Understanding Needs, Identifying Opportunities: ICT in the View of Universal Design

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Abstract. This article provides food for thoughts elaborated by peer researchers who, basing on their studies and on current literature on relationships between Universal Design (UD) and Information and Communication Technologies (ICT), wish to share few key issues related to the challenges offered by the involvement of final users in designing product and services. Referring to approaches from different disciplines, key questions will be highlighted on which a debate could start, focused on the issue of promoting inclusion and how a close relationship among these different areas of knowledge can contribute to bridge the gap between the potential of new technologies and the real and diversified need by persons. Thus, actively contributing toward the empowerment of the community of belonging.

Keywords: Accessibility · Usability · Design for All · Inclusive and Universal Design · Internet of Things

1 ICT as a Driving Force for Inclusion and People Empowerment

In order to implement the UN Convention on the Rights of Persons with Disabilities (CRPD), the EU Commission launched the "European Disability Strategy 2010–2020: A Renewed Commitment to a Barrier-Free Europe", which aims to increase the participation of people with disabilities in society and economy, and enable them to fully exercise their rights.

Analysing the areas for joint action between the EU and Member States pointed out in the Strategy, it becomes clear that for most of these (and in particular for Accessibility, Participation, Equality, Employment, Education and training, Social protection, and Health) the role of support represented by ICT to overcome discrimination and to achieve the goal of a wider inclusion is crucial.

The UN CRPD [1] further states that "to ensure and promote the full realization of all human rights and fundamental freedoms for all persons with disabilities without discrimination of any kind on the basis of disability" States Parties shall "undertake or promote research and development of, and to promote the availability and use of new technologies, including information and communications technologies [...] suitable for persons with disabilities, giving priority to

technologies at an affordable cost" (Art. 4); the Convention recognises therefore to persons with disabilities (PwD) the right to access, on an equal basis with others, "information and communications, including information and communications technologies and systems". It commits the States "to promote access for persons with disabilities to new information and communications technologies and systems, including the Internet" (Art. 9-g) and "to promote the design, development, production and distribution of accessible information and communications technologies and systems at an early stage" (Art. 9-h), to enable PwD to live independently and participate fully in all aspects of life, thus pursuing the goal of social inclusion.

Bearing in mind the ageing of the population in Europe, the envisaged actions in the strategic plan will specifically affect the quality of life of an important and increasing segment of population that includes, other than PwD, those who experiment disability in their lifetime due to aging or temporary reduced functionalities. ICT, with *assistive and enabling technologies* can be regarded as strategic drivers for the social evolution of a community: if truly usable and affordable, they are a fast, economic and reliable way to foster the inclusion of disadvantaged people and to tackle discrimination.

Nevertheless, to avoid the risk linked with the uncertain relationship between products and success/failure, innovative approaches to the design process should be based on a different values range, which considers what can effectively meet a user's need, perhaps latent at the moment, instead of what can be an exclusively technological achievement. This is a winning strategy in step with the idea that man should be placed again in the spotlight, with his/her needs, desires, tastes and disposition. And, above all, differences. Once again UN CRPD suggests the approach into achieving inclusive solutions, by means of Universal Design: that is "the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. Universal Design shall not exclude assistive devices for particular groups of persons with disabilities where this is needed" (Art. 2).

The best option will certainly be to mainstream the UD approach and the related Design-for-All principles as much as possible in goods and services, making them economically viable and avoiding the necessity for consumers with special needs, like the elderly and persons with disability, to look for specific products or to depend on others for their daily activities.

In this context, accessibility can be seen as a *key enabling knowledge* that allows everybody to manage at their best their relationship with the surrounding environment (that is with living spaces, goods, services). According to the Classification of Functionality, Disability and Health (ICF) [2], to provide the environment with facilitating elements that enable the largest number of persons means to affect positively the "disability threshold", above which they can participate actively to life, according to their capabilities, with the largest autonomy and at the best possible conditions. Promoting accessibility in a proactive way, thus, (i) benefits society and the economy in general making life easier for everyone; (ii) supports an active and productive participation of older persons

in their communities and labour market participation of PwD; and (iii) enables informal carers to reconcile work and care duties.

Researchers working in the field of UD are deeply (and often painfully) aware of the economic aspects of their studies. A recent EU study [3] demonstrates the socio-economic importance, and the related costs, of improving the accessibility to PwD of goods and services; among these services, ICT is a priority. Public financial support is managed differently in different countries, but in general countries with high investments and thus high accessibility standards in the built environment, transport, and ICT are those where the highest levels of employment of both older women and men are found; they are also those which perform best in terms of Healthy Life Years indicators [4].

The other way around, what can ICT do to increase the effectiveness of policies for the empowerment of PwD? One possible answer is to enable all stakeholders to make informed decisions. For this purpose, ICT is a fundamental source of data for the economic evaluation of the costs/benefits of a given policy. Understanding and exploiting the tools that contemporary studies in the economic assessment of health technologies employ is essential for people working in the UD field, to effectively interface with the agencies that define the spending policies of a country. One example of such tools is the Disability-Adjusted Life Year (DALY) indicator [5,6]. It is defined as the sum of two terms, evaluated in a selected test group: the reduction of the average duration of life due to the disability (Years of Life Lost, YLL), plus the quality loss in the life span (Years Lost due to Disability, YLD), which in turn is the product between the reduction of life quality and the average life duration with disability. The DALY can be determined using the data that are collected by ICT-based tools, and provides an a-posteriori estimate of the benefits of a given project.

2   Beyond Accessibility to Design ICT: Involving Users to Investigate Needs

UD, despite not being a new concept, is nowaday seen as innovative by an increasing number of stakeholders, including the final users who benefit from it and who, at the same time, are involved as *experts* into the participative process of conceiving the products. UD is based on the assumption that accessibility to spaces, objects and services is the key prerequisite to use them.

Before going any further, we need to set the meaning of some words we use hereinafter. In the field of computer science and ICT in particular, *accessibility* primarily refers to the distinguishing qualities that the design of devices and systems should have to allow their use by PwD. The World Wide Web Consortium (W3C) defines Web accessibility as an attribute through which "people with disabilities can perceive, understand, navigate, and interact with the Web, and they can contribute to the Web" [7]. Web accessibility includes all types of disabilities that impact access to the Web and thus includes visual, hearing, physical, and speech impediments, cognitive and neurological disabilities; elderly users benefit too from adherence to Web accessibility principles.

In a wider and cross-disciplinary view, accessibility is the basic requisite to use goods and navigate spaces, and it does not necessarily refer only to PwD; indeed, transposing the W3C definition we can assume that "accessibility is an attribute through which people can perceive, understand, navigate, and interact with the living environment, and they can contribute to the growth of the community".

The citizens' community lives and acts within an often unfriendly environment, which prevents persons to take an active role in daily life, and affects their independence and autonomy in respect of their capabilities and functionalities. Making the environment accessible, thus, means to integrate or to provide it with facilitating elements (for example using compensative solutions, eliminating barriers or resorting to Design for All resources) to raise its level of accessibility and allow its use by a wider range of persons. In the ICT field, while the focus of accessibility is disabilities, research and development in accessibility brings benefits to everyone, particularly users with situational limitations, including device limitations and environmental limitations [8].

The *usability* concept includes emotionally engaging a person by positively exciting him/her, thus fully meeting his/her expectations. The International Standards Organization's standard ISO 9241 defines usability as the "effectiveness, efficiency, and satisfaction with which specified users achieve specified goals in particular environments". A less formal interpretation defines usability as "an attribute of quality that refers to the promptness with which users learn to use something, the efficiency they attain while making use of it, how easy it is for them to remember how to use it, how error-prone it is, and the level of satisfaction that they attain from using it" [9].

In the ICT field, usability is slowly improving; however, the focus is still mainly on accessibility rather than on Design for All. While some ICT companies have developed accessibility devices to enable persons with disabilities to access their products, many people (among which especially the elderly) often feel excluded from a wide range of e-products and services which could otherwise be relevant to them. There is a genuine risk of departure of products from the real needs of users—that's typical in any field of innovation.

The slogan of the disability rights movement has long been "nothing about us without us". Far from being a mere challenging approach, asserting an attitude in claiming, it stresses the idea that PwD can contribute to the growth of a community moving from *passive recipients* to *co-producers* while involved in the process of visioning strategies, making policies, designing goods and services. It is truly PwD who understand best what PwD need: they just have a different opinion and different priorities than the current providers and decision makers. But as the movement progresses, and seeks the actions to realize its vision, difficult questions arise about exactly how self-determination can shape strategies and actions in the field of ICT. Key questions need to be asked, among which whether the modern disability movement is itself sufficiently inclusive of PwD and how to set requirements and pattern flows to ensure a proper and successful user participation in development and production processes. PwD are a

heterogeneous group, and the specific issues which shape their life opportunities are just as diverse; moreover, the risk of "divergence of effect" [10] is rather high when design process based on the theoretical principles of UD are developed avoiding an effective users participation. In a sense, there is the need to create a standard for the participation of the user [11].

A proper engagement of persons could allow the *mutual* adaptation between the different users capabilities and the performances required by a very often complex outer environment and its "devices" (spaces, goods, services).

Engaging people in the development of a new product/service is the ultimate result of the evolvement from the "products designed for the user" approach to "the development of user inputs" and finally the active involvement of users by designers: a current practice, focused on identifying the most relevant requirements expressed by targeted user categories and on testing of released products/prototypes. Nevertheless, optimal solutions vary greatly depending on the specific users and contexts of use, and this is more evident when target groups are (or involve) PwD. Very often, considering their needs we face the risk that labelling these as "special" leads to think in terms of separate, special solutions, thus highlighting the inherent contradiction between diversity and "special" needs: everyone has unique needs and resources [12].

An Inclusive and Universal Design (I&UD) can offer different thought patterns if the starting point is to realize that one-size-fits-all solutions seldom meet every person's needs and that accessible features can benefit the majority of the population. Therefore, as argued by Page, a shift in design thinking is required to consider the "normality of doing things differently" [13].

Engagement of users introduces divergent thinking and implies that different users should first reciprocally accommodate their specific needs and expectations, which are very often deeply different if not conflicting. If it is true that seeing problems from diverse perspectives and looking for solutions in different ways can locate more potential innovations [12], the setting of user groups including diverse PwD implies raising their awareness on the real scale of differences, expectations, needs "by all". And makes them aware that aiming to a solution that benefits all implies a high level of adaptiveness "by all" to the best of possible solution.

3 A Case Study: IoT and Inclusive Design

The deployment of the ever-increasing number of systems that belong to the so-called Internet of Things (IoT) is a concrete example that we can consider as a case study. Indeed, the forthcoming evolution of 5G technology foresees a pervasive wireless scenario, in which a huge number of devices will concur to support IoT applications, including intelligent metering, infrastructure management, health support, home automation, public transportation, safety, and security. The number of devices that will be wirelessly connected in the IoT are estimated to be around 20 billion by the beginning of the next decade [14].

IoT is interesting because it is a still relatively small field experiencing a very fast growing rate, due to the combination of several favorable conditions. Some

of these depend on its huge potential market (that in turn brings large available investments), others are more technical conditions related to the ICT world and concern this paper. For example:

– Electronics: IoT needs low-cost, high-volume, mature technologies on which research and development efforts have already been made by the electronic industry. The largest companies, indeed, have added to their traditional suite of products (such as sensors, analog and mixed signal components, microcontrollers, energy management devices) various dedicated development environments [15] that can be devoted to this purpose. In particular, IoT networks that are meant for the factory environment may be particularly suited to I&UD due to their attention to security and reliability [16].
– Telecommunications: the convergence towards an all IP solution for the telecom network, that started with 4G, and the seamless integration between the core telecom network and the local and the sensor networks, all based on international communication standards, allows now the development of a fully interacting system, connecting people and devices (things), leading towards the smart and fully connected society foreseen by 5G development, and avoiding the barriers deriving from the widespread utilization of "private standards" that have delayed and slowed down the full exploitation of the system capabilities [17].

A huge flow of information is expected to be available in IoT systems, not only that which is needed for the goals of the system, but also that coming as a byproduct of the system operation ("exhaust" data; e.g., in an inventory keeping system, the rate at which the quantities of the different goods change). A part of these data is used by the system itself (in home automation, to manage instantaneous power consumption by the different appliances), but in many cases an interaction with the user may be advisable. The user should be able to set the amount of data he/she is capable or willing to manage.

At the same time, since the flow of information is bi-directional, the IoT systems will also often collect data about the user (in a shop, the time spent in different sectors, the way goods are selected, etc.). It is widely acknowledged that this generates increasing privacy problems. If a person with disabilities is involved, the risk is even stronger; for example, the existence of the disability itself can be disclosed, which can be deeply undesirable for the user.

Under an economic viewpoint, the concept of exhaust data is in the focus of the attention of those who devise new business opportunities: data that have no value for the main purpose of the system could be extremely important for other potential users. For example, the long-term maintenance data of cars collected in a service station may become useful information for an insurance company. The presence of these data should be carefully considered also with respect to the potential benefits for a PwD. An open-minded design of an IoT system could provide these benefits at no or small cost for the owner. National and EU funding agencies should provide a financial support for the deployment of such systems, having verified the existence of such benefits.

A fundamental but still open issue is the one of standardization. To fully exploit the IoT capabilities and to avoid further digital divides, all the stakeholders should influence the standard development. Unfortunately, the main driving forces are the big companies and the standard bodies, while the SME and the consumer organizations are almost absent from the standardization process. One possible solution may be to invest some money to involve the user representatives in the standard activities [18].

However, given the high degree of flexibility of the standard under development, the robustness and the safety of which must be addressed by the standardization bodies and the big manufacturers, the user involvement may be addressed by I&UD which should work on the personalization and the interoperability of the communicating devices, to allow them to be really used by all [19].

4 Ongoing Research

We survey some recent works in which systems, tools, or methods related to the IoT have been proposed that were thought or adaptable for categories of weak users; we also consider studies which explicitly investigated about the relation between IoT and PwD. The aim is to understand if, to which degree, and in which form PwD have been involved in the design process.

The opportunities of the IoT for PwD depend on the involved technologies, which have to be related to different kinds of disability (e.g., hearing impaired, visually impaired). Some reference scenarios can be devised and discussed in detail from the technological point of view: for instance, the case in which a visually impaired person is assisted when autonomously shopping at a store. This approach is used in [20], and permits to outline some present research challenges: the paper acknowledges that the foremost consists in customizing and adapting the IoT for person with disabilities. However, the direct inclusions of those users in the design process is not explicitly mentioned. When the IoT belongs to a larger integrated IT environment (e.g., aimed at providing a so called Ambient Intelligence), a balance between Universal Design and adaptation is needed to cope with the design of tools or services for persons with disabilities; a fine-grained set of options should be considered for this purpose [21].

The inclusion of the final user in the design of IoT solution is instead the main focus of [22], where the EU project SOCIOTAL is presented. It lays down a "co-creation" approach in which the services arise from citizens for tackling their needs rather than being proposed by commercial service providers. From this point of view we are in line with the authors of the cited paper, who propose inclusion as a main requirement for designing effective IoT services; on the other hand, they do not mention disabled persons. A similar thesis is proposed also in [23], where the authors suggest that trust, user control, and transparency should be at the heart of IoT.

An interesting experimental study about the involvement of disabled or elder users in the design phase of an IoT-based tool is shown in [24]. The authors consider three relevant scenarios (smart homes, smart offices, and e-voting) and

elaborate on the impact of users' inclusion in the design stage on users' trust in the resulting tool. In particular, they show the results of a study with 85 subjects (including visually impaired and persons affected by dyslexia) who were asked to evaluate an IoT system in its early stage: the subjects found the system itself useful, but suggested several improvements on the user interface; the system design was hence adjusted to meet the subjects' recommendations.

Visual impairment is a disability for which many IT based system have been proposed or designed in principle, ranging from shopping assistants [25, 26], to tools for enabling social interactions [27, 28], or for allowing interaction with visual-based online social networks [29]. The degree of inclusion of the specific category of disabled persons in the design of the system greatly varies and is not clearly related with the degree of development of the system itself. For instance, we observed cases with no mentions to inclusion [26, 30], cases where normally sighted subjects wearing a blindfold were included in experimentation [25], and cases where actual visually impaired persons were included, either by collecting experimental data [31], or by participating in interviews aimed at guiding design choices [29], or by testing a system prototype [32].

5   Final Remarks

The good news in ICT, and specifically for the rapidly growing Internet of Things, is that a designer of a system can (and should) devote a large part of his/her attention to human aspects, since the basic technical tools suitable to build many types of network have already been made available. A 2015 McKinsey report provides impressive figures and facts about the impact of IoT [33]. However, among the different fields of application, from homes to factories to vehicles, the "human" field (especially related to health and social issues) is the one whose prediction has the largest uncertainty: it ranges from 170 to 1590 billion $ in 2025. We can easily deduce that much of this spread is related to the level of user's acceptance. Thus, this is a significant example of a field in which I&UD principles should be employed from the start. In fact, it has already been observed that "At a minimum, all parties involved in the development of IoT devices and applications should commit to upholding the principles of universal design" [34]. Engagement of final users is pivotal in shaping the Internet of the future, for the use of digital technologies to be successful to allow the Internet of Things to become the *Internet for People*.

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