (telework), consume (car-sharing), collaborate (co-working spaces). They also emerged within different sectors: civil society (urban farming), politics (parental leave), and economy (microcredits) [328]. Some of the main results of the SI-DRIVE comparative analysis are that social needs and societal challenges are the focus and driver of social innovation, that the empowerment and user involvement are a core element, that social innovation ecosystems are emerging, and that social innovation initiatives are driven by problems and depending on individuals [328]. One of the important findings is that lack of funding presents the biggest barrier for social innovators and that own resources represent their main financial source which confirms the importance of the existence and functioning of social innovation ecosystems [329].

The European Union in its Europe 2020 strategy pointed social innovations as means to achieve its targets in five areas which are:

- Employment: 75% of the 20-64-year-olds to be employed
- R&D/innovation: 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation
- Climate change/energy: greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990; 20% of energy from renewables; 20% increase in energy efficiency
- Education: Reducing school drop-out rates below 10%; at least 40% of 30-34–year-olds completing third-level education
- Poverty/social exclusion: at least 20 million fewer people in or at risk of poverty and social exclusion [322].

Key policy components of the Europe 2020 strategy that contribute to a well-functioning knowledge-based economy and industrial competitiveness are R&D and innovation. Since the INNOSID project is closely related to emerging technologies for which research and development (R&D) present the way to exploit their potential for developing new innovations, Europe 2020 target related to R&D/innovation is especially interesting for this report.

As it can be seen from above, the Europe 2020 strategy sets the target of 'improving the conditions for innovation, research and development', in particular with the aim of 'increasing combined public and private investment in R&D to 3 % of GDP' by 2020. Because R&D intensity in the EU is growing too slowly, this Europe 2020 target is still some distance away. Figure 5-1 shows the trends in R&D expenditure from 2000 to 2017. Out of the INNOSID partner countries, currently, only France is spending more than 2% of its GDP on R&D, while others are mainly in the 1-1.5% range. Croatia is the only partner country spending less than 1% on R&D.

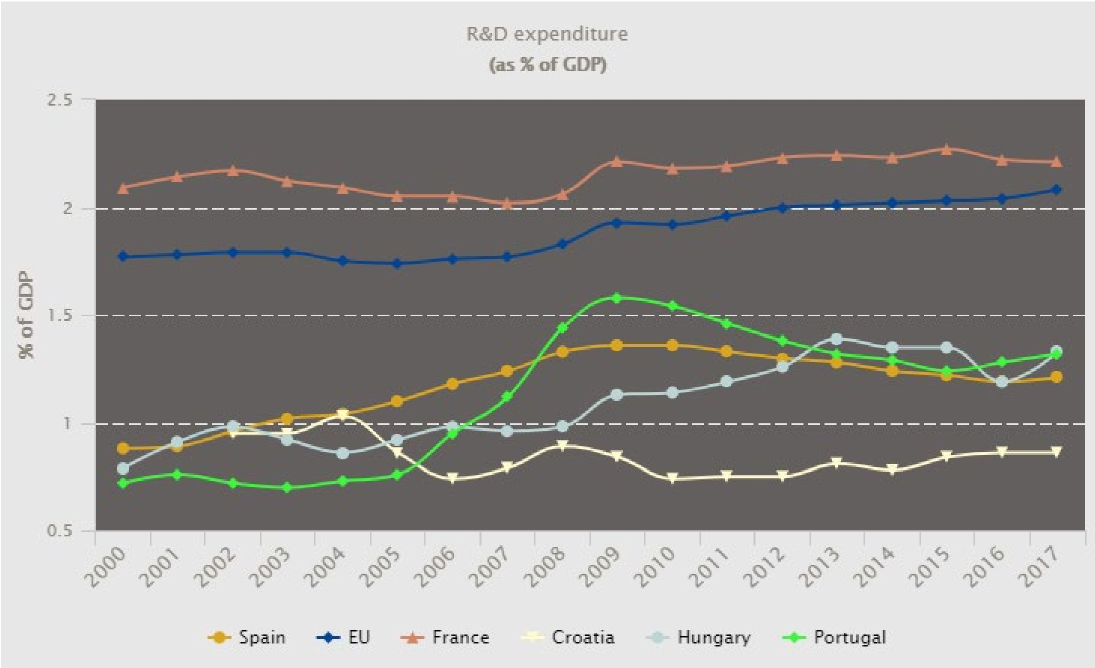


Figure 5-1 R&D expenditure in the EU and INNOSID partner countries (source: https://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_expenditure)

An important factor for R&D/innovation, in general, is related to Europe 2020 strategy target about education and early dropouts because highly educated people and people involved in science and universities represent an important resource in the innovation ecosystem. The EU has set a target to reduce school drop-out rates below 10% and to have at least 40% of 30-34–year-olds completing third level education by 2020. In 2019, Croatia had the lowest drop-out rate out of the INNOSID partner countries (Figure 5-2), and along with Croatia, only France has met the target. The other partner countries still have not reached the Europe 2020 target, with Spain drop-out rates still being above 15%.

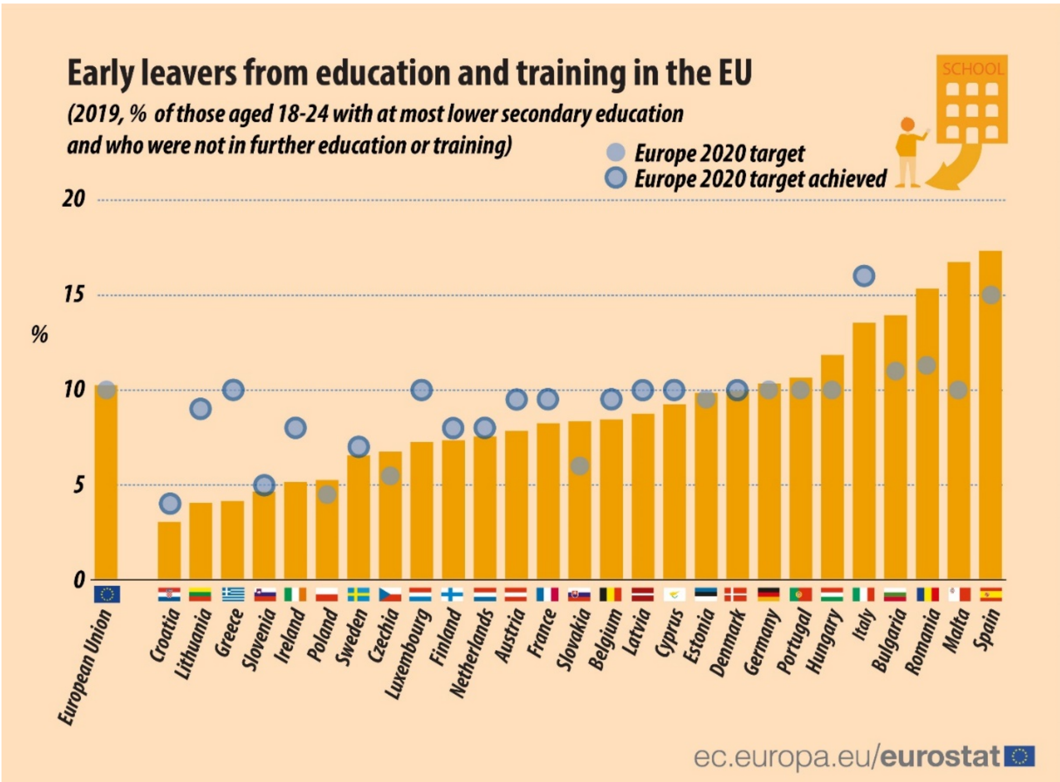


Figure 5-2 Early leavers from education and training in the EU (source: https://ec.europa.eu/eurostat/statistics-explained/index.php/Early_leavers_from_education_and_training)

European Innovation Scoreboard (EIS) 2020 report [330] provides a comparative assessment of the research and innovation performance of the EU Member States and the relative strengths and weaknesses of their research and innovation systems. Figure 5-3 shows scores for the Summary Innovation Index, which represents a measurement of the most recent performance of EU national innovation systems. The Summary Innovation Index is based on the 27 indicators from four different activity types (Framework conditions, Investments, Innovation activities and Impacts) such as new doctorate graduates, international scientific co-publications, R&D expenditure in the public sector, enterprises providing training to develop or upgrade ICT skills of their personnel, etc. [330].

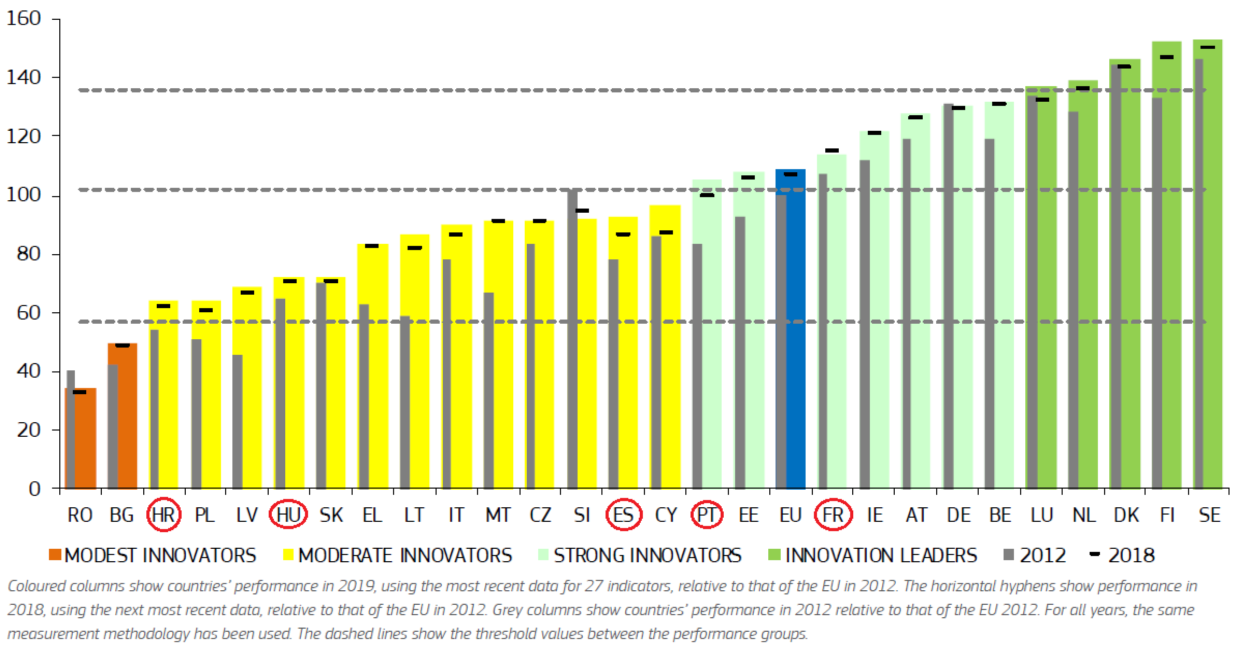


Figure 5-3 Performance of EU Member States' innovation systems with circled INNOSID countries [330]

When we compare graphs from two previous figures, we can see that although, for example, Croatia has achieved Europe 2020 target regarding early leavers from education and training, it is still in a group of Moderate Innovators where performance is between 50% and 95% of the EU average. Other INNOSID countries such as Hungary, Spain and Portugal are also in a group of Moderate Innovators, while Portugal and France fall into the group of Strong Innovators with a performance between 95% and 15% of the EU average. This comparison confirms that the innovativeness of some country depends on many different factors.

As it is concluded that social innovations can serve as tools to help achieve the Europe 2020 strategy targets, social innovation has already been supported by the EU through a whole range of programmes and initiatives (e.g. the structural funds). Also, regional and local authorities have already been encouraged in the past to use a community-led local development methodology and to promote partnerships between public, private and voluntary organisations, as well as citizens and local communities [322]. Having successful relationships of all actors in the social innovation ecosystem represents a solid foundation for solving great challenges, that is, for creating social innovations.

5.2 A conceptual framework for social innovation based on emerging technology

Innovation ecosystems already stimulate innovation in the field of technology, regional development and sustainability, so it is paramount that one such ecosystem is in place for social innovations. Social innovation ecosystems consist of actors from different societal sectors, each of them having unique responsibilities and goals. The relationships among the aforementioned actors would be best explained if they are arranged in a conceptual framework that will also help define how one can develop an impactful social innovation based on emerging technologies. This conceptual framework for social innovation based on emerging technologies consists of a **model** that is a graphical representation of key entities within the social innovation ecosystem and relationships between them; and a **process** that explains the approach that is necessary for the development of social innovation based on ET.

5.2.1 Quadruple helix model of social innovation based on emerging technology

The social innovation based on emerging technology ecosystem can be represented by a quadruple helix model (Figure 5-4) with the key actors being the academia, the industry, the government, and the civil society [329]. The actors work together to co-create the future and drive specific structural changes to society.

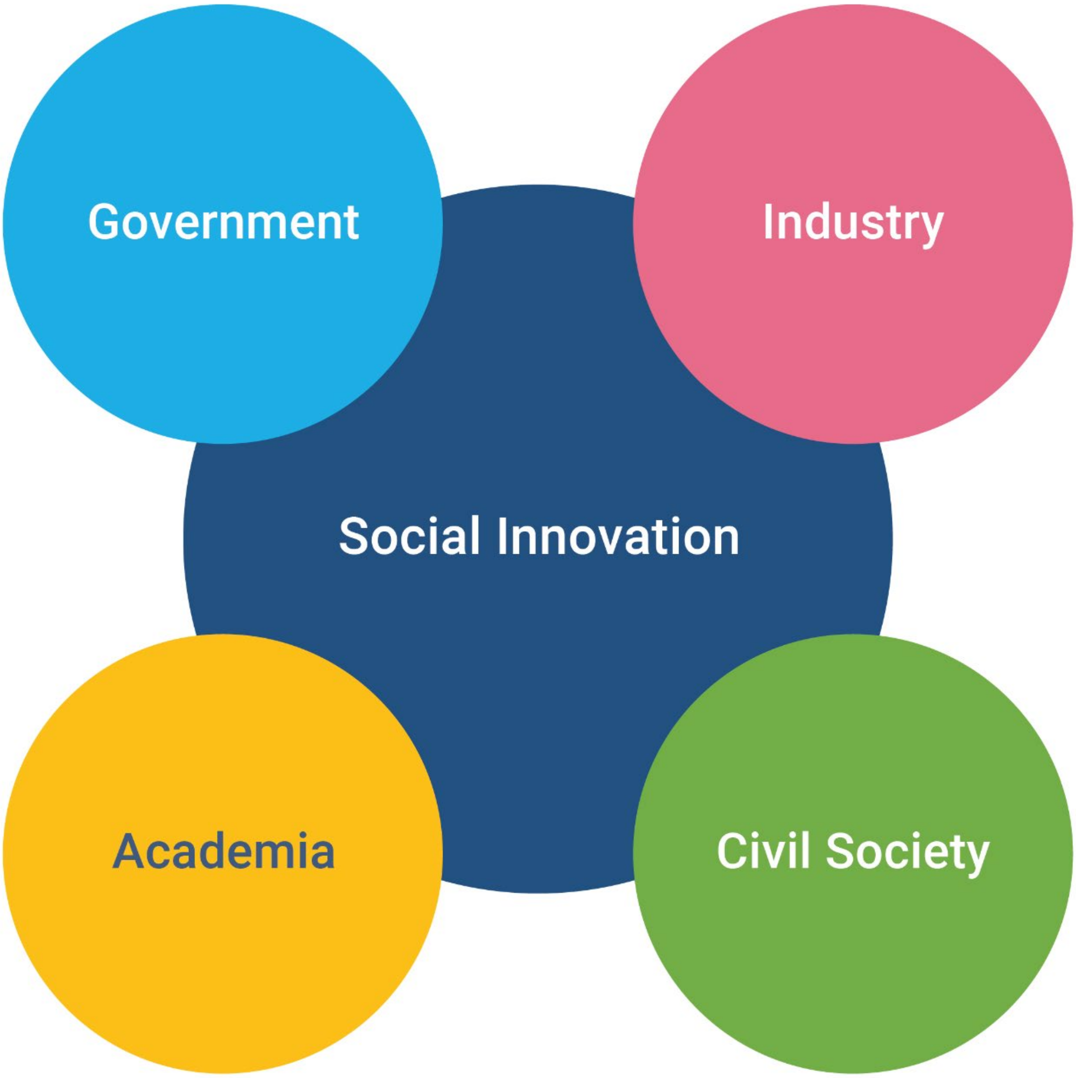


Figure 5-4 Quadruple helix model of social innovation based on ET

In this model, the **academia** is in charge of scientific research, elaborating and refining existing understandings of knowledge. A conventional method is to produce knowledge within the academia; however, social innovation demands interdisciplinarity, meaning that a knowledge transfer must occur between the actors in the model. At the same time, the number of publications and journal rankings are the most common measures of academic performance, so that remains the ultimate goal of the academia.

Industry, on the other hand, as an expert in product development, can turn scientific research inside the academia into something available to the public to use. As it is driven by profit, and as such cannot be successful without it, it also has access to funds which can be used to finance additional research. Exposure is also important for the industry, which is why any involvement in projects benefiting the society can lead to new customers and better user engagement.

The government should serve as a facilitator for collaboration among actors. It is in charge of regulation and control of the market and standardization based on a consensus of different parties. This cannot happen without the involvement of the public and other actors in the model. As always, the government should aim for economic growth and innovation that is responsible and sustainable.

Finally, **civil society** will be the main user of all social innovations which will result from this ecosystem. The society's goal is the improvement of life standard and social innovations are a great way to achieve that. For the society to participate in the innovation process, it needs a platform on which it can be heard. The participation of society in this process can be achieved through crowdsourcing, where other actors can hear the opinions and ideas of the public.

The next table shows in short what are the needs wants, and know-how of every actor described above.

Table 5-1 The needs, wants and know-how of every actor in a social innovation ecosystem

Actor	Needs	Wants	Know-how
Academia	Knowledge transfer	Publications	Scientific research Knowledge creation
Industry	Scientific research	Profit User engagement	Product development Financing
Government	Public involvement	Economic growth Responsible innovation	Regulation and control Standardization
Civil society	Collaboration platform	Improved life standard	Crowdsourcing Citizen participation

5.2.2 Prototype-driven process for the development of social innovation based on emerging technology

After the key entities and their relationships in a social innovation ecosystem have been explained, the appropriate approach for the actual development of social innovation based on emerging technology remains to be further elaborated.

As definition of social innovation states, in its early stage it starts with an idea (to respond to social demand, to deal with societal challenge, innovation in improved ways of designing and producing services, etc.). In the case where social innovation is based on emerging technology, the initial idea usually comes from technologists which is then evaluated and further refined with end users in further iterations. End users are able to articulate their needs by describing what problems or challenges they face in every day's life, but they most likely have a very limited knowledge on how a certain emerging technology can be used to address such needs. Therefore, they are primarily interested in technology-agnostic solutions which will have a direct positive impact on their lives. On the other hand, technologists have a strong understanding of the technical capabilities for a certain ET but, on their own, they may not be able to derive impactful and concrete real-life use cases. To facilitate the brainstorming discussions, technologists will often resort to showcasing the key innovative features of ET through an experimental prototype which was not necessarily designed with particular end user needs in mind. To summarize, in order to create an impactful social innovation based on ET, it is important to involve end users as soon as possible, preferably after the initial research on ET is finished and when technologists are able to develop interactive prototypes (e.g. prototype mobile application with support for augmented reality).

Given a high-level of uncertainties surrounding emerging technologies, it is evident that, work with emerging technologies demands exploration and experimentation in its early stages. Therefore, the first step, before the development of an ET-based product or even the thought of its practical application, is to make a quality foundational research and development (R&D) study, i.e. ET study, that identifies all the possibilities as well as advantages and limitations of the certain emerging technology, and allows us to obtain new knowledge having in mind both, the general research knowledge about the ET and the knowledge that can be applied for a specific goal, use or product.

In case of an R&D for a specific ET-based product that could be the next social innovation, this ET study should describe its overall vision, i.e. purpose and the positive change it could bring, its target group (users or costumers), what needs does it address or what problem does it solve, the feasibility of its development as well as the business goals. This R&D study on specific emerging technology can then serve as an input in a prototype-driven process for the development of social innovation based on that ET. It is important to emphasize that this process implies user involvement in every phase, e.g. representatives of youth, migrants, the elderly, socially excluded or whoever affects this innovation. In the development process, which is based on certain emerging technology, the introduction of the user with the ET is an extremely important step. This process with a detailed description of its phases is further elaborated for INNOSID case in 5.3.2. chapter.

The overview, i.e. a big picture, of the described approach for the development of social innovation based on ET is shown graphically in Figure 5-5.

Figure 5-5 The big picture of a creation of a social innovation based on ET

5.3 Framework for social innovation based on emerging technology for improving social inclusion of people with disabilities

This chapter will describe and put a visualization of the INNOSID project from the perspective of the conceptual framework for social innovation based on emerging technology described in the previous chapter. In INNOSID case, the framework proposes how to develop innovation based on emerging technology **for improving the social inclusion of people with disabilities** (hereinafter: Framework). As a first part of the Framework, key entities of INNOSID social innovation ecosystem will be named, described, and visualised through an instance of *Quadruple helix model of social innovation based on ET*. In addition, as a second part of the Framework, a process explaining the approach for the development of social innovation based on ET for improving the social inclusion of PWD will be visually represented and described.

5.3.1 INNOSID quadruple helix model

Like in the more generalized quadruple helix model from chapter 5.2., the key actors are the academia, the industry, the government, and the civil society. Figure 5-6 shows an instance of a quadruple helix model of social innovation based on ET with key actors from INNOSID social innovation ecosystem. Next subsections will name and describe the roles of the INNOSID key actors.

Figure 5-6 INNOSID quadruple helix model of social innovation based on ET

Government

The government should ensure that people with disabilities have the same rights and opportunities as everyone else, as well as to ensure that PWD can access the buildings, use services, public transportation and have open access to all publicly available information.

Government is also responsible for the creation and popularization of a national plan for social inclusion of people with disabilities. Furthermore, the government plays an important role in implementing such a national plan by passing the relevant laws and allocating funds for tenders. The government needs to ensure the resources for services and products that are designed to contribute to the aforementioned national plan for the social inclusion of PWD.

The most important role of the government is to promote the education and the employment of PWD, as well as to raise public awareness on PWD and their needs.

For the INNOSID project, the European Union is the body that through the Erasmus+ platform supports the project-based research and teaching activities. In particular, the Agency for Mobility and EU Programmes (AMPEU[47]) is a national agency responsible for monitoring and evaluating the INNOSID project results.

[47] https://www.mobilnost.hr/en

Industry

The industry is expected to take part in various projects that promote the social inclusion of PWD, as well as making the decision aimed at helping PWD within the company's corporate social responsibility (CSR) strategy. Finally, as a part of CSR strategy, it should aim towards employing the PWD and education of the staff about the social inclusion of PWD.

Since INNOSID is closely connected to the ICT-AAC, a great example of such a company is CROZ[48]. They provided the ICT-AAC with programmers and software development experts for the development of applications, and therefore, CROZ implemented their CSR through helping in application development and maintenance[49].

Besides the companies which can take part in the INNOSID quadruple helix model as part of their CSR strategies, it is worth mentioning that the model is also open for companies which core-business include products and services for PWD.

Academia (Universities)

Academia is the part of the ecosystem with the role of bridging other stakeholders and domains from the ecosystem, i.e., government, industry, and civil society. Universities should lead by an example and incorporate the topics of social inclusion in the existing curricula, as well as to conduct interdisciplinary research in the field of ICT and the assistive technologies. Projects that the universities are a part of should cover the topics of PWD and engage the students in those projects in order to help PWD and enable them to make the real-world impact.

The University of Zagreb, Faculty of Electrical Engineering and Computing (FER) is the coordinator of the INNOSID project that is aimed towards social inclusion of PWD, as well as to help them in their day-to-day life. Besides the coordinator (FER), there are five different Universities engaged in the INNOSID project, from different parts of Europe: Universitat Politècnica de València (Spain), University of Debrecen (Hungary), IMT Atlantique Bretagne-Pays de la Loire (France), University of Dubrovnik (Croatia), Polytechnic Institute of Santarém (Portugal). The INNOSID project outputs three different types of deliverables: (I) report, (II) multilingual support for the ICT-AAC applications, and (III) new tools based on emerging technologies. This report summarizes all activities on the project, as well as documents various findings relevant to the domain of the project. FER also provided developers to implement the multilingual support for the ICT-AAC applications, in order to make them more accessible across a larger number of the potential users. Besides the developers, INNOSID members provided researchers in order to research new technologies and decide how they suite for the application of increasing the social inclusion of the people with disabilities.

Civil society

Civil society for the support of people with disabilities mostly includes parents and experts in non-governmental and non-profit organizations (NGOs and NPOs). These organizations continuously look for the opportunities on how to ensure a better level of support of their members. Their main goal is to enable learning of the necessary skills and knowledge for everyday life and inclusion in society. Preparing a child for inclusion in the school and education system is also part of continuous learning. Children with disabilities should be well prepared for steps in learning like memorization, writing, reading, and math skills. According to the child's abilities and difficulties, these steps should be harmonized, changed, and additionally adjusted. Figure 5-7 shows a child with a disability playing and learning with materials prepared for him to practice different skills.

[48] https://croz.net
[49] http://www.ict-aac.hr/projekt/index.php/en/supporting-associates/croz

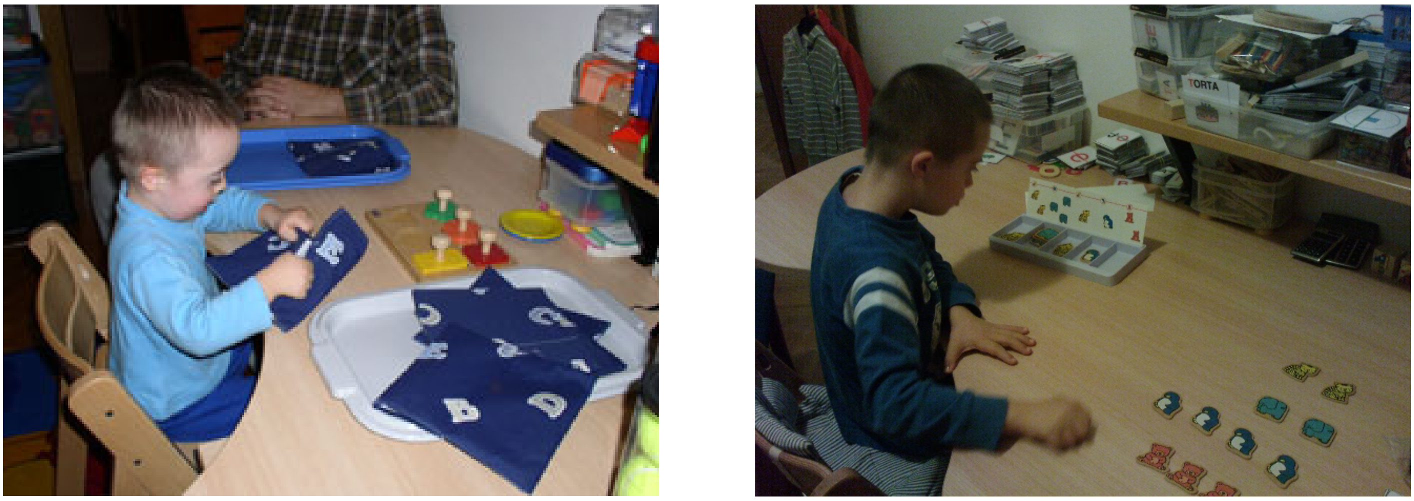


Figure 5-7 Child playing and learning with specialized materials

Furthermore, organizations for PWD aim towards the inclusion of PWD in ordinary schools instead of specialized ones. With the goal to increase the social inclusion for PWD, various organizations assess the quality of services for PWD, as well as raise the awareness of PWD and their needs. For aforementioned to be possible, organizations are, commonly in cooperation with universities, engaged in various research in the domain of PWD.

One of the largest organizations for PWD in Croatia: Croatian Down Syndrome Association (CDSA)[50], actively works on the social inclusion of PWD and is one of the partners on the INNOSID project. Their input for the engineering part of the INNOSID consortium is of great value since this interdisciplinary project requires a view from different perspectives. CDSA is also actively participating in the INNOSID project outputs, namely the new IT tool based on emerging technologies. Their input is the most important one since they work with people with disabilities on a daily basis and are familiar with their preferences and needs.

Organizations for PWD also have an intent to represent PWD on a local, national, and international level. The CDSA often organizes workshops for the parents of PWD, as well as for all other people to raise awareness about the social inclusion of PWD.

The impetus for social innovation ecosystem stemmed from the growing openness of NGOs, the recognition in society of people with disabilities, especially their involvement in the education system and their efforts to be among their peers, to learn together with them and to be as equal as possible.

The size of a social innovation initiative varies depending on the target groups. However, as the solutions themselves can very often be very acceptable to groups without difficulties, they have become much more used than it was initially thought. The possibility of using it for other groups also became one of the points in the analysis of innovative solutions. In some situations, the initial solution prompted consideration of added value (e.g. new application, multiple levels of word processing, or notation) for groups with their own specifics.

50 http://www.zajednica-down.hr/index.php/en

ICT-AAC project – a successful social innovation story

An exceptionally good example of a successful social innovation story is the ICT-AAC project[51]. The project involved different institutions as partners whose members included researchers from academia, experts from different social areas, different small and medium enterprises (SMEs), associations/NGOs for support of people with disabilities, as well as end-users - persons with disabilities.

One of the incentives for the ICT-AAC project was that there were no applications for learning or getting knowledge in some areas (e.g. learning mathematical skills) in the Croatian language or in the way proposed by the program in the Croatian education system. Parents and professionals used or adapted applications in other languages (mostly English) since there were no applications in the Croatian language.

With applications in the Croatian language, parents and experts get a new tool and a new opportunity to learn and encourage people with disabilities to learn in a new way.

Over a couple of years, innovative ideas came as they increasingly saw the needs that could be realized through innovative solutions and new applications, and the possibilities of ICT were rapidly increasing. NGOs in cooperation with the academic community continued to seek new funds for the continuation and implementation of new applications over the competition for NGOs.

All applications developed during the project are available to everyone without financial compensation, which means a lot for parents of people with disabilities. Through several initiatives and humanitarian actions, especially a couple of years ago, when tablets were not available to the majority, parents were helped by donating or giving away the use of tablets. Recently, availability has been much higher, and applications are very acceptable on mobile smart devices as well.

Although people with disabilities still need to work hard to develop motor and cognitive abilities and continue to use educational materials, the availability of learning via tablets and mobile phones helps them to have mobility and accessibility to learning and repetition outside their home and therapeutic spaces.

Younger parents of children with disabilities due to higher ICT abilities are more inclined to use technology and available applications than parents of “older” people with disabilities.

As people with disabilities increasingly love technology, they become motivators for developing innovative solutions and applications. Namely, their difficulties do not prevent them from playing games, watching movies, listening to music via tablets or mobile phones. Because they still need help with some important skills, the offered solutions or applications enable them to learn faster, navigate and even be more mobile.

All this would not be possible if there was no collaboration with other actors from “social innovation ecosystem”. The biggest challenges in working with other actors such as researchers, developers, students were how to explain and translate experience, knowledge, and methods into requirements for creating new platforms, new applications and what prerequisites need to be met in order to achieve the end result.

Also, parents and professionals working with children with disabilities needed to learn at least the basics of what new technologies allow so that the requirements they were supposed to specify could be realized. It takes a lot of learning, listening, and understanding of each other to make it easier for parents and children with disabilities to achieve the necessary skills and knowledge.

[51] http://www.ict-aac.hr/projekt/index.php/en

5.3.2 INNOSID prototype-driven development process

This section describes an approach for the development of social innovation based on ET for improving the social inclusion of PWD. It is visually presented with a prototype-driven process for the development of ET-based socially inclusive product for PWD (hereinafter: Process). In addition to the visual presentation, the key elements and phases of the Process are described in this section.

The Process is inspired by the model of a prototype-driven software development process for augmentative and alternative communication (AAC) applications proposed by Babic et al. (2015) in [318]. The proposed software development process model is directly applicable to the development of AAC software for mobile ICT devices, such as tablets and smartphones. As such, it presents an important building block in the overall value network for ICT-assisted AAC with its tangible and intangible values [331]. The efficiency of this process has been proven with every ICT-AAC application developed using the proposed development process, which includes all general software engineering best practices and extends them with specifics of the AAC domain [318].

Basing the Process on the aforementioned software development process model and extending the Process with specifics of any emerging technology domain, the proposal of the prototype-driven process in this section should help one to be able to answer how to develop an impactful social innovation based on emerging technologies for social inclusion of PWD. More specifically, how to design and evaluate an innovative product for social inclusion of PWD based on emerging technology (ET).

As mentioned in a more generalized Prototype-driven process for the development of social innovation based on ET in chapter 5.2.2., since we are dealing with emerging technologies, an input to a process for the development of any ET-based social innovation needs to be a quality R&D ET study that allows us to obtain the knowledge necessary for further proceedings.

In case of development of an ET-based product that will serve for social inclusion of PWD, this study should outline the next:

- What is the purpose of creating such a product?
- Since PWD is a broad term, who are the end-users of the product more specifically?
- Whether the product contributes to anyone other than people with disabilities, who else will be able to use the product, will the family or caregivers also benefit from this product?
- What problem does the product solve?
- Considering the emerging technology on which the product is based, is it feasible to develop it?
- Will the end-users be able to use it efficiently, considering different difficulties they might have?
- What are the business goals of developing such a product?

The overview of the prototype-driven process for the development of social innovation based on ET for social inclusion of PWD is shown graphically in Figure 5-8.

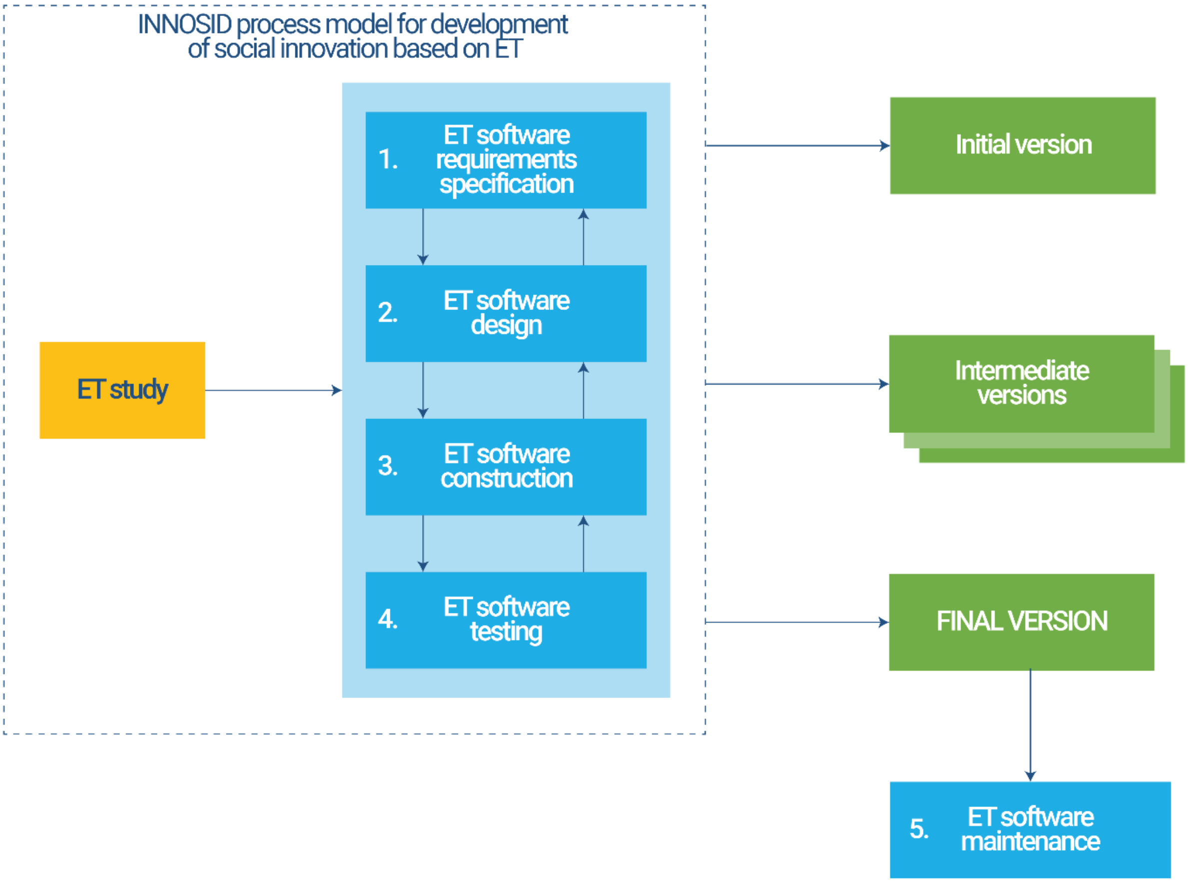


Figure 5-8 Prototype-driven R&D process model for the development of ET-based social innovation for social inclusion of PWD

As can be seen from the figure, the above described ET study is an input for further process that begins with a phase of ET software requirements specification. This is a phase that uses ET study that defines a general idea behind the ET-based product to create detailed software requirements specifications for the proposed product. This phase should describe all the features and behaviour of an ET-based product. In order to do that, a multidisciplinary approach is needed. Depending on the specific group of end-users, bearing in mind that those are people with disabilities, experts from different fields, e.g. information and communication technology, rehabilitation and education, psychology and graphic design, should be included in this phase. People with disabilities are a heterogeneous group of people whose disabilities are often very individual so that entails that they might have different needs as end-users. Therefore, this phase should include the end-users themselves (or their representatives) for requirements elicitation.

End-users, such as parents, professionals working with people with disabilities and people with disabilities are an important part of the development process for innovative solutions and applications. End-users have domain knowledge, experience and can transfer specific difficulties and needs to define requirements due to which the developed solution will be of high quality, useful and acceptable to the end-users. End-users with their ideas contribute to clearer solutions, of course, with experts involved in the development process.

In case of the ICT-AAC project, the NGO team was continually active in proposing solutions and applications, since the NGO worked together with their members on various methods of learning and acquiring skills, and thus gave their suggestions from experience. Namely, while working with people with disabilities, they knew what would make their work and learning easier and how certain tasks and steps in learning could be improved or realized differently in applications.

What is specific about the ET software requirements specification phase is that it requires additional preparation before gathering the requirements from end-users. Because we are talking about emerging technologies whose development still might be ongoing and practical applications are still limited, the experts and/or end-users might not be familiar with all the features emerging technology offers. Therefore, it is necessary to demonstrate the current situation of emerging technology and the way in which technology can be used. Ideally, a prototype demonstrating functionalities which are key to that technology, as well as possible user interaction mechanisms, is shown to the end-users. Based on the demonstration, end-users and/or experts will have a vision of the emerging technology and will suggest ideas and requirements for the software product based on that.

The demonstrations are important and necessary for users to understand how emerging technology can be used. This should be the first step in the development process.

End-users (PWD), as well as their representatives, usually do not have enough information about emerging technologies, such as augmented and virtual reality. To raise their competencies as well as inform them, workshops, short training and demonstrations of existing solutions or new prototypes should be organized.

After gathering and analysing the user needs, software requirements are defined and inspected by a multidisciplinary team. As mentioned before, the output od this phase is a fundamental document that describes the features and behaviour of an ET product and bridges the gap between user requirements and developers view. This also includes the ET-specific guidelines for software design, such as ET-driven user interface mechanisms, graphical design, mechanisms of customization of the content to the individual user etc. The output of this phase is a prototype with a high-level of abstraction.

The next phase that follows in the ET software development process is the **ET software design** phase. The input for this phase are abovementioned requirements and ET-specific software design guidelines that should provide a reference to software designers in order for them to be able to construct an applicable ET software design model. During the ET software design, the highest priority should be set on the user needs, i.e. user-centred design technique should be used. While analysing what users like, specific suggestions for software designers in the context of presentation and accessibility of the ET software product will be generated.

After modelling the ET software design model, the next phase of the ET software development process is the **ET software construction** phase. A refined ET software model that is the final output of the previous phase is used in the construction of the software solution. The software design model specifies appropriate software architecture for the ET-based software product according to which developers can implement the solution. This phase very much depends on the emerging technology on which the final product is based on since this is the implementation phase and each ET software implementation differs considering the ET itself as well as the device, system, platform, or headset on which the software will be used. Because of that, the best approach for ET software construction is a native coding approach, especially because the development of some emerging technologies might still be ongoing in the process. Outputs of this phase are: ET-based product prototype, i.e. its initial and intermediate versions, production-ready ET-based product, i.e. final version of the ET-based social innovation, and user guide for which it is especially important to be comprehensively written to resolve all doubts the users might have when dealing with new technology.

The next phase of the ET software development process is the **ET software testing** which follows the implementation of every ET-based product prototype version. This phase serves to verify all functionalities and features specified with the requirements and used design principles. In the beginning, it is important to evaluate the efficiency and correctness of a software solution. For this kind of usability testing, test scenarios are defined so that users appropriately test all the functionalities of the prototype. Since some of the emerging technologies demand specialized setup of devices and/or environment, testing of prototypes based on those ET should be conducted in a controlled environment with appropriate trial set up. The output of this phase is the report on ET software quality as well as formal and informal feedback from all the stakeholders (experts, users, etc.).

Involving end-users in the evaluation process of the solution developed for them is extremely important as during this evaluation the end-users can see whether the functionalities of the solution meet their needs, i.e. the requirements they helped define. Also, the user evaluation will show if the gap between the user requirements and developers view is addressed correctly and if the offered solution is acceptable for use. Having a solution that is not accessible and highly usable is not a desirable goal of any developer. That is why user evaluation is an extremely important phase of the solution development process.

During the ICT-AAC project and other smaller projects during which applications and solutions for people with disabilities were developed, feedback from end-users was important to refine the applications, to better solve some parts or supplement some data. Namely, end-users from NGOs had information about the ICT competencies of their members and those for whom the applications were the primary purpose and could competently point out the possible inappropriateness of the solution.

After having the final, production-ready version of the ET-based software product and realising it to the public, the **ET software maintenance phase** begins. The purpose of this phase is to track any changes or updates related to technology or platform used within or with ET-based released product in order to solve those issues specific to each technology or platform. Besides that, if users encounter on any problems, such as bugs, errors or inconsistencies, or they have suggestions and requirements for product improvement, they can report it to the developers, after which the fixes and the improvements of the ET software are performed, and a new version published.

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Abbreviations

3D	*Three-dimensional*
AAC	*Augmentative and Alternative Communication*
AAL	*Ambient Assisted Living*
AAT	*Animal-Assisted Therapy*
ADHD	*Attention Deficit Hyperactivity Disorder*
AGI	*Artificial General Intelligence*
AI	*Artificial Intelligence*
ANI	*Artificial Narrow Intelligence*
API	*Application Programming Interface*
AR	*Augmented Reality*
ARASAAC	*Aragonese Centre for Augmentative and Alternative Communication*
ASI	*Artificial Super Intelligence*
AT	*Assistive Technology*
CDSA	*Croatian Down Syndrome Association*
CMS	*Content Management System*
COVID-19	*Coronavirus disease 2019*
CRPD	*Convention on the Rights of Persons with Disabilities*
CSR	*Corporate Social Responsibility*
EASNIE	*European Agency for Special Needs and Inclusive Education*
EASPD	*European Association of Service providers for Persons with Disabilities*
EDF	*European Disability Forum*
ÉFOÉSZ	*Hungarian Association for Persons with Intellectual Disabilities*
EIS	*European Innovation Scoreboard*
ET	*Emerging Technology*
EUSE	*European Union of Supported Employment*
FDM	*Fused Deposition Modelling*
FER	*Faculty of Electrical Engineering and Computing*
GDP	*Gross Domestic Product*
GPS	*Global Positioning System*
HAKOM	*Croatian Regulatory Authority for Network Industries*
HMD	*Head Mounted Display*
ICF	*International Classification of Functioning, Disability, and Health*

ICT	*Information and Communication Technology*
ICT-AAC	*ICT Competence Network for Innovative Services for Persons with Complex Communication Needs*
IDD	*Intellectual and Developmental Disabilities*
INNOSID	*Innovative Solutions based on Emerging Technologies for Improving Social Inclusion of People with Disabilities*
IoT	*Internet of Things*
IPS ESES	*Instituto Politécnico de Santarém Escola Superior de Educação de Santarém*
IT	*Information Technology*
ITU	*International Telecommunication Union*
MIT	*Massachusetts Institute of Technology*
ML	*Machine Learning*
MR	*Mixed Reality*
NFC	*Near Field Communication*
NGO	*Non-governmental organization*
NLP	*Natural Language Processing*
OECD	*Organisation for Economic Co-operation and Development*
OER	*Open Educational Resource*
PIP	*Print-in-place*
PWD	*People with Disabilities*
R&D	*Research and Development*
SEN	*Special Education Needs*
STEM	*Science, technology, engineering, and mathematics*
UD	*University of Debrecen; Universal Design*
UE	*User Equipment*
UN	*United Nations*
UNESCO	*United Nations Educational, Scientific and Cultural Organization*
UNIZG-ERF	*University of Zagreb Faculty of Education and Rehabilitation*
UNIZG-FER	*University of Zagreb Faculty of Electrical Engineering and Computing*
UPV	*Polytechnic University of Valencia*
VR	*Virtual Reality*
WCAG	*Web Content Accessibility Guidelines*
WHO	*World Health Organization*

Appendix A

INNOSID consortium partners

Higher education institutions

University of Zagreb
Faculty of Electrical Engineering and Computing

CROATIA, Zagreb
Project Coordinator, Steering Committee, Partner

The University of Zagreb (1669), which consists of 34 faculties and academies, is the oldest and biggest university in the South-Eastern Europe. With its comprehensive programmes and over 50,000 full-time students the University of Zagreb is the strongest educational institution in Croatia. Specifically, the Faculty of Electrical Engineering and Computing, through education and innovation in fields of electrical engineering, computer science and information and communication technology, prepares students for leading technological and societal development of Croatia.

UPV is a public Higher Education Institution actively involved in international cooperation and mobility projects. UPV hosts over 36,000 students and employs over 5,000 people (teaching, research, administrative, services staff). It is the first technological university in Spain according to international rankings (e.g. Shanghai Ranking of World Universities) and offers 33 undergraduate programmes, 73 official Master's degrees and 28 Doctorate programmes.

Universitat Politécnica de Valéncia

SPAIN, Valencia
Steering Committee, Partner

University of Debrecen

HUNGARY, Debrecen
Steering Committee, Partner

University of Debrecen is one of Hungary's five elite-research universities, offering the widest choice of majors in the country for over 29,000 students, including 3,741 international students. UD's 1500 lecturers of 14 faculties endeavour to live up to the elite university status and to provide high quality education. Our goal is to train professionals possessing all necessary skills and knowledge to enter the regional, national, or international labour market with a competitive degree. More than 1000 lecturers with doctoral degrees (PhD), 25 doctoral schools, and the volume of internationally renowned research publications and projects attest to the scientific dominance of the university. 139 of the lecturers and researchers are Doctors of the Hungarian Academy of Sciences and 27 are members of the Academy.

Institut Mines Telecom Universitat Atlantique Bretagne Pays de la Loire

FRANCE, Brest
Steering Committee, Partner

In the 30 years since its creation, Telecom Bretagne has affirmed itself as a pioneering "Grande École" in education, research and enterprise. It trains multi-discipline engineers able to assume important responsibilities. Recognised for its dynamism and its very substantial international dimension, Telecom Bretagne has partnerships with more than 100 establishments of higher education and research throughout the world. It collaborates with MIT and the Lausanne École Polytechnique Fédérale on the subject of pedagogic innovation. More than a thousand students, from 50 countries, follow engineering courses on two quite exceptional campuses situated at the heart of very active high-technology clusters.

University of Dubrovnik

CROATIA, Dubrovnik
Partner

The University of Dubrovnik is the "youngest university in Croatia. It was established in 2003. on the foundations of a very long tradition which goes back to the 17th century, but also on decades of modern higher education.
By its programs, its organisation and its technical equipment, the University of Dubrovnik can be stands among very modern educational institutions.

Instituto Politécnico de Santarém

PORTUGAL, Santarém
Partner

The Polytechnic Institute of Santarém (IPSantarém) is a public Portuguese Higher Education Institution with more than 35 years of experience in the fields of higher education and applied research. IPSantarém integrates five Schools and a Research Unit, located in the cities of Santarém and Rio Maior. IPSantarém delivers vocational, bachelor and master degree programmes, regarding the specialization areas of the schools: 1) School of Agriculture (ESAS): Agriculture & Food Science; 2) School of Education, (ESES): Education, Arts & Multimedia Communication; 3) School of Management and Technology (ESGTS): Management & Technology; 4) School of Health (ESSS): Health & Nursing; 5) School of Sport (ESDRM): Sports & Physical Activity. During 2019, 51 research and technology transfer projects have been active in IPSantarém. Much of our research is supported by research programs like Erasmus+ and Portugal 2020. Some of these projects are developed under the research centre hosted by IPSantarém, Life Quality Research Centre (CIEQV) and the Digital Literacy and Social Inclusion Unit (http://pololiteraciadigital.ipsantarem.pt/) in which Maria Potes Barbas and Pedro Matos are integrated as full researchers.

Non-governmental organization

Croatia Down Syndrome Association

CROATIA, Zagreb
Partner

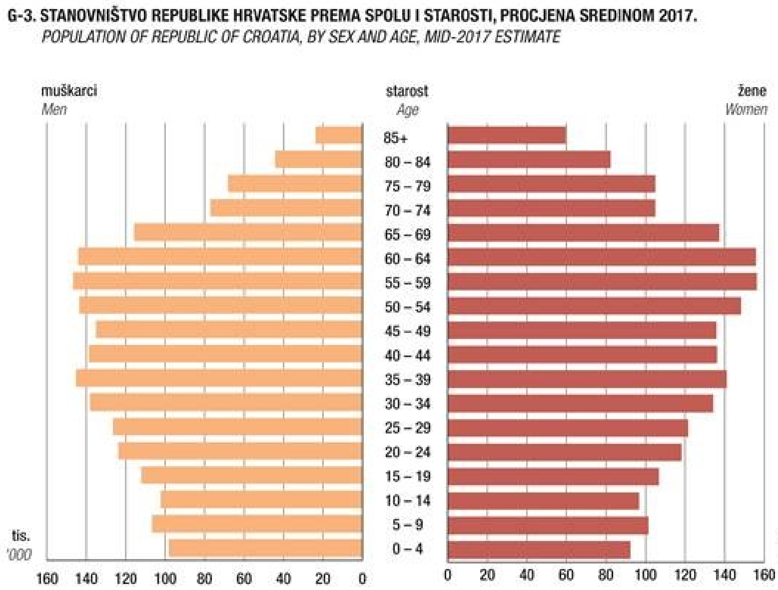
Croatia Down Syndrome Association, composed of caretakers and parents of persons with complex communication needs (CCN), is collaborating with Consortium Partners in identifying capabilities and needs of persons with Down Syndrome.

Appendix B

Statistical data and interesting facts gathered for INNOSID partner countries

Croatia

Statistical report by Croatian Bureau of Statistics from 2011 (the last official Census of Population, Household and Dwellings 2011, Population by Sex and Age)[52] shows that there are **4,284,889** people living in the Republic of Croatia, out of which there are **48.2%** men and **51.8%** women. However, more recent estimates (Population Estimate of Republic of Croatia 2017, Croatian Bureau of Statistics[53]) show that the total population is **4,124,531**, out of which there are **48.3%** men and **51.7%** women. This report states that the average age of the total population is **43.1** years (men **41.3**, women **44.8**), which places the Republic of Croatia among the oldest nations in Europe.



The population of Republic of Croatia, by sex and age, mid-2017 estimate[53]

According to the report on people with disabilities (2019)[54] by Croatian Institute of Public Health the total number of people with disabilities in the Republic of Croatia is **511,281**, which makes **12.4%** of total population (considering the estimated data on total population from 2017). Most people with disabilities (**49%**) belong to the age group of 65+, followed by **42%** at the age of 20-64 and only **9%** that are at the age of 0-19. **0.6%** of people with disabilities are 100% disabled.

Croatian Employment Service's report (2019)[55] indicates that from 1st of January until 30th of September **2,352** people with disabilities were employed with the mediation of the Employment Service which is about the same as the last year's numbers for that period. Furthermore, there are **5,402** unemployed people with disabilities which makes **4.8%** out of the total unemployment rate for that period. Report shows that most of the employed people with disabilities (the total of 526) are at the age of 20-24 and that the numbers are steadily decreasing with age (most of the unemployed people with disabilities are over 60 years of age). Most of the employed people with disabilities, for the previously mentioned period, work in **manufacturing (369)** and the most common occupation is **maintenance worker (319)**.

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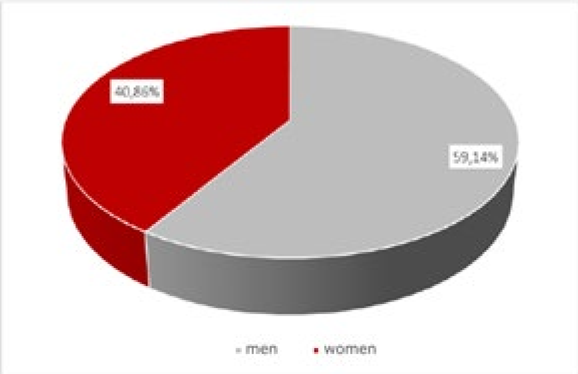
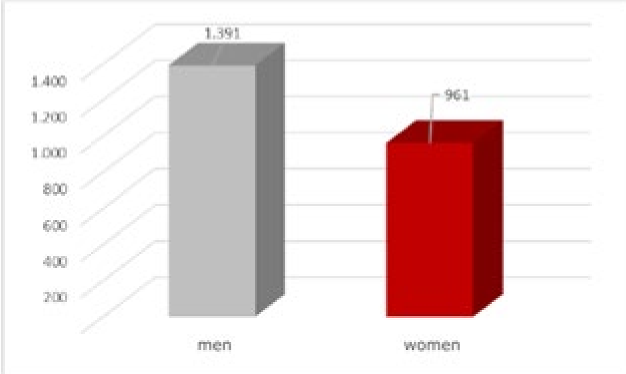
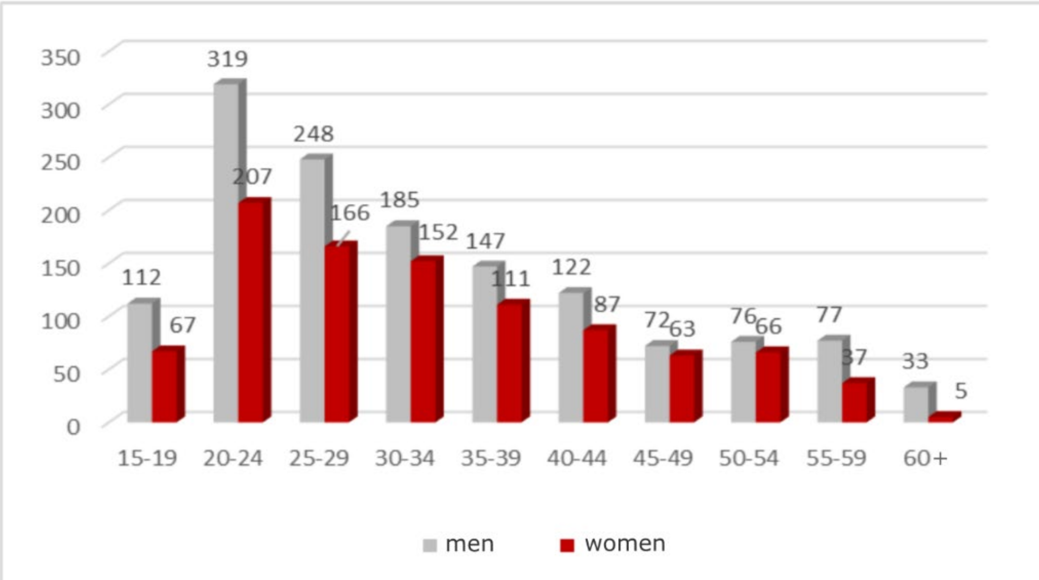
52 https://www.dzs.hr/default.htm
53 https://www.dzs.hr/Hrv_Eng/publication/2018/07-01-03_01_2018.htm
54 https://www.hzjz.hr/wp-content/uploads/2019/05/Invalidi_2019.pdf
55 http://www.hzz.hr/statistika/statistika-zaposljavanja-osobe-s-invaliditetom.php





Employment statistics of persons with disabilities by sex in Croatia[55]



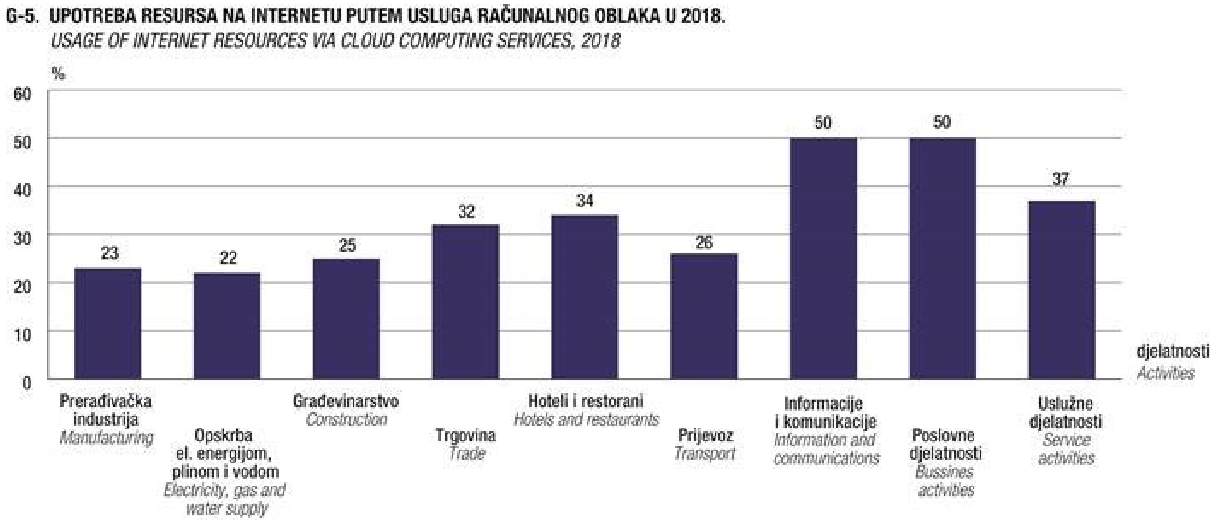
Employment statistics of persons with disabilities by age and sex in Croatia[55]

The previously mentioned report[55] also shows that most of the people with disabilities have **secondary education** (up to 3 years) or that they have finished school for a **skilled/highly skilled worker**. According to the report most of the people registered as unemployed **(30.86%)** and employed **(36.73%)** for the beforementioned period suffer from **a mental disorder**.

World Health Organization reports that in May 2017, **3%** of people registered as unemployed had a disability (**56%** of men, **44%** of women)[56].

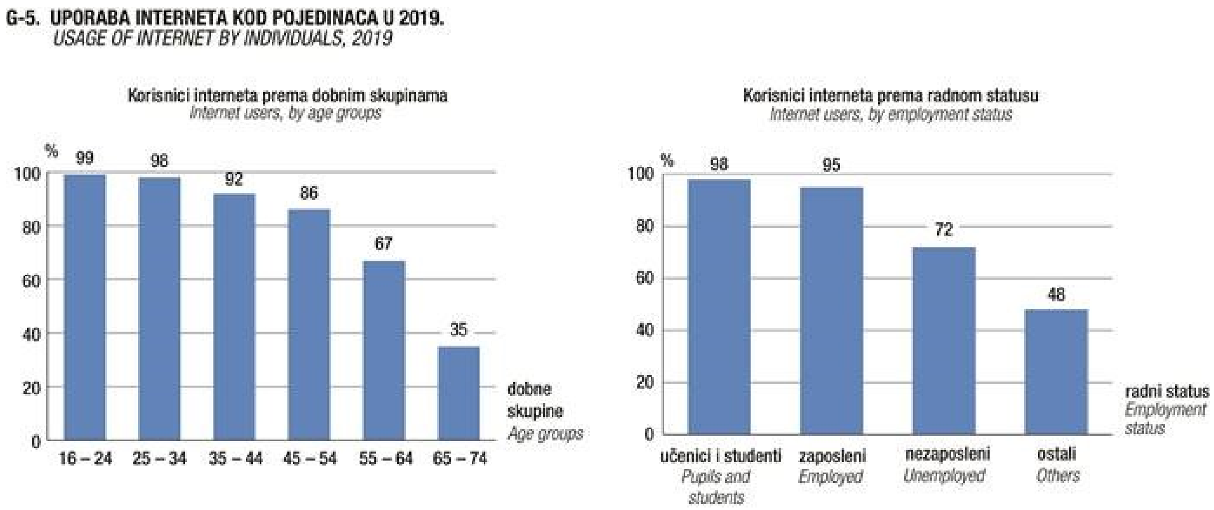
The report "Usage of Information and Communication Technologies (ICT) in Enterprises"[57], 2018 by the Croatian Bureau of Statistics states that **97%** of enterprises have Internet access and **73%** of them owns a website. However, Internet sales cover only **12%** of the total sales of goods and services. The usage of computing resources via cloud computing services is still in development and rising, it is used by **31%** of enterprises.

[56] http://www.euro.who.int/__data/assets/pdf_file/0008/397214/20190311-h1245-croatia-report-no-isbn.pdf
[57] https://www.dzs.hr/Hrv_Eng/publication/2018/02-03-01_01_2018.htm



The usage of the Internet resources via cloud computing services[57]

Croatian Bureau of Statistics also provides a report on the usage of ICT in households and by individuals (2019)[58]. This report states that the usage of broadband Internet access is rising – an increase of **4%** has been noted (compared to 2018) while the usage of online e-government services is lower than the last year's level (a decrease of **6%** compared to 2018). General statistics show that out of the total number of surveyed households **19%** did not have Internet access. Furthermore, there is an increase in all age groups of Internet users compared to the previous year, the largest one in the **55-64** age group (**8%**). However, the youngest population still maintains the lead in Internet usage (**99%** of people aged **16-24** use the Internet). Commerce via the Internet has also increased significantly – **45%** of Internet users have purchased goods and services via the Internet (**10%** increase compared to 2018).



The Internet usage by individuals[58]

[58] https://www.dzs.hr/Hrv_Eng/publication/2019/02-03-02_01_2019.htm

France

According to the National Institute of Statistics and Economic Studies (INSEE) statistics[59], the population of France at the end of 2019 was 67,063,703. There are 34,667 million men and 32,397 million females. The average age of the total population is 41.8 years (men 40.3 and women 43.1).

Approximately 12 million French people, i.e. 18.18%, have some form of disability, according to OCIRP[60]. The majority of the French population with a disability (school-age children not taken into account) is over 75 years old (44,8%) while 26.6% is at the age of 25-60[61]. Around 23% of women with disabilities 20% of men with disabilities are unemployed.

In 2015, 35% of people with disabilities were employed in companies that are legally obliged to employ disabled workers. This number corresponded to about 328,000 people and rose to 489,100 disabled workers by 2017. In 2015, 8% of the active disabled population was unemployed. According to these data from AGEFIPH[62], the private sector is the largest employer of people with disabilities in France. In the public sector, the positions occupied by these employees are mainly in local government.

According to the survey by INSEE (2015), people recognized as disabled are more often employed as unskilled workers and less often as managers. Compared to the working population as a whole, people with disabilities are more often employed in administrative or service sector positions, 34% compared to 28% for the working age population as a whole (15-64)).

The percentage of disabled people without a degree is higher than that of the total population: 51% compared to 31%. 7% of the population recognized as disabled have a university degree (compared to 27% of the population aged 15-64).

Profile of the French Internet user

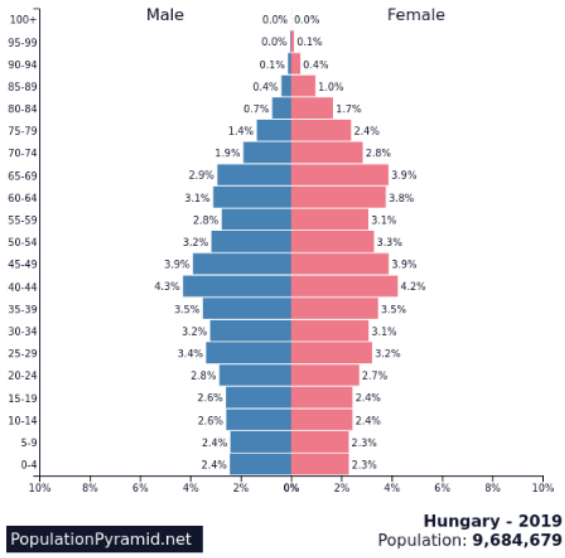
According to the CAPUNI survey[63] carried out in 2019 by Marsouin, a Social Science laboratory based in IMT Atlantique, 91% of the French population over 18 are Internet users. They are defined as individuals who have used the Internet in the last three months. This shows an increase from the previous survey which showed that 84% of the French population are Internet users (Capacity, Marsouin-FING, 2016). The conducted survey included topics regarding digital connectivity and equipment, diversity and intensity of use, computer skills, attitudes towards and representations of digital technology and empowerment. Age remains the most significant factor in relation to Internet use in 2019, only persons over 75 years of age, 47% of them, remain less connected than the national average. Other socio-economic factors, such as income per household, level of studies and socio-professional category are also a factor, to a lesser degree, in analysing the Internet use. Indeed, there are proportionally fewer Internet users among people with the lowest incomes (who make less than 1400 euros a month) - 86%, only 77% of people with primary and lower secondary education are Internet users, 60% among agricultural workers and 60% among the unemployed. According to the survey, living in a remote rural area does not generally influence Internet usage, whereas it does impact people with a similar socioeconomic background living in underprivileged urban areas. Out of the 9% of the adult French population who are non-Internet users, 29% report "no longer being capable" of doing so but also 10% of them deliberately limit their use of digital technology. 67% of the non-Internet users consider themselves happier without the Internet and more than half of them pride with that fact.

*With the contributions of IMT Atlantique students:
Lucia Fis Galende, Mateo Agudelo Jaramillo, Vinicio Gonzaelz Rodriguez, Helder Betiol

[59] https://www.insee.fr/fr/statistiques
[60] https://www.ocirp.fr/actualites/les-chiffres-cles-du-handicap-en-france
[61] Centre d'observation de la société, L'état du handicap, February 2018
[62] Association de Gestion du Fonds pour l'Insertion Professionnelle des Personnes Handicapées
[63] https://www.marsouin.org/mot303.html

Hungary

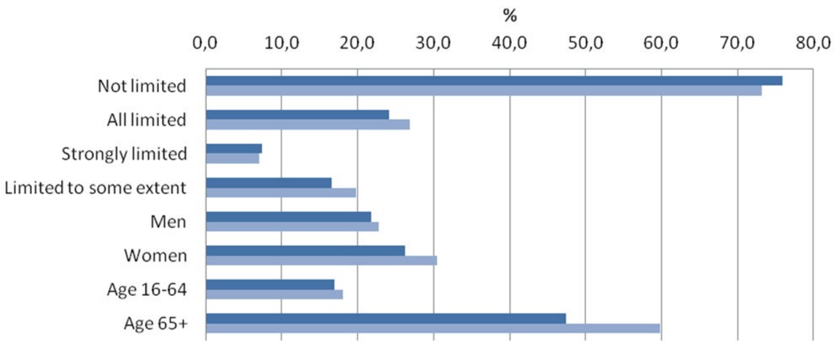
Statistical report 2011 by Hungarian Central Statistical Office based on the last official Census of Population (Household and Dwellings 2011, Population by Sex and Age)[64] shows that there are **9,937,628** people living in Hungary, **47.48%** of whom are men and **52.52%** are women. However, more recent estimates (Population Estimate of Hungary 2019, Hungarian Central Statistical Office)[65] show that the total population is **9,772,756** on 1st January 2019, out of which there are **47.85%** men and **52.15%** women. This report states that the average age of the total population is **42.7** years (men **40.5**, women **44.7**), thus Hungary is slightly above the European average age[66].



The population of Hungary, by sex and age, end-2019 estimate (https://www.populationpyramid.net/hungary/2019/)

Number of PWD by disability severity (in comparison to EU)

Although the Mikrocenzus survey conducted in 2016 did not examine the percentage of disability, but 50% of respondents feel severely limited, which is judged as subjective. According to sources, it applies much more to living conditions than to their actual health condition. The surveys were based on the categories of disability and not on their severity[67].



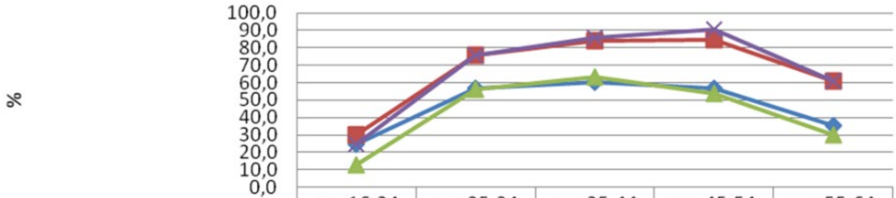
	Age 65+	Age 16-64	Women	Men	Limited to some extent	Strongly limited	All limited	Not limited
EU average	47,5	17,0	26,3	21,8	16,6	7,5	24,1	75,9
National average	59,8	18,1	30,4	22,8	19,8	7,0	26,9	73,2

Summarization self-reported activity limitations as a cause for impairment/disability based on data of Microcenzus 201667

[64] http://www.ksh.hu/nepszamlalas/
[65] http://www.ksh.hu/docs/eng/xstadat/xstadat_annual/i_wnt001c.html
[66] https://www.visualcapitalist.com/mapped-the-median-age-of-every-continent/
[67] https://www.ksh.hu/docs/hun/xftp/idoszaki/mikrocenzus2016/mikrocenzus_2016_8.pdf

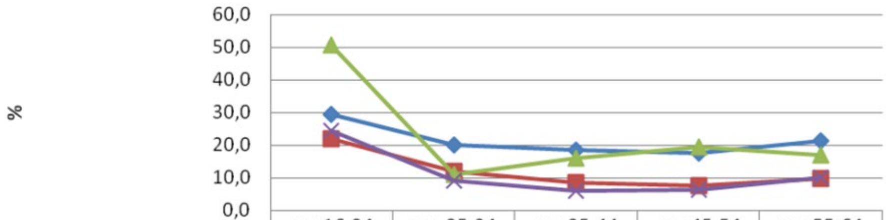
PWD employment (in comparison to EU)

People with disabilities are under-represented in the labour market. Their participation in employment is one of the lowest in the EU (39.6% vs. the EU average of 47.4 %). This hampers social and employment integration, leading to high risk of poverty or social exclusion for this group (32.2% vs. the EU average of 29.9 %)[68].



	age 16-24	age 25-34	age 35-44	age 45-54	age 55-64
EU (disabled)	24,6	56,9	60,3	56,9	35,1
EU average (non-disabled)	29,8	75,5	84,2	84,7	61,1
National (disabled)	12,9	56,2	63,2	53,5	29,9
National (non-disabled)	24,6	75,5	85,8	90,7	61,0

Comparison of employment rates by age group in EU and Hungary[68]

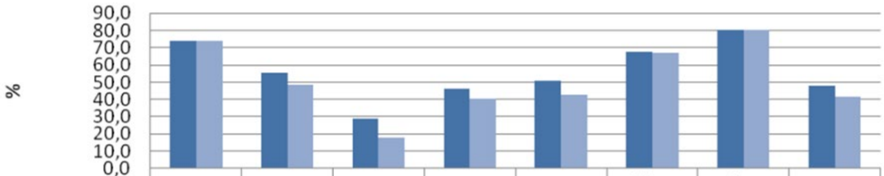


	age 16-24	age 25-34	age 35-44	age 45-54	age 55-64
EU (disabled)	29,4	20,0	18,6	17,5	21,2
EU (non-disabled)	21,9	11,9	8,5	7,6	9,8
National (disabled)	50,7	11,2	16,1	19,6	16,9
National (non-disabled)	24,5	9,3	5,9	6,3	10,1

Comparison of unemployment rates by age group in EU and Hungary[68]

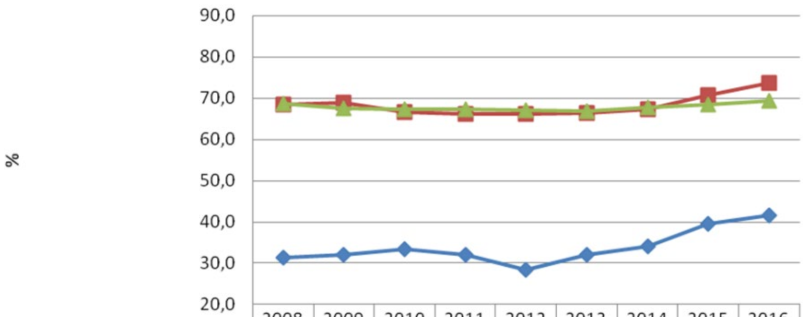
There are no accurate statistics on common sector and occupation for people with disability, but it is possible to bring up several unique examples. Persons living with Down syndrome are employed in some service industry jobs as cleaners. In the handicraft industry employing people with disabilities is more dominant, but their employment is not characteristic in mining, financial brokerages and the hotel and restaurant industry. It is likely that the IT sector is also emerging in the employment of people with disabilities. Based on the Economic Research 2007 approximately 80,000 people with disabilities were employed, out of which 47,000 by the processing industry[69].

[68] https://www.disability-europe.net/downloads/944-country-report-on-the-european-semester-hungary
[69] http://mek.oszk.hu/09700/09751/09751.pdf



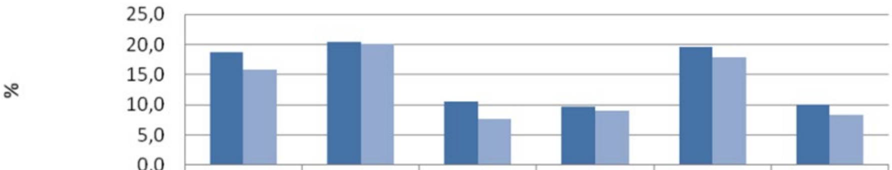
	No disability	Moderate disability	Severe disability	Disabled women	Disabled men	Non-disabled women	Non-disabled men	Disabled total
EU average	73,9	55,6	28,6	45,9	50,6	67,7	80,0	48,1
National average	73,8	48,6	18,0	40,5	42,9	67,0	80,4	41,6

Summarization of employment rates, by disability and gender (aged 20-64) comparing the EU average with the Hungarian average[70]



	2008	2009	2010	2011	2012	2013	2014	2015	2016
National (disabled)	31,3	32,1	33,5	32,0	28,3	32,0	34,2	39,6	41,6
National (non-disabled)	68,5	68,8	66,7	66,2	66,2	66,4	67,3	70,7	73,8
EU average (all persons)	68,7	67,6	67,2	67,2	67,0	66,9	67,8	68,4	69,3

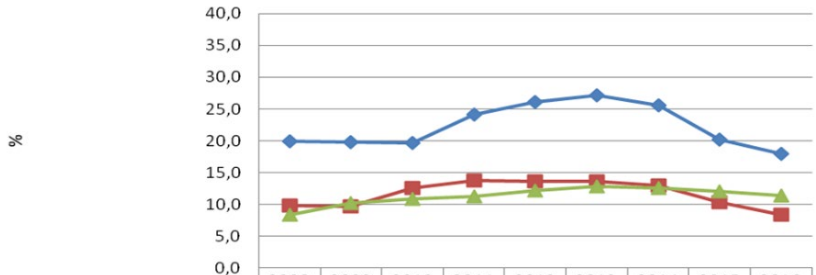
Trends in employment by disability status (aged 20-64) comparing the EU average with the Hungarian average[70]



	Disabled women	Disabled men	Non-disabled women	Non-disabled men	Disabled total	Non-disabled total
EU average	18,8	20,4	10,6	9,7	19,6	10,1
National average	15,9	20,2	7,7	9,0	17,9	8,4

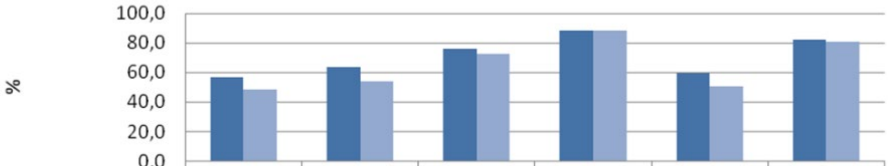
Unemployment rates by disability and gender (aged 20-64) comparing the EU average with the Hungarian average[70]

[70] https://www.disability-europe.net/downloads/944-country-report-on-the-european-semester-hungary



	2008	2009	2010	2011	2012	2013	2014	2015	2016
National (disabled)	20,0	19,8	19,7	24,2	26,1	27,1	25,6	20,2	17,9
National (non-disabled)	9,9	9,7	12,6	13,8	13,7	13,7	13,0	10,4	8,4
EU average (all persons)	8,4	10,2	10,9	11,3	12,2	12,9	12,6	12,1	11,4

Trends in unemployment rate, by disability status (aged 20-64) comparing the EU average with the Hungarian average[70]

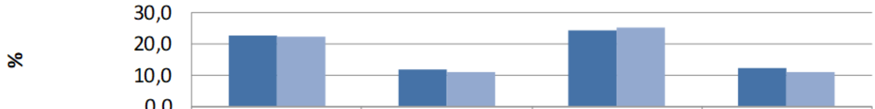


	Disabled women	Disabled men	Non-disabled women	Non-disabled men	Disabled total	Non-disabled total
EU average	56,5	63,5	75,7	88,6	59,7	82,2
National average	48,2	53,7	72,6	88,4	50,7	80,5

Economic activity rates by disability and gender (aged 20-64) comparing the EU average with the Hungarian average[70]

PWD education (in comparison to EU)

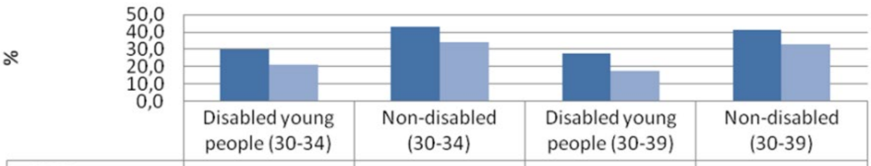
In 2017, the preliminary estimated rate of early school leavers (ESL) was 12.2%, higher than the EU-28 average of 10.6%, but slightly lower than the 12.5% Hungarian dropout rate in 2016. The ESL rate of disabled young people can only be estimated from the available EU-SILC data and may be almost twice larger than this rate, around 22% based on data of previous years. There are 2.4 times more students with special educational needs (SEN) at the primary and lower secondary level than at the upper secondary. Almost half of students with SEN in upper secondary education have severe learning disabilities, and 25% of them have mild intellectual disabilities. Their share in primary and lower secondary education is 40% and 25%. Early school leaving is a serious problem for young people with disabilities[70].



	Disabled young people (18-24)	Non-disabled (18-24)	Disabled young people (18-29)	Non-disabled (18-29)
EU28 average	22,7	11,7	24,2	12,4
National average	22,1	10,8	25,1	11,0

Three-year (2014-2016) average early leaving rates, by disability status (aged 18-24 and 18-29) comparing the EU28 average with the Hungarian average[70]

In addition, the indicated rate of tertiary education among disabled young adults falls significantly below the EU average and demands attention. In 2011, around 17% of people had at least one tertiary degree in 2011, while the corresponding figure for the disabled population is 9%. There is a substantial gap in the level of education between the disabled and the non-disabled[70].

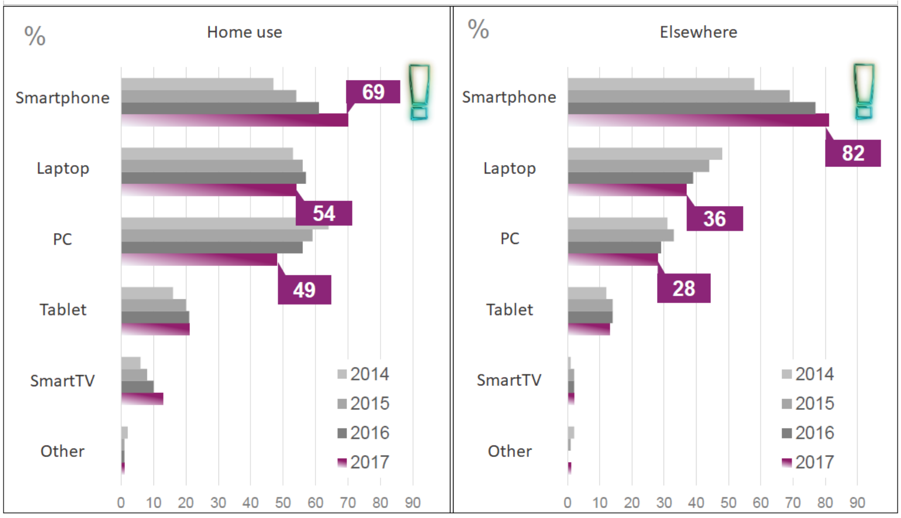


	Disabled young people (30-34)	Non-disabled (30-34)	Disabled young people (30-39)	Non-disabled (30-39)
EU28 average	30,1	43,0	27,9	41,4
National average	20,9	34,0	17,4	32,7

Three-year average tertiary or equivalent education rate (age 30-34 and 30-39) comparing the EU28 average with the Hungarian average[70]

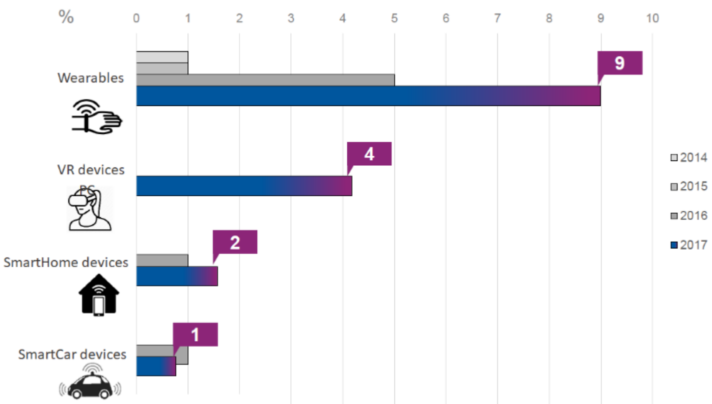
Internet connection and Internet enabled devices

By 2017, 4% of the total population aged 16+ does not have any home Internet subscription, 59% of the same age group has wired and mobile Internet connections as well[71]. 2016 was the first year that number of smartphones overtook PCs regarding the purchase of new equipment for personal use in Hungary. In 2017, the smartphone has gained even more in home and away use.



Overview of the devices for Internet connection used by population aged 16+, 2014-2017 period[71]

New equipment appeared on the market of Internet-enabled devices and these wearables became the most popular among them by 2017[71].

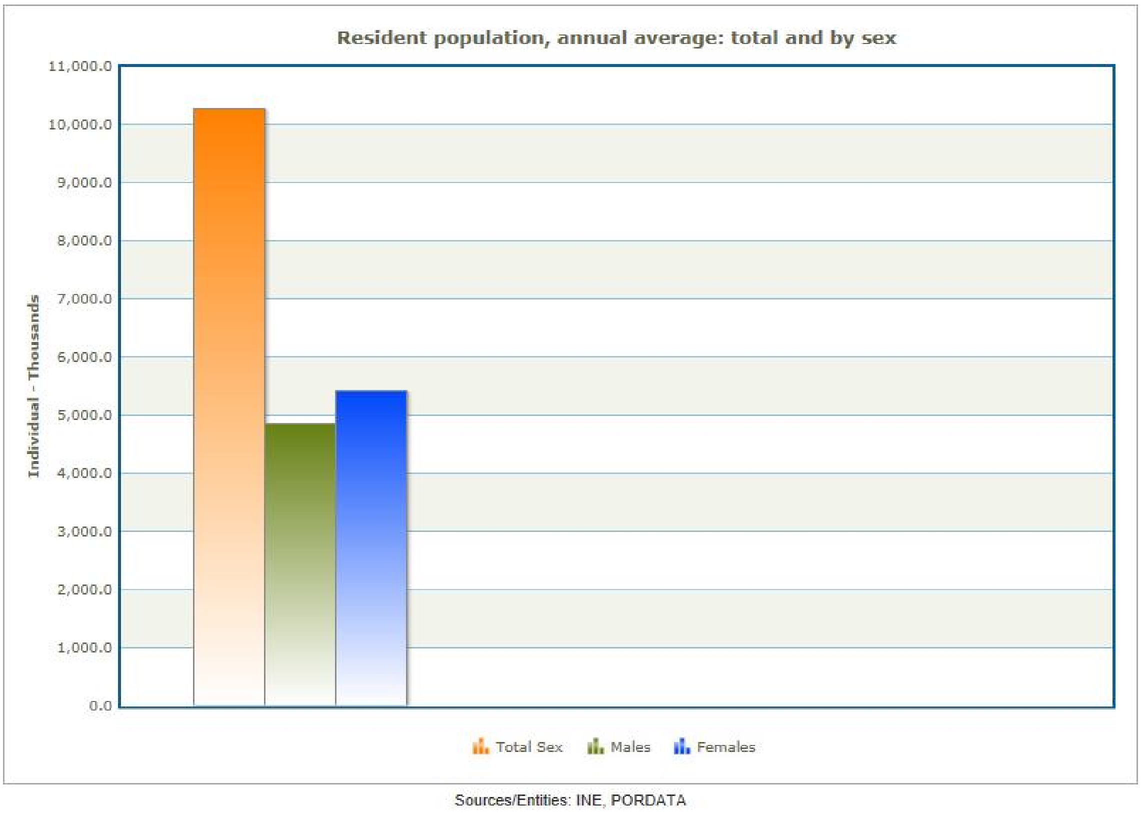


The possession of Internet-enabled devices by population aged 16+, 2014-2017 period[71]

[71] http://nmhh.hu/dokumentum/195102/lakossagi_internethasznalat_2017.pdf

Portugal

According to the latest Census from 2011 of the National Institute of Statistics and the Contemporary Portugal Database shows that there were 10,562,178 people living in Portugal, out of which there were 5,046,000 (47.8%) men and 5,515,578 (52.2%) women[72]. However, considering the latest annual estimates of the resident population from 2018 by the same official statistical frameworks there are 10,283,800, out of which there are 4,860,000 (47.3%) men and 5,423,800 (52,7%) women[73]. These statistical frameworks also state that the average age of the population in Portugal is 45.2 years.



The population of Portugal, by total and sex, 2018 annual estimates. Source: PORDATA[73]

According to the population Census of 2001 by the National Institute of Statistics the number of people with disabilities were 636,059, which represented 6.1% of total population[74] (considering the estimated data on population according to the 2011 Census). In 2011, concerning the population Census of this year, the numbers slightly increased in which were estimated a total of 1,900,000 people with disabilities, which made 18% of total population[75] (considering the estimated data on total population from 2011). Most of the people with disabilities belong to the age group of 65+ (53%), followed by 37% at the age of 20-64 and only 10% that are at the age of 0-19[76]. In terms of number of people with disabilities by percentage of disability, the population Census of 2001

[72] https://www.pordata.pt/Portugal/Popula%c3%a7%c3%a3o+residente+segundo+os+Censos+total+e+por+sexo-1
[73] https://www.pordata.pt/Portugal/Popula%c3%a7%c3%a3o+residente++m%c3%a9dia+anual+total+e+por+sexo-6
[74] https://www.pordata.pt/Portugal/Popula%c3%a7%c3%a3o+residente+com+defici%c3%aancia+segundo+os+Censos+total+e+por+tipo+de+defici%c3%aancia+e+sexo+(2001)-1243
[75] http://oddh.iscsp.ulisboa.pt/index.php/en/2013-04-24-13-36-12/publications-of-oddh-researchers/item/download/350_01f7265004ece0f0ea750e8023245c6c
[76] http://oddh.iscsp.ulisboa.pt/index.php/pt/2013-04-24-18-50-23/outras-publicacoes/item/281-estat%C3%ADsticas-sobre-defici%C3%AAncias-ou-incapacidades

showed that: **13.2%** demonstrated an auditive disability; **25.7%** were visually disable; **24.6%** had a motor disability; **11.2%** had intellectual disabilities; **2.4%** with Cerebral palsy and **23%** with other type of disabilities[77].

According to the Indicators of Human Rights of 2019 in which the Report for People with disabilities in Portugal can be found there were **315,093** people unemployed in the year of 2018. Concerning people with disabilities, the unemployment rate was **12,135** which consisted on **3.85%** of the total rate of unemployed people in Portugal[78]. As for the employment rate of people with disabilities the last indicator available was the 2001 population census which estimated that: a) only **23,790** people with auditive disabilities were working; b) only **59,844** people with visual disabilities were working; c) only **31,094** people with motor disabilities were working; d) only **5,701** people with mental disabilities were working; e) only **859** people with cerebral palsy were working[79]. However, according to the latest Employment and vocational training statistics for people with disabilities from the Portuguese Institute of Employment and Professional Training, in 2018, of the total number of people with disabilities that were unemployed, only **12.76%** were young people **under the age of 25** and **87.24%** adults (**25+ years**) and the majority were looking for a new job (**81.30%**, compared to **18.70%** in search of first job opportunity)[80].

According to the data from the last Social Balance Sheet – Statistics Collection 2017, carried out by the Office of Planning and Strategy of the Ministry of Labour, Solidarity and Social Security, it was possible to identify that the distribution of workers with disability in the private sector were: **28% Men** and **17% Women** in Manufacturing Industries, as the predominant labour sector. In addition, there were **11% Men** and **27% Women** in the area of health and social support. Lastly, there were **14% Men** and **14% Women** in the Commerce sector[81]. Concerning a similar study from the Office of Planning and Strategy of the Ministry of Labour, Solidarity and Social Security there are **13,950** people with disabilities that attend Occupational Activity Centres of the Network of Social Services and Equipment as one of the most common occupations[82].

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77 https://www.pordata.pt/en/Portugal/Resident+population+with+a+disability+according+the+Census+total+and+by+type+of+deficiency+(2001)-1239

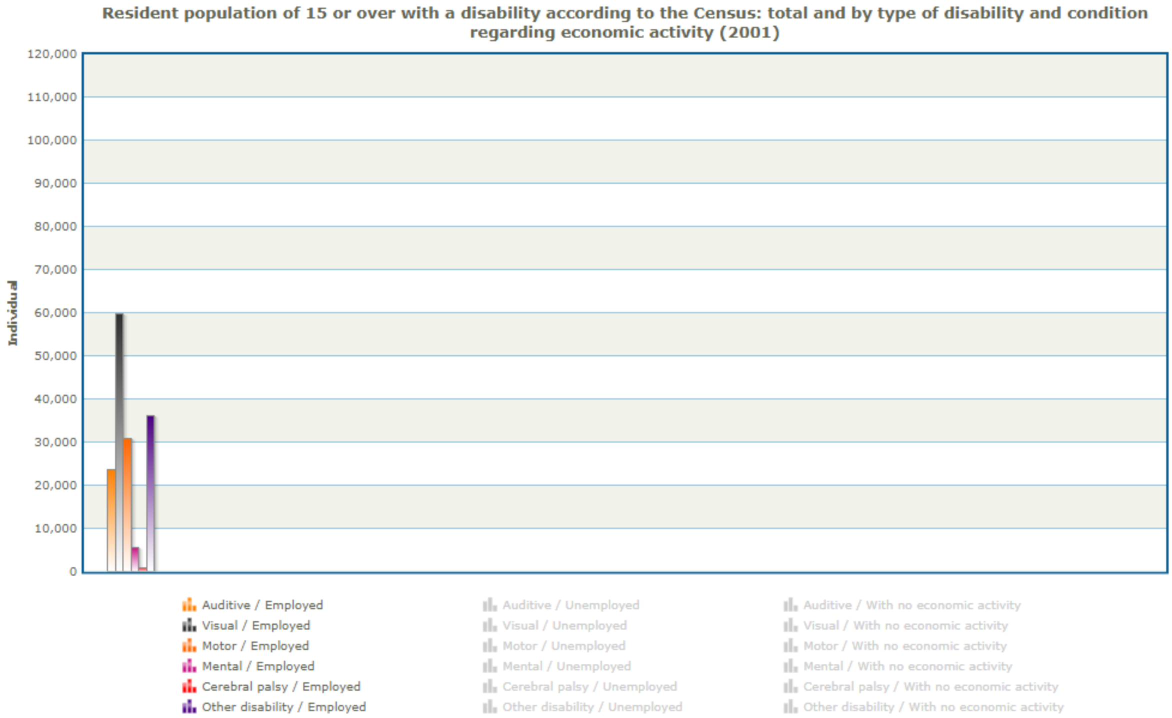
78 http://oddh.iscsp.ulisboa.pt/index.php/pt/2013-04-24-18-50-23/publicacoes-dos-investigadores-oddh/item/442-relatorio-oddh-2019

79 https://www.pordata.pt/en/Portugal/Resident+population+of+15+or+over+with+a+disability+according+to+the+Census+total+and+by+type+of+disability+and+condition+regarding+economic+activity+(2001)-1244-9866

80 http://oddh.iscsp.ulisboa.pt/index.php/pt/2013-04-24-18-50-23/publicacoes-dos-investigadores-oddh/item/442-relatorio-oddh-2019

81 http://oddh.iscsp.ulisboa.pt/index.php/pt/2013-04-24-18-50-23/publicacoes-dos-investigadores-oddh/item/442-relatorio-oddh-2019´

82 http://oddh.iscsp.ulisboa.pt/index.php/pt/2013-04-24-18-50-23/outras-publicacoes/item/download/153_628ad16544ad2313ae4bedbfdd8c5f52



The population of 15 or over with a disability according to the Census: by type of disability and condition regarding economic activity (2001). Source: PORDATA[79]

Evolution of number of PWDs in education (2012/13 - 2017/18)

According to the statistical report carried out in the 2017/18 school year by the Directorate-General for Education and Science Statistics, it was concluded that the total number of children and students with special education needs was 88,023. In which, of this total, 99% attended regular schools (86% Public Schools and 13% Private Schools) and that only 1% attended Special Education Institutions. Also, on this report, it was found that the percentage of students by level of education and education and year of schooling was designated by: 4.1% Preschool education; 78.7% Primary Education (which is part of the 1st, 2nd and 3rd cycles) and 17.3% Secondary Education[83].

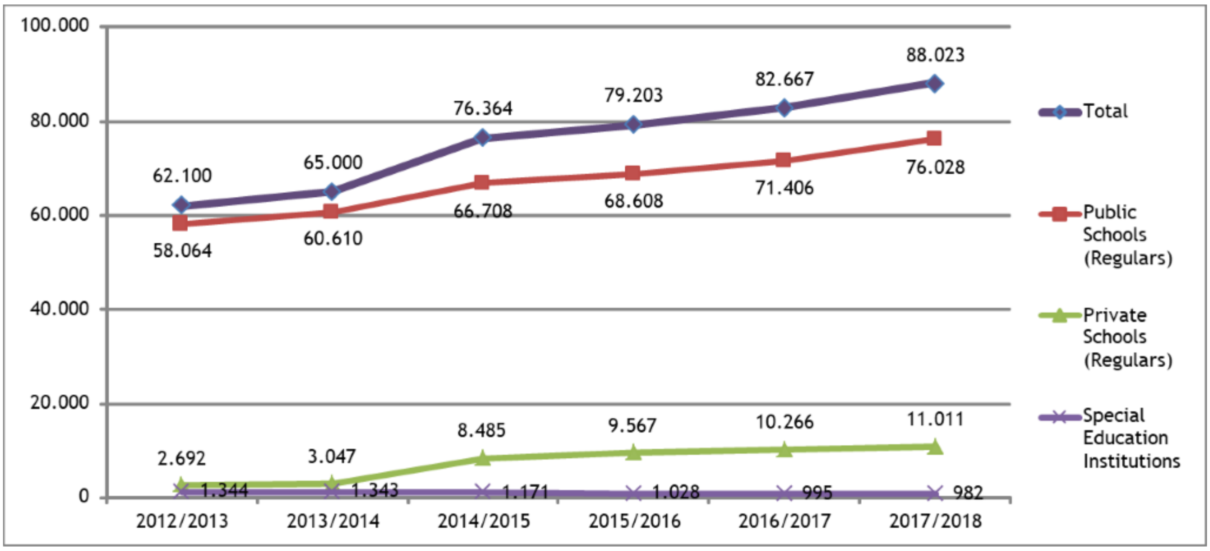
Evolution of number of PWDs in level of education (2012/13 - 2017/18)

With regard to the panorama of students with special needs of education in Higher Education, the last statistical report carried out in the school year 2018/19 by the Directorate-General for Statistics of Education and Science, found that 1978 students with special educational needs were enrolled in Higher Education. Of the 1978 students, 1700 were from Public Higher Education and 278 from Private Higher Education. Furthermore, on the statistical information in this report it was found that of the 1978 students only 526 graduates. Specifically, 70 in professional higher technical course; 346 in Bachelor's Degree 1st Cycle; 56 in Master's Degree 2nd Cycle; 50 in integrated Master's degree and 4 in PhD and PhD 3rd Cycle[84].

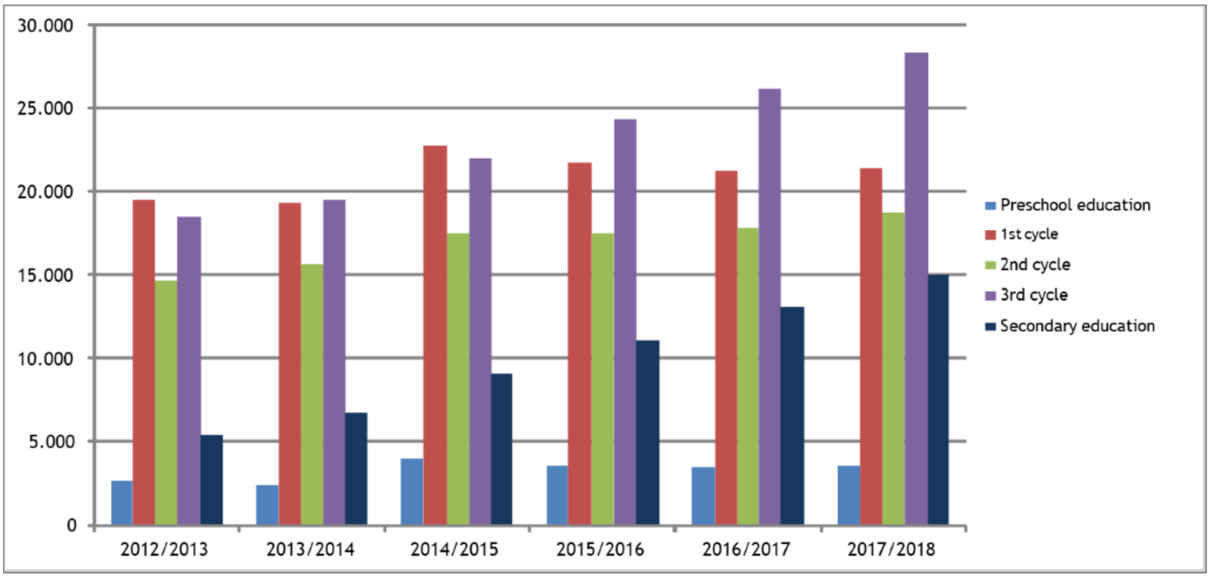
Health conditions of PWDs in higher education (2018/19)

Finally, considering the survey conducted for students with special needs of education enrolled in higher education in 2018/2019, by the same regulatory authority (DGEEC), it was found that the health conditions in total of 458 students entering higher education were: Hearing impairment - 50; Motor impairment - 103; Visual impairment - 51; Permanent or long-term illness - 101; Disturbance of the psychological and psychiatric forum - 60; Disease or neurological problem - 57; Specific learning disorder - 62; Attention deficit/hyperactivity disorder - 45; Autism spectrum disorder - 41; Disturbance of intellectual development - 9; Another condition - 62. It should be noted that in these answers some of the students indicated more than one health situation/condition[84].

[83] https://www.dgeec.mec.pt/np4/224/
[84] https://www.dgeec.mec.pt/np4/428/



Evolution of the number of children and students with special needs of education, by type of school. (Continent; 2012/13 - 2017/18). English adaptation from source: DGEEC[83]



Evolution of the number of children and students with special needs of education by level of education and education (Continent; 2012/13 - 2017/18). English adaptation from source: DGEEC[83]

Spain

According to statistical report by National Institute of Statistics of Spain (INE)[85], the population of Spain increases by 163 336 people in the first half of 2019, reaching **47,100,396** inhabitants on 1st of July 2019. In 2019 the average age of the population in Spain exceeded **43** years for the first time. For men, the average age is **41.8** years. For women, the average age is **44.4** years[86].

In Spain, a person who has obtained a degree equal to or greater than 33% will be considered a person with disabilities. Royal Legislative Decree 1/2013, of November 29th, which approves the Consolidated Text of the General Law on the Rights of Persons with Disabilities and their social inclusion, in Article 4 of the Law. Rights holders, establish that[87,88,89]:

1) People with disabilities are those who have physical, mental, intellectual, or sensory deficiencies which are foreseeably permanent and which, in combination with various barriers, may hinder their full and effective participation in society on equal terms with others.
2) In addition to the provisions of the preceding paragraph and for all purposes, persons with disabilities who have been recognized as having a degree of disability of 33% or more shall be taken into account.

Accordingly, the total number of persons in Spain to whom these conditions apply and who therefore receive the consideration is **3,177,531**, of whom 1,596,114 are men and 1,581,417 are women.

According to data from the INE 2016 (Employment of people with disabilities), 1,840,700 people of working age had the disability certificate, which represented 6.12% of the total population included in that age. And although the Spanish population between 16 and 64 years has decreased gradually in the period 2014-2016, people with disabilities have been increasing. Of these, 57.49% are men and 42.51% women. Most people with disabilities in the working age range from 45 to 64 years, while those under 25 do not reach 5%.

A very significant characteristic of this group with respect to their employment status is that the majority are inactive (64.84%), an aspect that increases markedly with age and with the degree of disability recognized. There is, therefore, a very low participation in the labour market, with a very high activity rate reduced, 35.16%; in the non-disabled, this rate is 77.98%, more than double. By sex, men have a higher employment rate while in women it is the unemployment rate that is higher, so the female condition brings even more difficulties of labour integration. The rate of activity is similar since the difference that separates them is only two hundredths[90].

The latest statistics on teaching show that there is a gap between the educational level of the population with and without disabilities of the same age, being especially striking a percentage of illiteracy significantly higher than in the general population, as well as a lower level of education[91,92].

In the 2017-2018 academic year the total number of students with specific need for support education that received a different educational attention to the ordinary one amounted to 668 769, which represents 8.3% of the total student body. Of these, 219,720 (32.9%) received it for special educational needs associated with

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85 https://www.ine.es/index.htm

86 https://www.ine.es/dyngs/INEbase/en/operacion.htm?c=Estadistica_C&cid=1254736176951&menu=ultiDatos&idp=1254735572981

87 https://www.imserso.es/InterPresent1/groups/imserso/documents/binario/bdepcd_2017.pdf

88 https://www.imserso.es/imserso_01/documentacion/estadisticas/bd_estatal_pcd/index.htm

89 https://www.observatoriodeladiscapacidad.info/el-observatorio/

90 https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736055502&menu=ultiDatos&idp=1254735573175

91 https://www.observatoriodeladiscapacidad.info

92 https://www.observatoriodeladiscapacidad.info/wp-content/uploads/2019/04/OED-ALUMNADO-CON-DISCAPACIDAD-FASE-I.pdf

disability or serious disorder; 34,113 (5.1%) due to high intellectual abilities; 24,458 (3.7%) due to late integration in the education system and 390,478 (58.4%) for other categories of needs.

The percentage of students with special educational needs who receive support presents 2.7% of the students enrolled in the teachings included in the field of this statistic. The highest percentages are presented in public centres and in the concerted education (2.9% and 2.8% of total students, respectively), being very reduced in private non-concerted education (0.5%). The percentage of men (3.6%) with special educational needs is twice as high than percentage of women (1.8%).

The most frequent disabilities in students with special educational needs are intellectual (28.4%), serious behaviour/personality disorders (23.1%) and generalized developmental disorders (18.9%)[93,94].

[93] https://www.educacionyfp.gob.es/dam/jcr:59c7fa10-d640-4437-bacb-91a32793ba9f/notaresumen.pdf

[94] http://www.educacionyfp.gob.es/servicios-al-ciudadano/estadisticas/no-universitaria/alumnado/necesidades-apoyo/2017-18.html

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