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Giuseppe Di Bucchianico *Editor*

Advances in Design for Inclusion

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Advances in Human Factors and Ergonomics 2018

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9th International Conference on Applied Human Factors and Ergonomics and the Affiliated Conferences

Proceedings of the AHFE 2018 International Conferences on Design for Inclusion, held on July 21–25, 2018, in Loews Sapphire Falls Resort at Universal Studios, Orlando, Florida, USA

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Preface

This book has two underlying messages, the emerging importance of the social issue of inclusion and human diversity in contemporary society, and the increasing awareness that there is no such thing as a 'standard human being.' The first question has to do with inequality and social disparity as a necessary milestone toward economic revival, among other things, while a vital role in the strategies adopted by the European Union's Horizon2020 framework program is played by the ones that focus on strengthening equality, participation, and accessibility for all to goods, services, and what Dahrendorf called 'life chances.' What this means is that the issue of social inclusion of diversity and for equality is firmly on political agendas all over the world, not least because of increasing awareness that new visions, new strategies, new tools, and new approaches are needed, if we are to tackle the challenges arising from recent phenomena of economic and cultural globalization, demographic change; economic migration from poorer countries and an aging population in wealthier countries, a phenomena that are destined to upset the entire planet's micro- and macro-economic and social structures in years to come.

The second issue tackled in this book is more technical in nature, since the paradigm change from 'designing for standards' and 'inclusive products and service design' to the enlightened awareness that there are no such concepts to fit the standard human being, this has immediate, direct repercussions on the specialized dimension of designing. The realization is at last taking hold not only that those individuals are physically, psychologically, and culturally 'diverse,' but they also have widely diversified skills, abilities, aspirations, and desires that make each one of us unique and not at all replicable. Since the diversity of individuals is the rule, not the exception, it makes sense to consider it as a resource, not as a limiting factor or a restriction on design, while equality between individuals, communities, and peoples should be treated as fundamental strategic inputs to the sustainable development of contemporary society, where everybody should have the same opportunities to experience places, products, and services. Numerous design approaches have been adopted to facilitate social and cultural inclusion in recent decades: Design for Disability, Universal Design, Inclusive Design, and Design for All. All of these philosophies, approaches, and methodologies aim to build value on all aspects of human diversity, from psycho-physical to cultural issues, and to offer equal opportunity to everyone in order to experience places, products, services, and systems. With this in mind, this book sets out to forge a climate conducive to discussion and comparison between these approaches, without any prejudice in favor or against any one of them, but attempting to identify the elements they hold in common and to build each one's heritage of originality, because we are convinced that the true resource of Design for Inclusion may well be found in this very diversity of opinions.

In particular, this book describes the state of the art of recent research conducted in a variety of fields that share the focus on Design for Inclusion and was presented in the second international conference on Design for Inclusion (AHFE 2018, Orlando, Florida). On this occasion, the numerous research papers presented were collected together into four different thematic areas, corresponding to different sections of this book:

Section 1: Design for Inclusive Daily Life and Human Diversity;
Section 2: Design for Inclusive Environments, Materials and Multisensory;
Section 3: Design for Inclusive Transportation, Information and communication technologies;
Section 4: Inclusive Service Design for Education and Learning;

Each section contains research paper that has been reviewed by members of the International Editorial Board. Our sincere thanks and appreciation to the board members as listed below:

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Design for Inclusive Daily Life and Human Diversity

Providing Context-Sensitive Mobile Assistance for People with Disabilities in the Workplace

Volkan Aksu[1(✉)], Sascha Jenderny[1], Sascha Martinetz[1], and Carsten Röcker[1,2]

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Abstract. Recent research has shown that computer-based Assistive Technology (AT) has the potential to support individuals with disabilities in production environments. At the same time, step-by-step instructions enable workers to be successful in their performance of industrial tasks that were formerly difficult to accomplish. We merged these two types of intervention and developed an application running on a mobile device that can assist disabled workers working more independently. In an evaluation study, we investigated how our assistive system affects the task efficiency as well as participants' subjective evaluation. Results show advantages when using the assistive prototype with regard to users' task efficiency and subjective evaluations.

Keywords: Assistive technology · People with disabilities
Human computer interaction · Industry 4.0 · Inclusion
Context-sensitive assistance · Step-by-step instructions · Production
Mobile assistance

1 Introduction

Recent studies show, that about 15% of the current world's population suffer from some form of disability and it is estimated that this number will increase in most countries [1]. Studies also show that the rate of unemployment for people with disabilities is significantly higher than for people without disabilities [2, 3]. At the same time, a growing shortage of qualified personnel is observable in many companies [4, 5]. In this context, new assistive devices and technologies are emerging, which bear great potential to enhance the quality and satisfaction of work life for individuals with disabilities by empowering their independence and inclusion in the workforce [6, 7].

In this paper, we demonstrate how such technologies could be used to support the inclusion of individuals with disabilities in production processes. The focus of our work is on enabling users to accomplish repetitive tasks in a more refined manner, without the need for support from any workers. To achieve this, we applied a user-centered design approach to set up an assistive prototype system. It enables people with disabilities to complete industrial tasks, like for example changing a broken drill head

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on an industrial machine supported by guided instructions on a mobile device. It enables the workers to create easily comprehensible maintenance instructions with associated QR-codes, which can be printed and subsequently placed on the corresponding machine. If required, users can access the instructions by simply scanning the code with a mobile device.

This paper is structured as follows. In Sect. 2, we present relevant related approaches to our work. In Sect. 3, the implemented prototype system is described. An evaluation study with users of the target group including results is presented in Sect. 4. Finally, results are discussed in Sect. 5.

2 Related Work

The usage of assistive technology has the strong potential to enhance the level of autonomy of individuals with disabilities [8, 9]. Studies have shown that employing assistive technology can be beneficial in physical [10–12] and mental rehabilitation [13], as well as in higher learning capabilities [14] and employment outcomes [15]. With the increasing dissemination of mobile technology, advantages of mobile phones and tablets such as ubiquitous access and portability [9] without any time, location and device restrictions [16], have been embedded into assistive technologies. Through the integrated features in mobile devices such as digital cameras, wireless internet access, location-detection, speech-to-text and user-centered applications, assistive systems extend their technical capabilities and cost-effective accessibility of information for people both with [17–20] and without [21–23] disabilities in all economic and social areas of life.

In particular, assistive systems with step-by-step instructions for disabled workers in industrial environments, including technologies such as Augmented (AR)/Virtual Reality (VR), have gained high attention in recent years. For instance, Korn et al. [6] investigated the potentials of using projection-based Augmented Reality for impaired people in production. They implemented an assistive system projecting assembly instructions immediately into the workplace (in-situ). Results showed that the impaired participants could reduce their assembly time and reduced error rates by using the prototype. However, some participants were overwhelmed by interacting with the new system and performed worse. Funk et al. [24] compared in-situ vs. pictorial instructions in a study with cognitively impaired workers. Results revealed that the workers are three times faster by using in-situ instructions and reduce their error rate with up to 50 percent. In a further study [25], they compared a contour-, a video- and a pictorial-visualization to a control group using no visual feedback. They found that disabled participants made fewer errors and were faster using the contour-visualization in an assembling task. In a comprehensive study, Büttner et al. [26] compared in-situ projection and hand-mounted display (HMD) to a paper baseline in a workplace scenario. Their results indicated that performing tasks with both ins-situ and paper instructions are significantly faster and more accurate than using HMD. Aksu et al. [27] investigated how step-by-step instructions affect users' task efficiency and subjective evaluation while performing an industrial task. They developed a prototype that is equipped with remote controlled LEDs in order to guide disabled workers through the cutting steps by presenting video instructions on a mobile device. Here, results showed a positive impact across experimental conditions time on task, task accuracy and user satisfaction.

In addition, Auto-ID technology such as RFID and QR codes seems to be a promising technology to support people with disabilities in their everyday live. Al-Khalifa [28] proposed a barcode-based mobile system to assist visually impaired and blind people to identify objects and products in their environment such as in museums or shopping malls. Utilizing a QR reader on the mobile phone, the user can scan objects and products tagged with QR-codes to get more information about them. Tatsumi et al. [29] investigated the use of barcodes and RFID tags in educational environments and showed that these technologies are effective in providing blind people with adequate information. They demonstrated their system in two examples. In the first scenario, they used bar codes on a bulletin board where blind students could scan them using a PDA ("Personal Digital Assistant") and get announcements from the server using a voice reader software. The second scenario was about building a messaging system connecting students and teachers by using a PDA with a RFID unit that read the messages from the RFID tag attached to a laboratory door. Similar assistive systems for mobile tagging can be found in healthcare [30] and location detection [31, 32]. Uzun and Bilgin [30] implemented a QR code-based system that identifies and provides medical information about the patient to decrease medical errors. In [31, 32], a wayfinding system using QR codes has been presented to provide current directions for people with special needs. Barcode-based technology is also applied to increase efficiency and flexibility in production environments [33, 34]. However, mobile systems using barcodes and step-by-step instructions have not yet been applied in production environments although this is a promising direction especially for people with disabilities. In this paper, we explored how to build a user-centered solution that can also be transferred to similar production tasks in a modified form. We tested our concept in a comparative user study with disabled workers from sheltered work organizations.

3 Materials and Methods

3.1 Prototype System

The prototype system was developed with user-centered design methodology. First, qualitative interviews were conducted with four disabled users and three attendants interacting with the industrial machine. On this basis, user requirements, needs and problems were analyzed as a starting point for the novel prototype. Based on this input, a simple interactive click-prototype was created using the tool Adobe Experience Design (XD). After evaluating the structure and usability of the design prototype with four disabled workers and three attendants, an application was developed using the IDE *Visual Studio* Professional 2017. The application consists of a front-end and a back-end (see Fig. 1). The front-end was realized with the framework Xamarin. Forms and provides a graphical user interface for guiding the workers through the instructions using QR codes to the retrieve the instruction for the machine to be maintained. The frontend also allows disabled users to add their open questions and notes by text or audio recordings. The back-end was implemented in C#. It provides attendants with comprehensive access to all application settings and is responsible for creating, editing and storing step-by-step maintenance instructions with associated QR-codes.

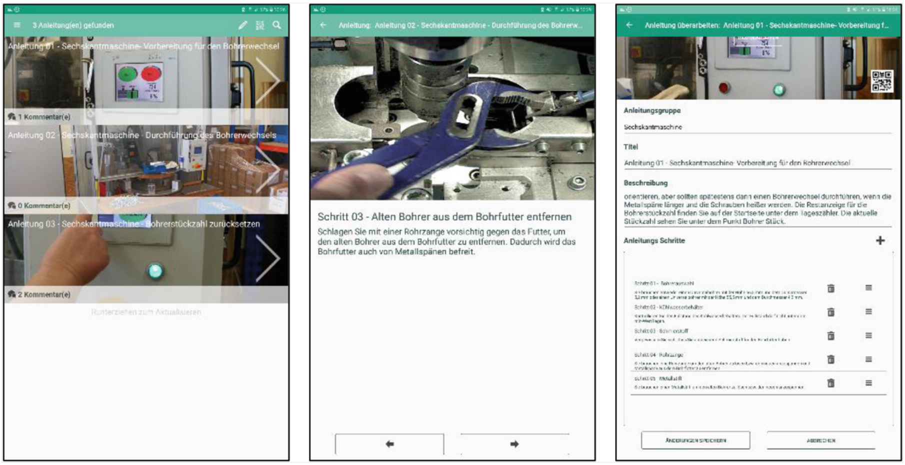

Fig. 1. Application screenshots: Overview of existing instructions (*left*), an instruction step (*middle*), admin area (*right*).

The application runs on a Tablet PC Samsung Galaxy Tab A with 16 GB, WiFi and Android 6.0. The MVVM (Model-View-ViewModel) architecture was used to structure the code for the application. Data persistence is achieved using a single file SQLite database running inside the applications environment.

In the present study we focus on evaluating the impact of our mobile prototype on disabled workers performing a challenging and complex industrial task.

3.2 Evaluation Study

The aim of our study was to compare the assistive prototype against what is otherwise often used to support disabled workers: paper-based instructions. To avoid a carry-over effect, the study applied a between-subject design with two experimental conditions: *paper-based interaction* and *tablet-based interaction*. As dependent variables we measured the following:

- *Mental Effort:* Participants' perceived mental effort in conducting the specific tasks, was assessed with the SEA scale ("Subjectively Perceived Effort") [35]. The one-dimensional scale ranges between 0 ("no cognitive effort") and 220 ("maximum cognitive effort").
- *Consequences of intuitive use:* To assess users' subjective satisfaction with intuitive use of the interface prototype, we employed the standardized QUESI questionnaire

("Questionnaire for the Subjective consequences of Intuitive use") [36]. It consists of 14 items grouped into five sub-scales: (1) subjective mental workload, (2) perceived achievement of goals, (3) perceived effort of learning, (4) familiarity, and (5) perceived error rate. The answer scale is a Likert agreement scale with five levels from 1 (fully disagree) to 5 (fully agree).

Finally, we also investigated participants' efficiency in performing tasks. To this end, we measured how long it took them to complete the tasks (*time on task*), whether they succeeded or failed at a task (*task success*) and whether they solved the task without help (*task accuracy*).

3.3 Procedure

The study was conducted as part of a workshop for handicapped people in a real production environment. First, participants were welcomed by the experimenter. Prior to participation, all participants were given a brief description about the aim and procedure of the study. The participants were divided into two groups. Disabled workers with no previous experience in using industrial machines were assigned to the paper-based experimental condition, in order to avoid overwhelming them with a use of mobile device. Workers who were already familiar with the machine because they used it multiple times before were assigned to the tablet-based condition (see Fig. 2).

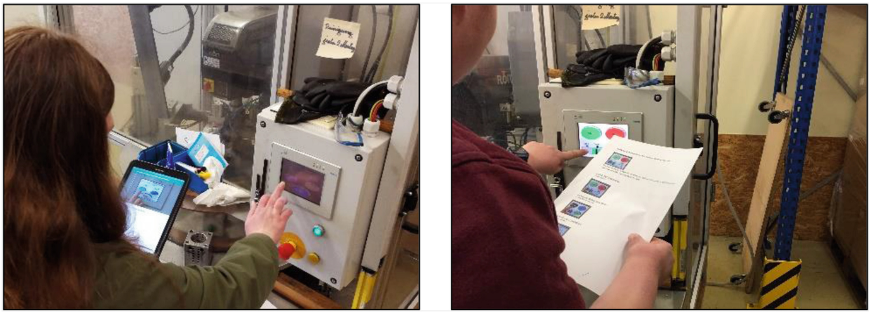

Fig. 2. Setting: Participants performing a task in tablet-based condition (*left*) and in paper-based condition (*right*).

Then, the experimenter explained the general task in a detailed manner, answered questions and clarified issues. Subsequently, participants were asked to conduct the task on the industrial machine either with the help of digital or paper instructions, depending on their assigned condition. The task consisted of three subtasks: (1) preparing the change of the drill head, (2) changing of the drill head, (3) resetting the settings after changing the drill head (see Table 1).

Table 1. Overview of the three subtasks for changing the drill head on the industrial machine.

Nr.	**Subtask 1**: Preparation (textural+pictorial)	**Subtask 2**: Changing the drill head (texturial+audio)	**Subtask 3**: Resetting settings (textural+pictorial)
01	You need a universal bit with diameter of 5.2 mm	*Open the machine door:* To change the bit, open the left door of the machine by pressing the START-button	Press the key "Tipp" on the display to get the settings
02	You need oil	*Loosen the chuck:* Grasp the chuck with the pliers while you hold the handle of the chunk with the long screw. Twist the chuck counter- clockwise to loosen it	Press the key "Amount of Pieces"
03	You need a pliers	*Remove the bit:* Remove the bit by tapping gently on the chunk with the pliers	Press the key "Reset"
04	You need a long screw	Grease the chuck with the oil	Press the key "Save"
05		*Set the new bit:* Insert the bit into the chuck and tighten the chuck with your hands	Press the key "Duration" to get back to the main page
06		*Control the bit:* The head of the bit should be 1 mm above the drill bush. Please check it	
07		*Tighten the chunk:* Tighten the chuck clockwise using the long screw and the pliers	

The first and third subtask included pictorial- and textural elements and were conducted in both condition. The second subtask consisted of video- and textural elements was just performed in the tablet-based condition because presenting video instructions was not comparable to the paper-based one. This is why the second subtask was examined individually for the tablet-based condition.

All step-by-step instructions were defined with the help of attendants to ensure being easily to understand for impaired workers. Therefore, pictorial, textural and video-based elements were used to create the instructions.

After finishing the task, participants provided a post-task rating of their perceived cognitive workload on the SEA scale. After finishing all three tasks, participants were requested to fill out the QUESI questionnaire. Finally, participants were debriefed and thanked for their time.

3.4 Participants

Six German speaking participants (4 males, 2 females) with a minor impairment of intelligence took part in this study. They ranged in age from 20 to 35. The participants mean age was 27.2 years (*SD* = 10.34). Four of the participants had clinically diagnosed disruption of social behavior. One of the female participants had epilepsy. The study was conducted at the Werkstatt Begatal of Lebenshilfe Lemgo e.V., a German sheltered work organization supervising about 600 workers with cognitive and motoric limitations. Neither of the participants had previous experience with our assistive system.

4 Results

In the following we report results regarding the effect of experimental conditions on (1) measures of task efficiency, (2) subjective evaluations (measured with standardized inventories). Due to the small sample size, we report only use descriptive statistics to assess general trends in boths conditions. The reported results are not meant to be interpreted in the sense of inferential statistics.

Task Efficiency

Here, we investigated participants' efficiency in performing the subtasks (1) and (3) with regard to *time on task*, *task accuracy*, and *task completeness*. All three variables were noted by the experimenter who observed the participants' activities on performing the task. Results are visualized in Fig. 3.

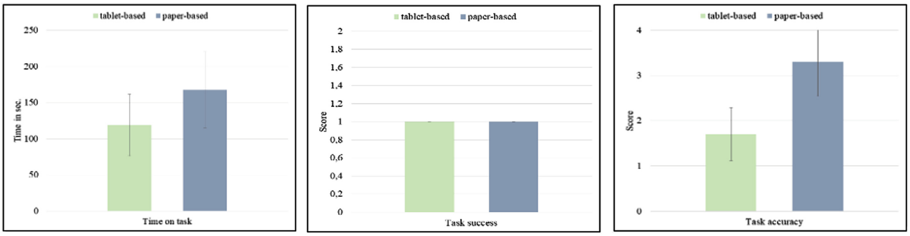

Fig. 3. Comparison of mean values and standard deviation for variables time on task (*left*), task success (*middle*) and task accuracy (*right*).

Time on task: We compared the sum of participants' completion time for finishing the task across experimental conditions. The mean task completion time in the tablet-based condition was 118 s while tasks performed in the paper-based condition took about 167 s on average.

Task success: Task success measures whether participants succeeded or failed at a task. A score of 1 was given for "full success" on a task, 2 for "partial success" and 3 for "no success" (see Fig. 2). In both experimental conditions, participants' success rate was maximal (M = 1, SD = .00).

Task accuracy: Participants' accuracy in task performance was measured as follows: 1 for "participant solved the task without help", 2 for "participant solved the task with trial & error", 3 for "participant solved the task with a single hint of the lab member" and 4 for "participant solved the task with constant support of the lab member". On average, participants' accuracy in the tablet-based condition (M = 1.7, SD = .58) was higher as in the paper-based condition (M = 3.4, SD = .76).

Subjective Evaluation

Participants' subjective evaluation of the interaction was measured with standardized inventories in the dimensions of perceived mental effort and consequences of intuitive use.

Mental effort: We measured participants' perceived mental effort in task performance after performing the task with the SEA scale ranging from 0 ("no effort") to 220 ("extremely high effort"). On average, participants judged their cognitive effort in the tablet-based condition lower (M = 13.3, SD = 23.09) than in the paper-based condition (M = 33.3, SD = 11.54).

Consequences of intuitive use: The intuitiveness of using the prototype was measured with the QUESI questionnaire on a 5-point Likert scale from 1 (fully disagree) to 5 (fully agree). Mean values and standard deviations are visualized in Fig. 4. For the QUESI sub-scales, tablet-based interaction was rated as more intuitive as paper-based interaction for the following dimensions: *perceived achievement of goals* (M = 5.0, SD = .00), *perceived effort of learning* (M = 4.87, SD = .23) and *perceived error rate* (M = 5.0, SD = .00). The dimensions *mental workload* (M = 3.33, SD = 1.53) and *familiarity* (M = 4.87, SD = .23) in the tablet-based interaction were rated lower than in the paper-based interaction.

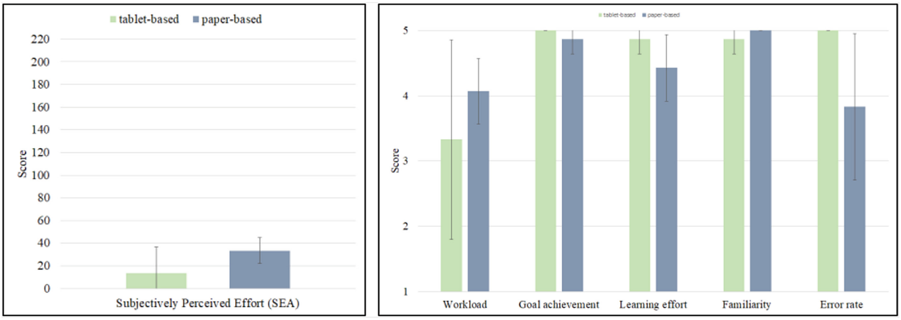

Fig. 4. Comparison of SEA (*left*) and dimensions of QUESI (*right*) in tablet-based and paper-based condition.

Video-Based Instructions Using a Mobile Device

The experimenter conducted thinking-aloud tests with three disabled workers while performing the second subtask using step-by-step video instructions. It was observed that all participants could complete the task successfully and had no difficulties interacting with video instructions. They were satisfied using videos and could well manage to carry out the task without an attendant presence. For instance, autoplaying and looping videos show to be important for our participants as they need to see the instructions several times and otherwise would have to start the videos again and again. Crucially, a short pause should be integrated at the end of a loop to give participants enough time to conceptualize the work process before it is shown to them again.

5 Discussion

In this paper, we investigated the potential of step-by-step support for people with disabilities using a mobile assistive system in production. We applied a user-centered methodology and implemented a prototype application which enables disabled workers to perform industrial tasks with step-by-step support. In an evaluation study, we compared the tablet-based support against a paper-based one. Our results can be summarized in two major points.

First, participants' efficiency on using the mobile prototype was assessed with regard to *time on task, task accuracy* and *task completeness*. Along the dimension *time on task* and *time accuracy*, the tablet-based prototype turned out to be more efficient than the paper-based condition. However, we did not observe any difference between both conditions across the *task completeness*.

Second, participants' subjective evaluation of the interaction was assessed with regard to *mental effort* and *consequences of intuitive use*. Again, our results showed a clear advantage for the tablet-based interaction. Participants' perceived cognitive effort using the assistive system with support was lower as compared to the paper-based condition. The advantage of the tablet-based interaction was also found in terms of intuitiveness of using the prototype: Here, the tablet-based condition was rated higher with respect to the dimensions perceived achievement of goals, perceived effort of learning and perceived error rate than the paper-based condition. Paper-based interaction, however, outperformed tablet-based interaction in terms of the dimensions mental workload and familiarity.

Overall, our assistive system *with* mobile step-by-step support showed to have several benefits over paper-based support. That is, the supportive technology we developed seems to be a helpful aid for disabled workers. Nevertheless, our pilot study has some limitations we plan to overcome in future work.

First, due to the small amount of five participants, only trends could be seen regarding differences in both conditions. Therefore, we conclude that the same study should be repeated with a larger amount of participants. Another major hurdle was the distribution of participants into the two conditions. Three participants had no prior experience using such an industrial machine. In order not to overwhelm the disabled workers with too many information, the participants with no experience were assigned to the paper-based condition. This design decision, however, might have affected our results as we cannot rule out that differences observed between the conditions might be due to participants' prior experience with the machine. In the next study, it should be taken care to conduct the study with experienced participants.

Second, participants didn't have the full cognitive ability to read, completely understand and fill in the QUESI questionnaire. Therefore, the experimenter read out each question from the questionnaire and noted participants answers. In some cases, participants gave uninterpretable responses to the experimenter which may affect the results. The same applies to placing a check mark on the SEA scale to measure participants' mental effort. Future research includes a study with special questionnaires for people living with cognitive impairments.

Third, to enable for a comparison of paper- vs. tablet-based instructions, the tablet-based prototype was not used to its full extent. The most important task of changing the drill head with a video instruction was not included in the evaluation study. So, a crucial advantage of using a mobile device was lost in this study. Also, we eliminated QR-based support in the tablet-based instructions as there was no equivalent available in the paper-based condition.

Despite these obstacles that are still to overcome in a more compressive follow-up study, we could show in this paper that an assistance system can enhance the quality of work and thus improve job opportunities for people with disability to employment. Also, we plan to extend our prototype with the integration of an augmented reality software that shows users the instructions as guided steps and the current status of the machine with graphical overlays. It has been proven that this technology reduces error-rates and time on task in manufacturing [37].

Acknowledgments. We thank the sheltered work organization “Werkstatt Begatal of Lebenshilfe Detmold e.V.” for participating in the evaluation and proving pedagogical support during the project.

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User Perceptions of Haptic Fidgets on Mobile Devices for Attention and Task Performance

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Abstract. Fidgeting, while primarily recognized as a distinguishing characteristic of neurodevelopmental conditions such as autism or ADHD, has also recently been recognized as a potential focus and attention aid for learning in traditional classroom environments. Everyone fidgets to greater or lesser extents, perhaps everyone can benefit from fidgeting aids to refocus attention. The recent explosion in popularity of fidgeting aids, such as fidget spinners, fidget cubes, and other toys highlights the broad appeal of these objects. Human-Computer Interaction researchers have taken an interest in the contributions of fidgeting to productivity. While these works connect the concepts of visual and motor stimulus as meaningful fidgets, little investigation has been done as to the potential contributions of haptic stimulus in digital fidgets. We designed and tested haptic mobile fidgets and compared their effects on task performance and user preference against the traditional spinner and no fidget apparatus.

Keywords: Assistive technology · Haptic feedback · Human factors Productivity · Tactile interfaces

1 Introduction

1.1 Motivation

Everybody fidgets. We have all, at one time or another, found ourselves bouncing a leg under our desk, clicking a pen, drumming our fingers, folding a napkin, and so on. Neuropsychological conditions, such as autism and ADHD, are often characterized by more frequent, more idiosyncratic, more perceptible fidgeting [1]. The relationship between fidgeting and concentration has historically been misunderstood, with parents and teachers being somewhat fixated with restricting and extinguishing these behaviors [2–4]. In recent years, the research has revealed that fidgeting and other forms of movement may actually have a positive effect on focus and retention of information [5–9].

"Fidget Toys" have been on the market for decades. Silly Putty first appeared in 1949 [10]. Now owned by Zuru, Tangle Creations was incorporated in 1981 [11], manufacturing the plastic infinite knot toy. Crazy Aaron's Thinking Putty, an advancement in toy putty composition and aesthetic, followed in 1998 [12]. The first

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known “fidget spinner” is thought to have appeared in 1993 [13]. Antsy Labs launched their kickstarter for the Fidget Cube in January of 2017 [14]. Following the success of their campaign, fidget toys exploded into the pop culture market, with affordable and various new takes on the fidget spinner and fidget cube making headlines worldwide.

As fidget spinners became increasingly popular, school staff took to blogging about their disruptiveness [15]. Unfortunately, many schools decided to ban the fidget spinner almost as soon as it arrived in the pockets and backpacks of their students [16]. This has exposed many students with Individualized Education Plans (IEPs) or 504 provisions to the tension of having to out themselves amongst their peers. Either they give up the fidgets which help them self-regulate and focus in the classroom, or they are given special permission, which outs them as potential targets of ridicule. It is within this tension that our research team set out to investigate mobile device alternatives to these highly visible, uniquely satisfying, yet remarkably simple devices.

Based on previous observations, personal experiences, and related work (presented in Subsect. 1.2), we designed a mobile application to simulate some of the tactile aspects that make fidget spinners appealing to use and manipulate (described in Sect. 2.1). We then designed an experiment (described in Sect. 2.2) to test the performance impacts of fidget spinners and our mobile simulated fidgets. Our experiment also sought to investigate user perceptions of these fidgets, and whether our mobile fidgets were comparably enjoyable to fidget spinners.

1.2 Related Work

Human-Computer Interaction researchers have taken an interest in investigating the relationships between fidgeting and productivity. Choi et al. investigated user experiences of active workstations in 2016 and reported that active workstation use did not significantly impact performance [17]. Users were more likely to use active workstation aids during simple, repetitive tasks. It seems as though users did not feel the need to engage physically for tasks that required a sufficient cognitive load, and that active workstations (or fidgeting) helped them maintain attention on dull tasks. Chalkley et al. devised a wearable sensor metric for fidgeting in 2017 [18]. They found that wrist and ankle movement reduced during moments when the screen was producing visually stimulating content, even if later user reports indicate that they were uninterested in that content. Though Chalkley et al. do not offer explicit interpretations themselves, it seems possible that engaging screen activity is necessary for inhibited motion and increased user attention. However, it is just as likely that any stimulation has the potential to support attention, be it audiovisual stimulation, wrist and ankle movement, or playing with fidgets. In the Chalkley et al. experiment, the audiovisual stimulation provided by the “engaging screen content” can be interpreted as a kind of fidget aid.

Karlesky and Isbister have specifically investigated digital fidgets in workspaces [19–22]. They have devoted significant attention to common physical fidgets and their effects on embodied self-regulation, with an eye toward developing comparable digital artifacts to suit these needs. At the time we were running our studies, however, there was little in the research beyond a cursory mention of haptic fidgets on digital devices. Many mobile applications were published in the wake of the fidget spinner craze to capitalize on this new popularity of fidgeting. However, none that we found during development of our experimental application were using the phone's vibration feature. We explore vibration as a means of generating tactile experiences for mobile devices that can support effective and satisfying fidget aids.

2 Materials and Method

2.1 Materials

This was a four-level study measuring three different fidget apparatuses and no fidget apparatus (shown in Fig. 1). For one level of the study participants used a fully metallic smooth weighted fidget spinner. For two other levels participants used a mobile application on an Android Samsung Galaxy S4. The application was made with Android API native calls to control the rate of vibration since intensity is not able to be controlled directly.

In one of the two mobile application levels participants used the vibration mode (shown in tables as V). Vibration mode presented the user with a variable vibration intensity across the screen surface, with more intense vibration at the center of the screen, and a linear fall off to zero vibrations at the edges of the screen. Colors approximating those of the metallic fidget spinner were mapped to the vibration intensity. The other mode was the virtual spinner mode (shown in tables as VS), which resembled in color the physical spinner used in the study. Virtual Spinner mode presented a fidget spinner graphic that users could spin by flicking the screen. The vibration was mapped to the virtual spinner's speed. In the last level the participants did not use a fidget apparatus.

Fig. 1. Mobile Haptic Fidget (V), Mobile Haptic Fidget Spinner (VS), and Fidget Spinner (S)

A Lenovo Yoga Laptop was used during the study for participants to perform visual search tasks [23]. After each task set, participants answered questions in a Qualtrics survey about their self-perceptions of performance and the provided fidget apparatus. The visual search task asked participants to find an orange upright **T** in a screen presented with blue **T**'s and orange upside down **T**'s. If the participants found an orange upright **T** they were instructed to press the spacebar. If no orange upright **T** was shown on the screen they did not need to interact with the system and the screen would change after an allotted amount of time. Visual search tasks were developed to investigate factors of selective and sustained attention [24–26]. Therefore, we feel the use of this task is appropriate to investigate effects of fidgeting on attention.

2.2 Method

The study was a within-subjects study with 33 participants. These participants were students recruited from the University of Florida through professors offering extra credit in classes for participating in studies, as well as through an email sent out via mailing list. Each study lasted between twenty to fifty minutes with only one study happening at a time. Researchers explained relevant information and gave the consent form to participants. After signing the consent form participants began the study with one of the fidget apparatus. Each participant completed the four levels of the visual search task using the: Fidget Spinner, Mobile Fidget Spinner, Mobile Haptic Fidget, and Nothing. The participants received the apparatus according to a Williams Latin square design to balance for first-order carry-over effects. They were each given a set time to familiarize themselves with the fidget apparatus before beginning the visual search task. After each visual search task set, the participant took a Qualtrics survey to report perceptions of the assigned apparatus and self-report the impact the apparatus had on their performance. Questions on this survey included:

1. How often during assessment did you use the fidget aid? If you were not assigned a fidget aid, tell us how often you felt the urge to fidget.
2. What impact, if any, do you feel the fidget aid supplied to you had on your expected performance on the assessment?
3. How likely would you be to use a fidget aid like the one provided today while attending lecture or studying?

At the end of the fourth attention visual search task the participant completed a final survey to gather demographics and ask closing questions. Questions on this survey included:

1. Please rank the fidgets from most helpful to least helpful.
2. Please rank the fidgets from most enjoyable to least enjoyable.
3. Have you ever used a fidget aid in class before?
4. If you would like to leave any additional comments for the researchers, do so below.

3 Results

To compare the participants' performance to their perception, the time to complete a visual search task was recorded while participants used each fidgeting toy. Using the data, the average time to complete search task with only 20 objects on the screen was calculated using the One-Way Analysis of Variance (ANOVA) function within the

Statistics and Machine Learning Toolbox in MATLAB. The graph in Fig. 2 shows that the average time was relatively equal among the fidget apparatus (no fidget object, fidget spinner, mobile haptic fidget, and mobile fidget spinner); as a result, there was no significant statistical difference (p-value = 0.6826) between the fidget apparatus when completing the visual search task with only 20 objects on the screen. In addition, the graph in Fig. 3 shows the overall average time was relatively equal among the fidget apparatus. Therefore, there was no significant statistical difference (p-value = 0.8227) between the fidget apparatus when completing the visual search task for any number of objects on the screen. Based on these results, it can be suggested that fidget apparatus do not have a negative impact on one's performance since the average time for no fidget apparatus is close to the average times for each fidget apparatus.

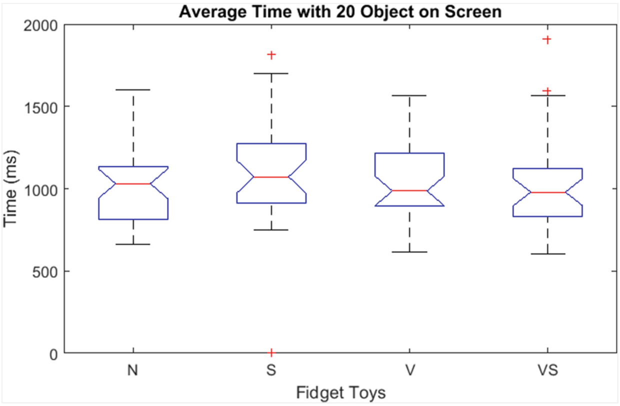

Fig. 2. Average time to complete visual search task with 20 objects on screen; N - No Fidget, S - Fidget Spinner, V - Mobile Haptic Fidget, VS - Mobile Fidget Spinner

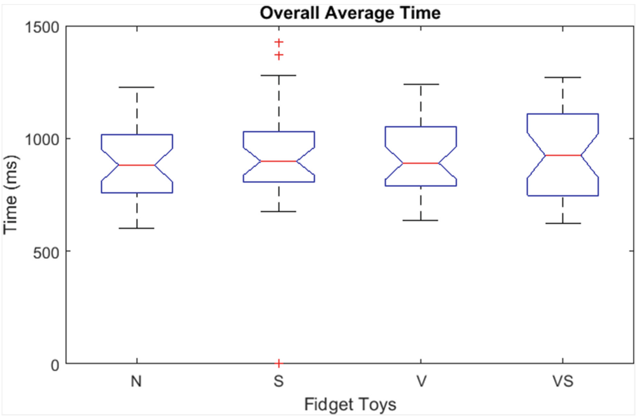

Fig. 3. Overall average time to complete visual search task (5–20 objects on screen); N - No Fidget, S - Fidget Spinner, V - Mobile Haptic Fidget, VS - Mobile Device Fidget Spinner

The results of the 5-point Likert scale questions, as seen in Sect. 2.2, were analyzed using a Wilcoxon Signed-Ranks Test. The analysis was completed using IBM SPSS Statistics 25. The Wilcoxon Signed-Ranks Test indicated that there were no significant differences in reported perception of performance between the trials of different fidget objects. This confers with the timing results in that not only did participants perform the same on the tasks using the different fidget objects, their perception of their performance matched their actual performance.

Table 1. Wilcoxon Signed-Ranks Test for "How likely would you be to use a fidget aid like the one provided today while attending lecture or studying?"

	S-N	V-N	VS-N	V-S	VS-S	VS-V
Z	−1.935	−3.248	−3.045	−1.956	−1.767	−.288
p-value	.053	.001	.002	.050	.077	.774

A summary of the Wilcoxon Signed-Ranks Test of the reported likeliness of using each of the fidget objects in the future is in Table 1. Participants did report having differing preferences for the fidget objects during the study. The participants were statistically more likely to use the spinner ($z = -1.935$, $p = 0.053$), the virtual spinner ($z = -3.045$, $p = 0.002$), and the virtual fidget ($z = -3.248$, $p = 0.001$) than use nothing. Additionally, participants reported being statistically more likely to use the mobile haptic fidget than the physical spinner ($z = -1.956$, $p = 0.05$).

4 Discussion

The results showed that none of the fidget aids significantly impacted participant performance on visual search tasks. None of the fidget conditions was shown to have a statistically significant impact on visual search task completion time. There were not enough task errors to calculate fidgeting impacts on error rates. This result is good news for fidgeters, as it supports the use of fidgets on the basis that they were shown not to negatively impact attention. Overall, participants reported a preference for fidgets over no fidgets in a classroom context, and even a specific preference for the Mobile Haptic Fidget over the traditional Fidget Spinner. This result was surprising, as the mobile apps were designed to simulate the tactile and proprioceptive feedback from fidget spinners but were not expected to be as satisfying, as they cannot emulate momentum shifts from manipulating the spinner as it spins.

Participants were asked to engage with the fidgets as much as possible but use of the fidget apparatus could not be enforced. In this way, fidget impacts on performance were self-limiting. It is unlikely that participants would engage with the fidgets in ways that would compromise their performance on the visual search task. This limitation of our study design is actually more representative of the actual classroom setting. For people who enjoy fidget aids, or feel that they support their attention, our results agree that fidgeting is not harmful to performance.

5 Conclusion

Our study design produced no evidence for negative effect of fidgeting on participant attention and task performance. Participants reported a preference for fidget aids in a classroom context, and ranked the mobile fidgets, in particular the Mobile Haptic Fidget, above the traditional fidget spinner toy.

While our results will do little to dissuade school administrators from lifting the ban on fidget spinners, we hope that more developers will begin embracing the stimulating and soothing potential of haptic feedback on mobile devices. Haptic fidgets for mobile devices have the benefit of being more discreet than the brightly colored, quickly moving, occasionally noisy physical fidget toys, a feature that we feel appeals to adult fidget users in particular. Though it was not used in this experiment, the mobile fidget app that we designed does have a “stealth mode” in which users can deactivate the device display while still manipulating the vibration feature.

Future studies may investigate cross-participant distraction factors. It is likely that certain fidget aids are more disruptive to the people around the user than to the user themselves. It would be interesting to investigate how mobile fidget aids can provide tactile stimulation without distracting classmates and coworkers.

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Evaluation of Design Recommendations for the Development of Wheelchair Rugby Sports-Wear

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Abstract. Currently, wheelchair rugby athletes face the challenges of playing the sport without specifically designed sports-wear kit. A few designs and recommendations have already been proposed by researchers but none have made it to market yet. The purpose of this study was to evaluate a set of design recommendations for the development of wheelchair rugby sports-wear. This was done so that the products to be created are developed in collaboration with their potential users, responding to their particular needs and requirements. The evaluation was done through an online survey, where the athletes were presented with a visual representation of the design recommendations. The results indicate that the people questioned agree with the majority of the proposed designs and would be happy to have these improvements made to their current sports-wear. The most criticised recommendations were for the gloves, as they are the most important part of the kit, so it is important that they are adequate and allow for a good performance.

Keywords: Sports-wear · Wheelchair rugby · Design recommendations Inclusive design · Gloves

1 Introduction

Wheelchair rugby is a team sport for male and female athletes with a disability, however able-bodied people can also participate. This is one of the fastest growing wheelchair sports that has been especially developed for individuals with tetraplegia. Athletes' performance is as important in wheelchair rugby as in any other sport, and it can be influenced by both individual and team components [1–3].

Sports-wear is one of the several factors that can affect not only the athletes' performance, but also their safety and comfort. In the sports-wear field, users search for comfort, quality, durability, and style, but comfort and fit are presumably the two most

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important features in this type of clothing [4]. Kratz et al. [5] compared the difference between wheelchair users wearing adapted clothes and non-adapted clothes for some sports. They concluded that less effort had to be made and more comfort was felt when wearing the adapted clothes. In the study of Bragança et al. [6], it became clear that there is a lot of scope for innovation in wheelchair rugby sport-wear. The authors identified the athletes' needs by means of a questionnaire and a focus group, which then led to the development of some design recommendations for gloves, tops and bottoms, specifically though for wheelchair rugby.

The basic information designers use to create products should be derived from the real end-users, to assure that their real needs are being met and the problems are being solved. This is a more challenging way of creating novel solutions but it optimizes commercial success [7]. Many designers see design for disability as part of engineering and human factors [8]. The human factors and ergonomics hierarchical approach to design gives preference to environmental design to fit the human; selecting or training people to fit the environment is only an option when there is no other alternative [9]. According to Curteza et al. [10], to meet the special requirements of wheelchair users, fabrics with special properties, capacities and functions should be preferred (e.g. antibacterial, water proof, wear resistant, non-flammable).

Due to the limited choice or even unavailability of specialized garments, wheelchair users tend to adapt clothing designed for able-bodied people. In wheelchair rugby this happens very frequently, especially with the gloves. Gloves are an important part of the equipment for wheelchair rugby players, as they directly influence the wheelchair–user interface – more than protecting the hands, the gloves are used to have a better grip while maneuvering the chair and handling the ball [11, 12]. As no pair of gloves, specific for wheelchair rugby has been introduced in the market yet, athletes must use other types of gloves include adaptation to make the gloves more suitable for their needs, such as adding materials like glue, tape or extra rubber for obtaining sufficient grip on the hand rims and ball [6, 12].

The purpose of this paper was to evaluate and validate a set of 18 design recommendation for wheelchair rugby sports-wear that had been previously developed by the authors. The goal was not only to obtain the feedback from wheelchair rugby players but also to take their opinions and reformulate the initial design recommendations so that on a later stage the products can be developed according to the users' requirements.

2 Methodology

42 non-professional wheelchair rugby athletes, from 16 different teams/clubs in the United Kingdom, participated in this study. Table 1 shows some characteristics of the sample, such as the distribution of age, gender and team where the sport is played.

This study used a short online survey as a means of gathering data. This survey was used to evaluate a set of design recommendations that the authors had developed for the design of wheelchair rugby sports-wear. A total of 18 design recommendations; divided into recommendations for gloves, tops, and bottoms; was initially proposed for evaluation. The full list of design recommendations can be seen on Table 2.

Table 1. Characterization of the sample.

Variable	Categories	N	%
Frequency in each age group	Under 18	1	2
	18–30	8	19
	31–40	12	29
	41–50	13	31
	51–60	6	14
	60+	1	5
Gender	Male	37	88
	Female	5	12
Team	Bristol Bears | Bristol	3	7
	Caledonian Crushers | Glasgow	7	17
	Dorset Destroyers | Poole	2	5
	Glasgow Panthers | Glasgow	1	2
	Gloucester Wheelchair Rugby | Gloucester	2	5
	Gravesend Dynamite | Gravesend	1	2
	Hull FC Wheelchair Rugby | Hull	1	2
	Leicester Tigers | Leicester	2	5
	London Wheelchair Rugby | London	6	14
	Ospreys | Cardiff	1	2
	Solent Sharks | Southampton	2	5
	Stoke Mandeville Maulers | Aylesbury	7	17
	West Coast Burn | Southport	1	2
	West Country Hawks | Plymouth	3	7
	Woodbridge Wheeled Warriors | Woodbridge	1	2
	Yorkshire Lions | Featherstone	2	5

The respondents were presented not only with the textual description of the design recommendation but also with a sketch of how the design recommendations would look if implemented on a pair of gloves, on a shirt and on a pair of trousers, respectively (Fig. 1).

To evaluate the designs, for each design recommendation three questions were asked:

- Please rate your level of agreement with this design recommendation: (i) Strongly agree; (ii) Agree; (iii) Neutral; (iv) Disagree; (v) Strongly disagree;
- What would you change or do differently to solve the problem/need identified in the Figure above?;
- Do you think that implementing this design recommendation would improve: (i) Performance; (ii) Comfort; (iii) Safety; (iv) Nothing.

The results of the questionnaire were analyzed in terms of distribution of frequencies and other descriptive statistics.

Table 2. Design recommendations.

Garment	Design recommendation
Gloves	DRglo 1 | Velcro wrap cuff
	DRglo 2 | Elastic fingertips
	DRglo 3 | Central opening
	DRglo 4 | Palm coated with sticky material
	DRglo 5 | Sweat-absorbent, breathable, malleable, resistant gloves
Tops	DRtop 1 | Tight but not form-fitting tops
	DRtop 2 | V-necked tops
	DRtop 3 | Detachable sleeves by sections
	DRtop 4 | Reinforced back of sleeves
	DRtop 5 | More adequate textile structure and combination of materials
	DRtop 6 | Longer back
Trousers	DRbot 1 | Tight but not form-fitting bottoms
	DRbot 2 | Elasticated waistband
	DRbot 3 | Consider anthropometric measurements
	DRbot 4 | Higher rise on back and lower rise on front
	DRbot 4 | Higher rise on back and lower rise on front
	DRbot 5 | Detachable legs by sections
	DRtop 6 | Mix of synthetic and natural fibers
	DRbot 7 | Softer material in the back and minimal, flat seams

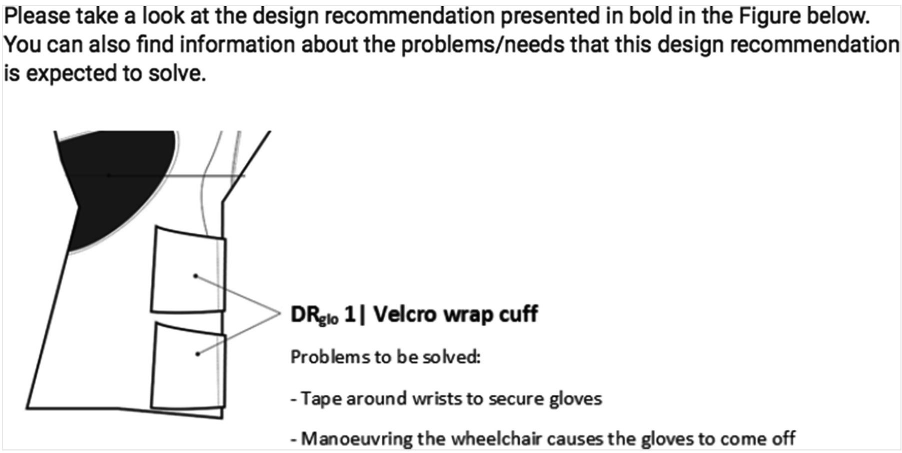

Fig. 1. Example of visual representation of the design recommendations on the questionnaire.

3 Results and Discussion

In general, the feedback obtained on the several design recommendations was very positive. The athletes seemed to be enthusiastic and excited with the possibility of having such improvements to their current sports-wear kit. Some of them were even surprised by some of the proposed interventions, as they had not yet thought about some of the ideas presented. The level of agreement with the design recommendations was mostly classified as “Agree” or “Strongly Agree”. Figure 2 shows the distribution of the levels of agreement with each design recommendations.

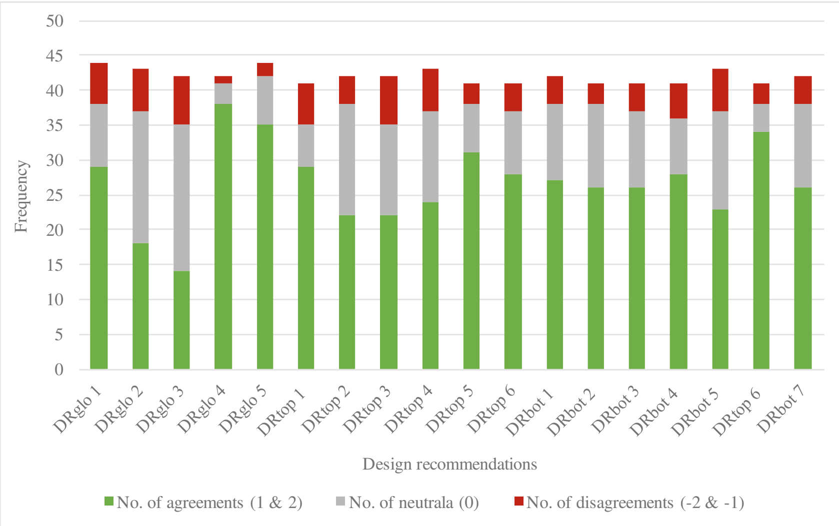

Fig. 2. Distribution of the responses regarding the agreements or disagreement with each design recommendation.

Of the 42 responses obtained, the highest number of disagreements for a single design recommendation was only 7 (for DRtop3), which means that the majority of the participating athletes agree with the proposed solutions. Accordingly, a relatively high number of strong agreements were registered for two design recommendations: DRglo5 and DRbot6 with 40% and 44% of people rating their opinion on the design recommendations as strongly agree, respectively.

The following sub-sections provide more detail on the athletes’ opinions about each particular part of the sports-wear kit, namely, gloves, tops, and bottoms.

3.1 Gloves

The most recommended alterations to the initially proposed design recommendations occurred for the gloves. Nonetheless, the athletes agreed that implementing these design recommendations for the gloves would improve mostly performance and comfort (Fig. 3). In general, the athletes agreed with most design recommendations but some of them had a few ideas that would improve the designs even further.

For the first design recommendation (DRglo 1 | Velcro wrap cuff), the athletes suggested that the Velcro wrap should be longer so that it wraps around further into the forearm, making it more secure and tight. It was also mentioned that the fastening should be placed on top rather than the underside to make it more comfortable.

Additionally, the importance of a long strap was also heightened as it would help to improve the athletes' independence levels as they would be able to put it on with their teeth. Hence, the improved design recommendation would be DRglo 1 | Long Velcro wrap cuff with extension to forearm.

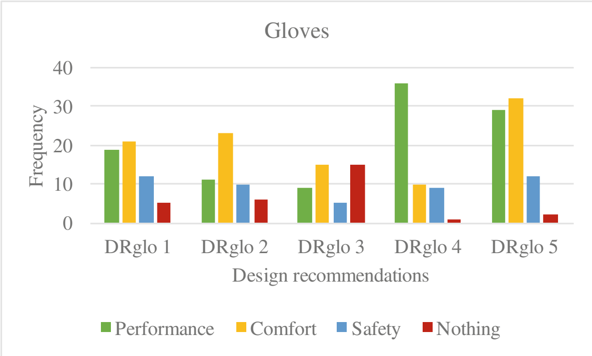

Fig. 3. Distribution of the responses regarding what aspects could be improved for each design recommendation regarding the gloves.

The athletes did not seem to agree as much with the second design recommendation (DRglo 2 | Elastic fingertips) and mentioned that they would prefer to have a more resistant material on the fingertips instead of them being elasticated. To solve the issue of fitting every athlete's hands, they propose that a wider range of sizes (rather than the usual small, medium, and large) should be made available. It was stated that it is important that the fingers are well protected during the game, so the gloves should provide an extra reinforcement in this area. Consequently, the newly proposed design recommendation would be DRglo 2 | Extra resistant material on fingertips and greater availability of sizes.

The third design recommendation (DRglo 3 | Central opening) was another of the ones with which the athletes did not agree as much. They recognized that it would improve the ease of putting on and taking off, but as there are some players that push the wheelchair with the back of their hands it could be a safety risk. The athletes were concerned that this opening would represent more stitching and that would leave areas of the hand more vulnerable. Some suggested that a soft discrete zip could be included in one of the sides to make it easier to put on and take off. Thus, the new design recommendation would be DRglo 3 | Soft side zip.

The fourth design recommendation (DRglo 4 | Palm coated with sticky material) was the most successful one, with 92,5% of agreement. As happened for other design recommendations, some athletes pointed out that some of them push the wheelchair with the back of their hands and hence, this coating of sticky material would also be useful if applied to the back of the hand. To cater for everyone's need it was suggested that two models were created, one with the palm coated with sticky material and the other where the back of the hand is coated. Another suggestion was to extend the surface covered by the sticky material. The athletes mentioned that the thumb is a very important area to be coated, as it is one of the main pushing areas. Additionally, some concerns were also raised on what regards the resistance to dust and the durability of the stickiness. To solve that problem some suggested that the sticky material would not be part of the glove, but instead a detachable part that could be replaced whenever necessary. So, the enhanced design recommendation would be DRglo 4 | Thumb and palm/back of the hand coated with replaceable sticky material.

The final design recommendation for the gloves (DRglo 5 | Sweat-absorbent, breathable, malleable, resistant gloves) was also well accepted and not many alterations were suggested. The only aspect pinpointed by the athletes were the fact that there are different levels of players, with different requirements. The gloves should always be sweat-absorbent, breathable, malleable and resistant but perhaps with different demand stages. As such, the fifth design recommendation remained unchanged.

Table 3 lists the updated design recommendations for the gloves.

Table 3. List of reformulated and original design recommendations for the gloves.

Reformulated design recommendations	Original design recommendations
DRglo 1 | Long Velcro wrap cuff with extension to forearm	DRglo 1 | Velcro wrap cuff
DRglo 2 | Extra resistant material on fingertips and more availability of sizes	DRglo 2 | Elastic fingertips
DRglo 3 | Soft side zip	DRglo 3 | Central opening
DRglo 4 | Thumb and palm/back of the hand coated with replaceable sticky material	DRglo 4 | Palm coated with sticky material
–	DRglo 5 | Sweat-absorbent, breathable, malleable, resistant gloves

3.2 Tops

Regarding the tops, the majority of the design recommendations were very well accepted by the athletes and consequently, only two of them were changed (DRtop 2 and DRtop 4). According to the athletes, the implementation of these design recommendations would improve mostly comfort, but also safety and performance (Fig. 4).

The athletes agreed that the tops should be tight but not form-fitting and suggested materials such as Lycra (DRtop 1 | Tight but not form-fitting tops). They also agreed that having sleeves that can be detachable in different sections would be very useful but warned that they should be durable, breathable, and resistant so that the sections do not divide while playing the game (DRtop 3 | Detachable sleeves by sections). Positive feedback was also given to the materials proposed, even though attention was drawn to the selection of fabrics with good sweat absorption capabilities (DRtop 5 | More adequate textile structure and combination of materials). Finally, agreement was also found for designs with longer backs (DRtop 6 | Longer back).

Concerning the neckline of the tops (DRtop 2 | V-necked tops), the athletes seemed to prefer round-necked tops due to the aesthetics. Nonetheless, they agree that some athletes struggle to put on the tops and suggest that small discreet zips could be added

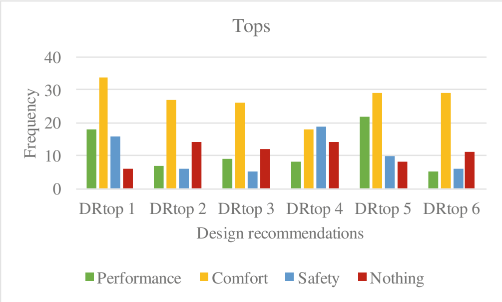

Fig. 4. Distribution of the responses regarding what aspects could be improved for each design recommendation regarding the tops.

to the shoulder seams to facilitate the putting on and taking off processes. Hence, the improved design recommendation would be DRtop 2 | Round-necked tops with shoulder openings.

The athletes indicated that the sleeves of the tops (DRtop 4 | Reinforced back of sleeves) should not be solely reinforced on the back, but all over as players sometimes push with different parts of their arms, and sleeves can twist during the game. As such, they recommended reinforcing the whole sleeve, making sure that the material used is breathable and durable. Thus, the new design recommendation would be DRtop 4 | Reinforced whole sleeves.

Table 4 lists the updated design recommendations for the tops.

Table 4. List of reformulated and original design recommendations for the tops.

Reformulated design recommendations	Original design recommendations
–	DRtop 1 | Tight but not form-fitting tops
DRtop 2 | Round-necked tops with shoulder openings	DRtop 2 | V-necked tops
–	DRtop 3 | Detachable sleeves by sections
DRtop 4 | Reinforced whole sleeves	DRtop 4 | Reinforced back of sleeves
–	DRtop 5 | More adequate textile structure and combination of materials
–	DRtop 6 | Longer back

3.3 Bottoms

The design recommendations initially proposed for the bottoms were also very well accepted and, in this case, no alterations were made to any of them. The athletes seem to believe that implementing these design recommendations would improve mostly comfort (Fig. 5).

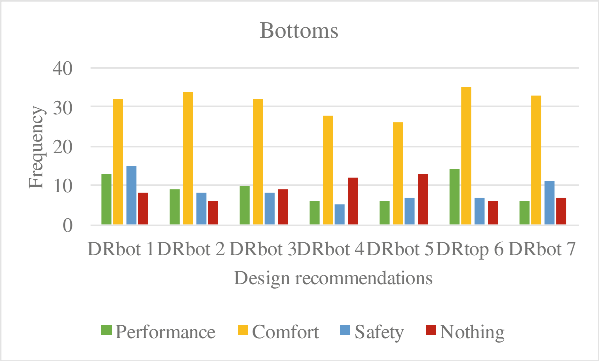

Fig. 5. Distribution of the responses regarding what aspects could be improved for each design recommendation regarding the bottoms.

The athletes agreed that the design of the bottoms should be tight but not form-fitting (DRbot 1 | Tight but not form-fitting bottoms) and that there should be no pockets for safety reasons. They affirmed that having an elastic around the waist with a pull cord to tighten or loosen the bottoms as required would suit most players (DRbot 2 | Elasticated waistband). Different sizing systems were also viewed as a very important factor to improve the fit (DRbot 3 | Consider anthropometric measurements) as well as a design that is higher on the back than on the front (DRbot 4 | Higher rise on back and lower rise on front). The idea of having a pair of trousers in which the legs can be detachable in different sections was also well received, especially to fit amputees (DRbot 5 | Detachable legs by sections). Finally, the ideas for the materials (DRtop 6 | Mix of synthetic and natural fibers) and seams (DRbot 7 | Softer material in the back and minimal, flat seams) were also supported by the majority of the athletes.

4 Conclusion

The results of this study showed that wheelchair rugby players are, in fact, interested in having sports-wear kit specific for this sport. Their feedback on the proposed design recommendations allowed for the reformulation of some designs.

The evaluation of the design recommendations was every useful to ensure that the products to be developed are in line with the athletes needs and wants from a sports-wear kit.

Once again it was clear that the most important part of the sports-wear kit are the gloves, whereas tops and bottoms despite being especially important for comfort, are sometimes overlooked even by the athletes. The gloves are the sports-wear item that impact the most on the athletes' performance and hence, should be the priority in terms of new product development.

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Emotional and Stress Responses to Cyberbullying

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Abstract. This article presents a literature review of emotional responses and stress attributable to cyberbullying. It begins with a summary of the definition of cyberbullying and then describes types of cyberbullying and the emotional reactions it can produce. Next, theoretical background studies relevant to cyberbullying are discussed. Findings indicate that most previous research used transactional model theory as a valid measure. However, this review draws attention to reliance on variations in stress and emotional state. Finally, the need for future research exploring how people momentarily cope or deal with cyberbullying events is suggested as a means of providing a temporal prediction of cyberbullying incidents.

Keywords: Cyberbullying · Emotions · Stress · Verbal harassment Social exclusion

1 Introduction

Bullying research has focused on underage bullying, workplace bullying, burnout, mobbing and, most recently, cyberbullying. Bullying, in general, became a subject of research because of its harmful effects on human well-being. Individuals who are bullied might suffer from depression or lower self-esteem, or worst of all may attempt suicide [1]. The increased use of social media among all age groups in today's world has made it necessary to explore bullying in cyberspace from a different perspective, particularly among youth. Unlike previous generations, most youth today own smartphones and have grown up with the Internet. Thus, whether positive or negative, Internet use is undeniably part of their daily life.

Cyberbullying statistics show that one-fifth of teens have experienced cyberbullying sometime in their lives [2]. According to research by the Crimes Against Children Research Center (CACRC), the number of cyberbullying acts among teens increased from 6% to 11% between 2000 and 2010 [3].

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Cyberbullying received significant attention from researchers as a result of increasing incidents of verbal and non-verbal aggressive acts in social media and the considerable risk associated with those incidents. It has had negative emotional and physical impacts on people and has been cited as a contributing factor to many attempted suicides [4]. Cyberbullying attacks take various forms, but the greatest consequence has been the unlimited accessibility to the target [5, 6].

Researchers have used different experimental models to study cyberbullying (e.g., cyberball [7], chatrooms [8–12], role-playing [13] and online-ostracism paradigm [14]). Wolf and colleagues [14] compared the computerized cyberball and an online-ostracism paradigm and concluded that both were effective and easy to use, and provided a valid measure of social exclusion. Players Interacting in a virtual environment via role-playing games may exhibit negative effect equivalent to those in real life [13].

Although studies have used different techniques to elicit responses to cyberbullying, they relied solely on self-reported measures. This review presents the latest research and findings concerning emotional responses and stress caused by cyberbullying. This integration of knowledge will promote efforts to prevent and detect cyberbullying. This literature review was conducted using published works combining the terms cyberbullying, bullying, emotions, stress and coping.

2 Cyberbullying Definition

"Cyberbullying" or "Internet harassment" is defined by the Canadian Center for Occupational Health and Safety (CCOHS) as "the use of the Internet to harass, threaten, or maliciously embarrass" [15]. Researchers and government regulators disagree on how to define and characterize cyberbullying. Willard suggested the term, "Digital Aggression" [16]. The National Conference of State Legislatures (NCSL) differentiate cyber harassment from cyberbullying based on the cyberbullied individual's age [17] as cited in [18, 19]. Cyberstalking is an alternative term used to describe "the repeated pursuit of an individual using electronic or Internet-capable devices" [20]. Patchin and Hiduja [21] defined it as "willful and repeated harm inflicted through the medium of electronic text." Even though the definition of cyberbullying seems similar to that of traditional bullying, the cyberbully's actions are more severe because of his or her unlimited access to the target and larger audience [16, 22–25]. Despite this difference, most of the literature uses the term cyberbullying [26].

Little is known about the negative effects of cyberbullying as compared to traditional bullying in the workplace. According to a study by Gardner and colleagues [27], 2.8% of the population reported being cyberbullied during the last six-month period. They also indicated that most of the cyberbullied employees were in managerial positions. In their study, both cyberbullying and workplace bullying negatively impacted the target's emotional responses, which in turn reflected poorly on their work performance and susceptibility to stress.

Cyberbullying is considered a part of so-called 'social vulnerability' [28, 29]. Social vulnerability is defined as "the disadvantage faced by somebody while s/he endeavors to survive as a productive member of the society" [28]. Both cyberbullying and bullying are described as "aggressive conducts whose objective is to harm another person, which most certainly refers to violent social behavior" [30]. As cited in [31], there are four forms of cyberbullying attacks: social, relational, physical and psychological [32]. Bullying can be classified as direct, "face-to-face" contact, and as indirect attacks where the "bullied target is not present" [25].

Cyberbullying may leave the targeted individual with lower self-esteem, depression, sadness, loneliness, suicidal thoughts [5] or social dysfunction [16]. Cyberbullying could create feelings of worry, terror, fear, depression, shame, exclusion and nervousness under the weight of never-ending threats [18]. Attacks can take the form of playing a joke on someone; teasing the target; making mean, rude, threatening or aggressive remarks; or spreading hurtful rumors and lies [24].

Whether bullying is a form of aggression or not has been the subject of much debate [33]. Berger [25] indicated that "not all aggression is bullying, but bullying is always aggression, presented as hurtful and hostile behavior." Cyberbullying was classified as "indirect or relational aggression" due to its damage to the target's social relationships [24].

Because of the anonymity available in the cyber-world, a cyberbullying target can be "introvert, extrovert, popular, famous, physically strong or weak" [34, 35]. Cyberbullying is considered a crime that leads to the target's fear, stress or anxiety. It is also a repetitive action that instills fear in the target based on not knowing when the cyberbully might appear again [18].

3 Types of Cyberbullying

Eight types of cyberbullying were identified by Willard [5], including (1) exclusion: when a group of subjects blocks or isolates an individual from his or her social group or chat room; (2) harassment: sending verbally rude and offensive messages to someone continuously; (3) flaming: offensive arguments posted online between two or more aggressive users; (4) cyberstalking: sending threatening messages or repeatedly spying or following a person so as to make him or her feel unsafe; (5) denigration: posting online rumors to hurt an individual's reputation; (6) impersonation: creating a fake profile online to make the targeted individual appear as someone else for destroying his or her dignity or putting him or her at risk; (7) outing: sharing personal or confidential information online without disclosed permission; and (8) trickery: deceiving someone into revealing confidential or embarrassing information for sharing it online [36]. Willard [5] indicated that the "Harassment" type produces incidents similar to those that occur in direct bullying.

4 Theoretical Perspectives

Social Information Processing states that "Computer-Mediated Communication (CMC) users can use the virtual medium to develop social interactions similar to face-to-face interactions" [37]. This suggests that the nonverbal cues of face-to-face contact have an alternative form (e.g., time) in the CMC. This section discusses the theoretical background relevant to cyberbullying regarding emotional and stress responses.

4.1 Emotional Responses

Although joy, sadness, happiness, and anger are just some of the emotions intuitively recognized by people, the definition of emotion until recently was subject to debate. Kleinginna and Kleinginna [38] gathered and classified ninety-two proposed definitions of emotion and found little consensus in the literature. Despite the disagreement over the definition, researchers did agree on two aspects of emotion: (1) Emotion is a natural reaction to an event related to the goals, needs and concerns of an individual; and (2) emotion involves affective, behavioral, physiological and cognitive components [39].

Many theories of emotion have attempted to describe the sequence of responses to a given stimulus. For example, the James-Lang theory held that emotions were caused by physiological arousal triggered by the emotional stimulus [40]. The Cannon-Bard theory [41] stated: "Emotional stimulus simultaneously triggers physiological response and the experience of emotions" [40].

Emotion theories have been divided into two categories to properly classify and distinguish emotions. Discrete emotion theories suggested the use of basic main emotion from which all secondary emotions can be derived [42]. Other theories classify emotions on a dimensional basis. For example, Watson and Tellegan [43] created the positive affect-negative affect model (PANA). PANA separates negative and positive affect into two different systems, where the vertical axis represents positive affect, and the horizontal axis represents negative affect.

Even though the acronym PANA might suggest measuring emotions as opposite affective state (e.g., positive affect should possess a strong negative correlation with negative affect), they are two different dimensions. Positive affect depicts the degree to which an individual feels active, enthusiastic and alert. A high level of positive affect indicates enjoyable engagement. Negative affect, in contrast, is correlated with subjective distress and unpleasant engagement, both of which reflect aversive states, such as anger, guilt, nervousness or disgust. The lower level of negative affect produces a state of serenity and calmness [44, 45].

The measurement of emotional responses is a function of both positive and negative affect dimensions. Thus, during cyberbullying or negative social interactions, we would expect a lower level of positive affect and a higher level of negative affect [46, 47].

Cyberbullying produces negative emotional impacts [2], that vary based on the cyberbullying type that the target experiences and his or her reactions to it [48].

Many psychometric instruments have been constructed to assess emotions. One of the instruments that have been validated and cited in more than 21,900 published works is the Positive and Negative Affect Schedule (PANAS). Built on a PANA model, this is an instrument designed to measure the two aspects of emotions (negative and positive) [45].

4.2 Cyberbullying and Stress

According to the Conservation of Resources (COR) theory [49], a person experiences stress when threatened with losing something that he or she values most, such as social interaction [50]. Under this theory, a person maintains multiple resources, including objects, personal characteristics, social supports, conditions, and energies [51, 52]. Cyberbullying can lead to stress because it threatens basic human needs, such as the need to belong [53]. On the other hand, the transactional model of stress theory provides that an individual's appraisal of a stressful event is supported by how they cope with that event [54]. Thus, cyberbullying events have been shown to create stress for some people [55], and the transactional model of stress theory has been used in much of the cyberbullying research [56].

Repetitive stressors over time can induce emotional distress and, in turn, lead to decreased performance levels [50]. On the other hand, social support can attenuate the negative impact of stressful events [57, 58]. Stress is perceived as a source of diminished performance [59]. Therefore, cyberbullying induces immediate emotional responses (affects) and stressful responses (cognitive). Repetitive events of cyberbullying can cause not only immediate emotional responses but also persistent ones. Cyberbullying thus can have both chronic (long-term, longer lasting) and acute (short-term) effects. Chronic stressors are those lasting longer and deviating from the short-term characteristics of an acute stressor [60]. The Dundee Stress State Questionnaire (DSSQ) developed by [61] has been widely used in task-related experimental designs requiring assessment of the level of stress attributable to manipulated tasks. [62] linked stress state factors from the DSSQ to the Lazarus [54] Transactional Model of stress. This theory characterized stress as the result of appraisal and all perspectives that support this view [63]. DSSQ assesses three forms of stressors: Task engagement, distress, and worry.

4.3 Coping with Cyberbullying

Coping is defined as the behavioral and cognitive capabilities an individual deploys to tolerate and control stressful events [54]. According to the Lazarus transactional theory, two types of cognitive appraisals—judgment and evaluation—are associated with coping demands. Both types reportedly provide valid predictors of coping [64, 65].

Sources of stressors and their related coping strategies vary significantly among individual human characteristics and differences [66]. People who employ problem-focused coping tend to be less affected by stressful events than those who use emotion-focused coping [67]. In the context of cyberbullying, the problem-solving strategy is far better than reacting to avoid or deny the problem [56]. Emotion-focused coping toward cyberbullying has been found highly associated with health complaints [68]. Female teenagers who tended to use avoidance strategies were observed to possess lower self-esteem [69].

An appraisal is the self-perception of an attack and the evaluation of how to use available resources to face a threat [70]. This can take many forms, including threats to self, threats of harm and threats of loss [65]. In general, the selected coping strategy is based on individualistic differences and the personal capability to appraise each threat differently.

5 Cyberbullying Factors

What makes cyberbullying different from bullying, in general, is publicity and anonymity: The potential of reaching a large audience and doing so anonymously [22, 71].

5.1 Publicity

Publicity has been described as the number of audiences communicating in social media either privately (one-on-one) or publicly (many-to-many). Cyberbullying publicity can be either private (e.g., email) or public (e.g., Twitter or a public website) [71]. Publicity has been reported as a factor of cyberbullying [72]. Prior studies found that public cyberbullying to be more stressful than private [71, 73]. However, a different experimental study concluded that publicity was not a relevant factor in cyberbullying [74].

Subjective measures indicated that cyberbullying was more destructive in a public forum than in private [23]. This result was consistent with [22, 75] in proving that publicity ranked higher than the medium it uses (e.g., traditional bullying vs. cyberbullying). This study offers further evidence of the important role that publicity plays in cyberbullying [76]. According to a self-report study conducted by Vasquez and colleagues [77], verbal harassment triggers more emotional impact in public than in private. This was attributed to the "larger emotional processing" triggered in public, which in turn increases brain activity [76].

A key aspect of private cyberbullying is the so-called "silent treatment"—a "relational aggression" from a personal partner [78, 79]. This is viewed as a form of social exclusion, where the target is being ignored and rejected (e.g., sending repeated text messages to another and not receiving any in return) [80]. Out of 2,000 Americans surveyed, 75% reported having experienced "silent treatment" from their partners [81]. This finding reflects the private angle inherent in social exclusion.

5.2 Anonymity

Anonymity as a factor of cyberbullying has received the least amount of attention in cyberbullying research [71]. Qualitative studies have shown that anonymity induces a higher level of distress if the individual who was cyberbullied suspected or perceived that the attack came from people around him or her, including friends or schoolmates [82]. Anonymity can be less severe if perceived as misaddressed or sent randomly as a hoax [71, 83]. Being cyberbullied by someone known was found more distressing than if the source had been unknown [84].

6 Conclusion

The advancement of socio-technological devices such as smartphones has granted virtually unlimited and certainly easier access to the delivery of hateful and aggressive communications. This form of bullying is classified as an extreme aggression attack, which compels extensive and multidisciplinary study. The indications thus far are that "as the number of people participating online increases, the severity of cyberbullying increases" [75]. Therefore, in efforts to provide a prevention mechanism, interactive applications may help to identify and label cyberbullying incidents via textual-based analysis [85].

The definition of cyberbullying remains in dispute. The transactional model of stress theory has been used in many cyberbullying studies to assess the coping process. Cyberbullying is a broad area of research that covers not only verbal harassment but also many other types, such as social exclusion. The subject literature still lacks consensus on how people appraise being cyberbullied [70]. Researchers offer differing perspectives on the severity of publicity as a distinctive factor in cyberbullying.

Cyberbullying adversely affects human well-being. It is therefore essential that thorough studies be performed using multidisciplinary approaches to combat this phenomenon and thus help to create safer and healthier socio-technical systems. In this regard, multiple research methods should not be limited to self-reporting aspects, but instead should combine the association between subjective and objective measures as well. Future research should explore how people momentarily cope or deal with cyberbullying events and how can cyberbullying incidents be predicted.

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Wellness for All: Novel Design Scenarios and Concepts of Products-Systems for an Inclusive User Experience in Indoor Physical Activity

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Abstract. Today's aging phenomena is bringing about important changes in the make-up of our population with consequential need for assistance and cures, thus substantially increasing the costs sustained by society. The policies of the European Community aim to maintain general health and to promote life styles capable of sustaining a level of self sufficiency and at the same time an "intelligent" process of aging, where one remains active and healthy for as long as possibile. The education to physical activity and to sports is a very important objective, which require the development of a conscious attitude of citizens towards their own health. With emphasis on the ergonomics of design and on methods of innovation, Human Centered Design designates likely scenarios in the near future and proposes possibile solutions which concentrate on needs and expectations, allowing one to maintain an active life, through wellness and prevention. This paper presents the results of the "Smart Running" workshop, promoted by the Laboratory of Ergonomics and Design (LED) of the University of Florence in collaboration with Technogym, a leading-edge company that develops fitness equipment for any physical activity. The projects represent innovative solutions for indoor running, particularly intent on involving an increasing number of participants.

Keywords: Social inclusion · Human centered design · Wellness Treadmill · Smart running

1 Introduction

The phenomenon of population ageing is shaping the demographic trend of developed countries by the growth of the population aged over 65.

In order to face this phenomenon, the European Commission has developed the Horizon 2020 program, which heads towards the health protection of young and old citizens and to promote lifestyles able to preserve over time the individuals' autonomy. It encourages a smart, healthy, active, sustainable and inclusive ageing for as long as

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possible. WHO identifies Activate ageing as a “global demographic revolution” that demands international, national, regional and local action [1].

A population composed of more and more old citizens requires an increase of treatments and care and, at the same time, it entails a rise of social cost.

This new social model aims to promote and improve the independence of ageing people as a growth factor and social value.

In contemporary society, the containment of public spending for healthcare and for services addressed to the non-self-sufficient aged people and their family have a significant impact on public expenditure.

Physical activity is a key tool for the healthy ageing, as well as the improvement and maintenance of quality of life and human’s independence. In order to reduce the likelihood of age-related disability, physical activity plays an important role in creating and sustaining the well-being at all ages [2].

The diffusion of everyday physical activity and sport education since a young age are important goals, that require the development of a conscious attitude and a growth of citizens’ responsibility towards their health.

The benefits of physical activity can be enjoyed in old age also. Improving flexibility, balance and muscle tone may help to prevent falls, one of the main cause of disability among old people. At the same time motor activity may counteract most of the typical risk factors of the ageing process, such as cardiovascular disease, arthritis, osteoporosis and hypertension. Disabled people should be provided with enough opportunities and support to perform sport and physical activities adapted to their physical conditions. They should have the possibility to improve their muscular strength, their psychological well-being and to perform everyday activities [2].

Design, intended as a strategic factor of innovation, is able to create new possibilities and scenarios for human-beings and it can offers a contribution in creating innovative products and services that encourage people to manage a healthy and physically active life.

Usability, extended to a wider audience, and design are capable of creating inclusive solutions to be handled by users with physical, sensory and cognitive limitations.

The Ergonomics in design, the Human-centred Design methodologies and the smart technologies, through wellness and prevention, allow to identify possible future scenarios and solutions focusing on human needs as a personal commitment and social responsibility.

The research focuses on the concept of wellness, defined as “a multidimensional state that describes the existence of an individual’s positive health as exemplified by the quality of life and the sense of well-being” [3], proposes virtuous behaviors in motor activities, in nutrition and in the maintenance of our own emotional state.

The concept of wellness focuses on the personal well-being and suggests regular physical activity, regeneration practices and mental training together with healthy food and a positive mental approach which favor a state of well-being and psychophysical balance.

The first phase of this research has been finalized to collect data and information about demographic change, people’s lifestyle, humanity’s diversity, the motivations which lead people to practice physical activity and pleasures and sorrows linked to it.

The second phase of the research has been finalized to define design-oriented scenarios and products-services able to look into the opportunities offered by design and innovation. Furthermore, it has been focused on the to evaluation of how new solutions can encourage and assist people, including the infrequent user, towards an active, dynamic and sporting life, as a means to increase the user's wellbeing and health, from the prevention point of view also.

The Design research was aimed to use the "project" as a field of research and experimentation in order to create new sport inclusive scenarios addressed to global sport users for the achievement of a healthy and active life. This experimentation has been achieved using the design tools and its original and specific characteristic: the project [4].

The design way, developed by Ergonomics and Design Laboratory (LED) of Florence University with Technogym S.p.A., concluded with a design workshop. The design workshop involved some young designers and its goals were the creation of innovative concepts about "*smart running*". Parts of the results obtained are presented in this article.

1.1 Physical Activity and Wellness for Contemporary User

The human was born to move and physical activity is one of the main functions of the human-being.

The practice of physical activity reduces risks of cardiovascular disease, hypertension, diabetes and some types of cancer. It plays an important role in the management of certain chronic conditions. Physical activity also produces positive effects for the mental health, reducing stress, anxiety, depression and even perhaps delaying the effects of Alzheimer's disease and other forms of dementia [5]. Although the benefits of physical activities are already known, the global trend is the reduction of physical everyday activity [6].

Systemic and environmental factors, busy life, laziness and lack of time promote a sedentary lifestyle as opposed to a healthy lifestyle.

Recent EU data indicate that among people over 15 years old, 6 out of 10 rarely do physical activity, and over a half practices rarely or never practices any kind of physical activity, such as cycling, dancing or gardening [7].

Physical inactivity is one of the major risk factor for our health. In Europe the inactivity causes 1 million death each year (about 10% of the total amount). The cost of disability is estimated to 8.3 million per year. WHO estimates 55 of coronary disease, 7% of type 2 diabetic, 9% of breast cancers and 10% of colon cancer due to physical inactivity [8].

In EU the percentage of overweight and obese people increased in the last decades. Figures are worrying: in 46 countries over a half of adults are overweight or obese (about 87% of EU) and in other European countries about 70% of adults are overweight or obese. In Southern Europe many children and teenagers are overweight or obese. It is demonstrated that physical inactivity contributes to energy imbalance that is the basis of weight gain. At a global level, physical inactivity has a negative impact on health system, on the increase of sick leave, work inability and early deaths [9].

From an analysis conducted by Eurobarometer (2014) on sport and physical activity, Italy is the second worst in Europe for the percentage of people who regularly practice physical activity (3%), followed by Bulgaria (2%). Ireland is ranked first with 16%. The results show that Northern European citizens regularly practice physical activity [10].

It is necessary to strengthen the sport culture as a fundamental factor for a healthy life. Reducing physical inactivity levels would produce substantial benefits for the health of the population. It has been estimated life expectancy would increase of 0,63 age by putting an end to physical inactivity [8]. This means that every single citizen would benefits and also the environment, social participation and interpersonal relationships would improve.

1.2 Inclusive Design Approach for the Sport Innovation

The British Standard Institution (BSI) defines the Inclusive Design approach as: "The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible […] Without the need for special adaptation or specialised design" [11].

This approach focuses on population's diversity and variability and on the impact that these aspects have during the design process, considering them as a strategic resource for the sustainable development of contemporary society.

Inclusive design approach allows to create innovative and "socially usable" products, it contributes to the improvement of the corporate image, to the expansion of the market and to create a greater customer loyalty without compromising company profits and the customer's satisfaction.

Technogym S.p.A, global company leader of sport instruments sector, with Ergonomics & Design Laboratory (LED) conducted a design workshop with young designers, with the aim to define new inclusive sport scenarios for indoor.

2 Wellness for All: "Smart Running" Workshop

The aim of the "Smart Running" workshop, organized by LED in collaboration with Technogym S.p.A, was to define new scenarios and products-services system to improve the running outdoor experience with a focus on infrequent users (e.g. old people, disabled people etc.).

With reference to demographic change of Western countries and its emerging needs, the workshop's targets were focused on the usability and the user experience evaluation of existing products. After such evaluation, a new vision of indoor running was proposed, with particular emphasis on the involvement of an increasing number of users. Particular attention has been paid on three users categories:

- Adults;
- Disabled people, with particular attention to blind and visually impaired people;

- Old people, with particular attention to two categories. Over 65 in good health and over 65 in slight critical conditions (from a physical, psychological and sensorial point of view) [12].

3 Methodology

The methodology was planned to identify the accessibility requirements and the strategic factors useful to improve the actually levels of inclusiveness of the traditional treadmills. Through to the application of Focus groups [13], the Personas and the Task Analysis (TA), the following aspects were investigated:

- The motivations that encourage people to practice physical activity and reducing sedentary behavior;
- The strategies that motivate people to conduct a healthy and active life;
- The role of physical activity, as a prevention factor for a healthy life, as a means of social cohesion and occasion to share emotions, experiences, information, and capable of increasing social relationships;
- Demographic change trends;
- New users and their needs and expectations, with particular attention to infrequent users;
- New technologies applied to the sport sector.

The methodology approach began with a definition of needs - by using Personas, Task analysis, preliminary user capabilities simulation - and it was followed by a

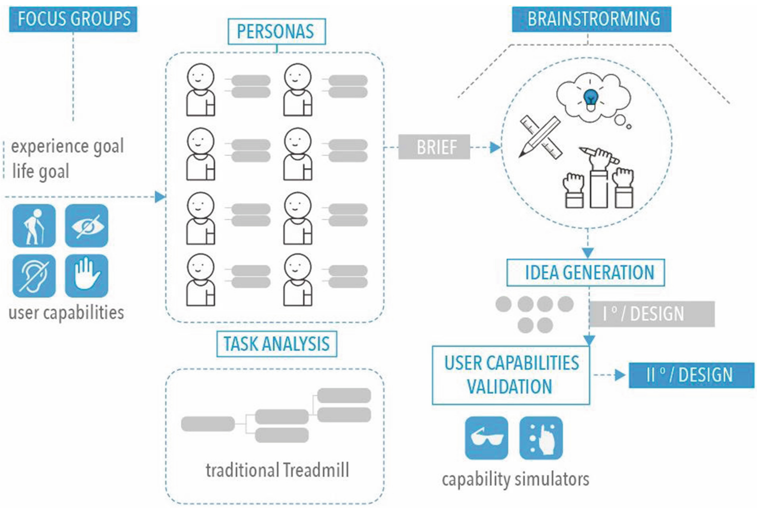

Fig. 1. Methodology for action

brainstorming design phase (Fig. 1). The solutions developed were validated through a phase of user capability simulators. Lastly, it was possible to implement and to identify new design ideas.

3.1 Personas and Task Analysis

The Personas methods provides a qualitative representation of users' behavior and bring users to life by giving them names, personalities and lifestyles. They identify the motivations, expectations, goals, capability, skills and attitudes of users, which are responsible for driving their product purchasing and usage behavior [14, 15]. For each profile the following aspects were identified:

- *Experience goals:* physical activity at home (autonomy vs collaboration), perception of risks, comfort and adaptability, training flexibility;
- *Life goals:* health monitoring, active lifestyle (which affects and determines a sedentary lifestyle), environmental factors, social factors. 8 new user profiles were developed, 4 men and 4 women aged between 50 and 80 years old;
- *Specific experience goals, life goals and definite levels of user capabilities:* Cognitive factors (as low vision, hearing loss, reduced tactile sensitivity) and mobility factors (balance, lower and upper limbs mobility) were associated to each profile.

This phase allowed to identify the following aspects:

1. Motivation aspects. To be able to decide the intensity level in a natural way, without the need of interacting with a user interface;
2. Reduction of the complexity of the human-interface interaction mode;
3. Transformability and reduction of the volume/weight of the treadmill;
4. Possibility to use the system in an alternative way (e.g. monitoring activity and increase blood circulation, stretching, holistic activities and rehabilitation);
5. Integration of voice commands and sensory communication codes for the management and control of physical activity.

The results emerged were further analyzed during the development of the task analysis [16]. The TA was conducted to analyze tasks and goals previously identified and to define new requirements of concepts. It allowed to define what follows: manual and voice commands, handling and transformation of the system.

3.2 Brainstorming

The human skills identified through personas and TA were discussed during the brainstorming. Brainstorming method allowed to define a design brief.

During this phase, the experience and the life goals were discussed and simulated through the use of dark lenses and gloves, so that specific conditions of use could be simulated.

4 Results

The design experimentations developed during the workshop propose a new vision aimed to facilitate the user's interaction with the machine, making the indoor running experience more comfortable and satisfying, even for more extended users.

This is the case of *Natfeet* project (Fig. 2), a treadmill designed for walking indoor.

The idea was to recreate the barefoot walk experience, "bringing" the human into nature, with all the benefits that implies. Stimulating blood circulation, eliminating stress and depression, improving posture are just a few of physiological and psychological benefits offered by the product. Lastly, the user interface (UI) includes the stimulation of the senses of sight and smell, thanks to a system of components for the chromotherapy and aromatherapy integrated into the machine.

MentoRunning (Fig. 3) is another project developed during this workshop. Treadmill and bluetooth headsets compose the machine. These items have been designed to give the possibility to exercise to people with visual impairments (such as blind and visually impaired people).

On the one hand, the sensors placed in the structure allow to supervise the user and his/her performance, to record the necessary data and to collect and compare them. On the other hand, the sensors placed on the handles and vocal commands, permit to record the user's activity and to guide he/she towards the right race setting to keep through sound feedback. To make the product more accessible, the front display has been eliminated. The commands are placed on the handles.

Hybrid project (Fig. 4) is a treadmill for both indoor and outdoor use. It has been designed to be wrapped and moved everywhere. This peculiarity allows to consider two users categories: outdoor life lovers and users who prefer a private life.

Hybrid has a conveyor belt on which users can run. It offers a range of different levels of intensity and different running surfaces, necessary for various types of physical activity. It includes the wireless bracelet, able to recognize the heart rate and data training, and plantar detector to wear whenever the user begins his/her physical activity.

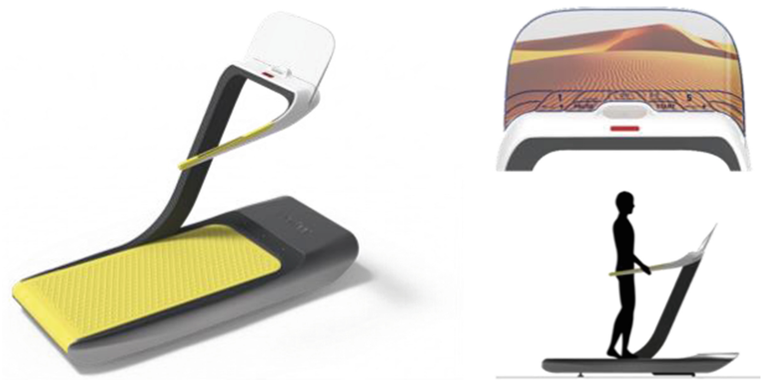

Fig. 2. Natfeet. Design by E. Gravante, M. Piramide, Y. Sperduto.

Fig. 3. MentoRunning. Design by S. Favero, L. Marianera, E. Pizzoni.

Fig. 4. Hybrid. Design by S. Corsi, G. Leone, G.T. Patti

5 Conclusion

Nowadays it is extremely important to educate and to encourage people to practice physical activity regularly. This is an important goal and it requires the development of a conscious attitude and a growing responsibility by the citizens towards their health, with positive effects on the society.

Many human needs are emerging, and they concern aspects like usability, as extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction [17], and human-machine interaction. These aspects need to be handled by the Human-centred approach.

Sport seems to be a "breeding ground" to try the theoretical foundations of Inclusive Design. Also the methods of Ergonomics in Design offer many opportunities for intervention, that allow to define new use scenarios and new services-products.

This is the case of the results showed in this paper. Each project deals with the collective participation of users and it can be considered as an opportunity for growth and sustainable development in contemporary society, namely to exercise for a healthy and active life.

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Evaluating a Proposed Design for All (DfA) Manual for Architecture

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Abstract. This paper outlines the evaluation of a print-based Design for All (DfA) manual. The purpose was to understand if and how a DfA manual can be used as a tool to inspire students (future architects) in designing an inclusive project to transform theory into practice. The DfA manual has been used and tested during a workshop that took place at the UDweek 2016 in Hasselt, Belgium. Our results show that the manual was favorably received, particularly in the areas of the manual's visual presentation. Conversely, short guidelines, as mean to transfer knowledge, was perceived as too prescriptive. Furthermore, more information to generate insights on users' needs are required and the static format of the manual can't satisfy the different ways students prefer to access information. The research provides interesting criteria on how to create a more relevant and useable DfA manual; however, further studies are required to elaborate upon these.

Keywords: Built environment · Inclusive design · Design criteria Student workshop · User needs

1 Introduction

Design for All (DfA) is defined in the Stockholm Declaration by The European Institute for Design and Disability (EIDD)[1] as "design for human diversity, social inclusion and equality" [1]. Additionally, the DfA approach represents a "creative and ethical challenge for all planners, designers, entrepreneurs, administrators and political leaders" [1]. However, while theoretical studies in the field of DfA are growing, a solution including insights and ways of linking knowledge and practice is yet to be found [2]. Universal Design (UD) Principles [3], for instance, are proposed as a tool for designers; however, the principles are still very open to interpretation, which is a serious barrier to use [4]. In this regard, evidence-based approaches and especially knowledge-translation activities are fundamental in bringing research into practice by

[1] In 2006, European Institute for Design and Disability (EIDD) changed its name to Design for All Europe.

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increasing DfA adoption around the world [5]. Investigating the way to translate this knowledge into practice in an actual project becomes imperative also through support tools for designers. This research is part of a wider study with the goal of developing a tool towards inspiring and supporting architects to apply a more concrete DfA strategy. In particular, this paper describes the application and evaluation of a manual (see appendix for sample page) that was used in a workshop with students in order to gain useful information about the knowledge translation of DfA concepts in practice. In this way, the workshop set the stage to test and evaluate a DfA manual's performance by putting it to work during the workshop and making it an integral support for the students to enhance accessibility and usability into their proposed designs.

Different studies demonstrate that Evidence Based Design (EBD) can produce further research and its applications are scientifically taken into account, indeed it supports designers in their architectural and technological choices for creating design knowledge [6]. Thus, it is estimated that by testing the DfA manual with potential users (future architects) that a more accurate view on its usefulness would be revealed.

This study represents an opportunity to understand if tools, specifically a print-based manual that was developed by using four criteria, are actually effective in transferring knowledge of DfA strategy. As Steinfeld confirms: "Research and knowledge translation are critical for developing international standards and establishing best practices." [5]. Thus, the main purpose of this research are RQ1: How can we assess the features used to transfer knowledge in a specially designed print-based DfA manual; RQ2: How can we evaluate the proposed DfA manual with an aim towards developing a future DfA manual projects.

2 Methodology

This section establishes the methodology used towards our study. This methodology involves the creation of a print-based DfA manual with four significant design criteria. Further to this, this section provides information on how we evaluated the manual within an intensive student workshop that occurred across four days during the Universal Design Week 2016 [7] in the city of Hasselt, Belgium, from October 10th to 13th at Hasselt University. The focus of the workshop was on the design of St. Katarina Square, within the city of Hasselt. The aim of the workshop was to make the square accessible and inclusive for all persons. Two professors, one from Belgium and one from Canada, and the EIDD DfA Ambassador[2] along with various city of Hasselt officials led 21 students. The student group included 15 pursuing a Master's of Architecture (Hasselt University) and 6 in Master of Healthcare (PXL College). The students had earlier divided into four groups in order to propose four different design proposals.

[2] The three curators of the workshop were Pete Kercher ambassador at EIDD - Design for All Europe; Jasmien Herssesn architect and professor at the Faculty of Architecture and Arts of Hasselt University; and Megan Strickfaden designer, anthropologist and associate professor at the University of Alberta.

2.1 Proposed DfA Manual

A print-based manual was developed as a support for DfA approach with the objective to allow designers to apply its concepts in design practice. Its content focuses in particular on “haptic design”, which investigates the perception of the built environment through the body, in relation to the sense of touch [8, 9]. The manual is devised to establish a descriptive transfer of knowledge [10] in order to look beyond the prescriptive approach of accessibility legislation and the reductive design adapted for disabled users. In order to develop the manual, we carried out a literature review to know the characteristics of existing tools and methodologies that are aimed towards transferring DfA knowledge to designers. The analysis of literature and previous manuals resulted in being able to define common items of knowledge transfer in the DfA strategy and were used as references in proposing four criteria for transferring design guidelines, on which the manual have been developed.

HOW communicate/representation method: DfA information needs to be transferred by using graphics and indirect methods, as well as by referring to case studies, which will jointly enable its understanding. This graphic methods would cater to establishing greater empathy for the users’ needs [11]. Information should be provided to designers preferably through representational materials that do not require direct user involvement [12]. In general the tool should provide information in fast and smart way.

WHERE organize/built environment: the information provided in the manual needs to be contextualized with a focus on the built environment, in order to provide a reference confident for architect [10]. Thus, information should be organized based on different architectural elements that encompass outdoor and indoor spaces. For instance, in the manual each chapter is associated to one element of the built environment.

WHY understand/users’ needs: the design guidelines that are within the manual need to be the result of significant research that comes directly from a variety of user needs and wishes. Information about users’ needs should be the first information to provide, in order to introduce the reader at the reasons for design guidelines [14].

WHAT use/descriptive information: the information within the manual need to give designers a clear understanding on how to transfer knowledge in a descriptive way [10]. Guidelines are meant as short tips for designers and each of them is associated to an illustration. The descriptive information should directly refer to case studies and legislation that designers need to be aware of throughout their designs.

In particular, in the manual sample[3] used in this research the four criteria have been applied as follows (Fig. 1). HOW: illustrations, pictures of case studies and symbols are used to better understand the meaning of the information provided. WHERE: each chapter represents an architectural element that can be applied easily. Four architectural elements of the outdoor space are considered: parking, paths, green areas, and access (to public building). WHY: for each architectural element the design guidelines are

[3] Appendix.

divided according to the three affordances[4] of users, in terms of haptic design, developed by J. Herssens: move, guide, rest [8, 9] In the manual we refer to them as goals that can be reached by following design guidelines. WHAT: Design guidelines constitute the wider part of information of manual's content. Each design guideline is related to a specific haptic parameter[5] [8, 9] that characterizes its scope, for instance a guideline can belong to the parameter "Elasticity", which is expressed in terms of hardness: hard, flexible, rigid, pliable, soft [8]. While references to legislation are placed at the beginning of the chapter together with the users' needs, the chapter ends with references of case studies related to design guidelines.

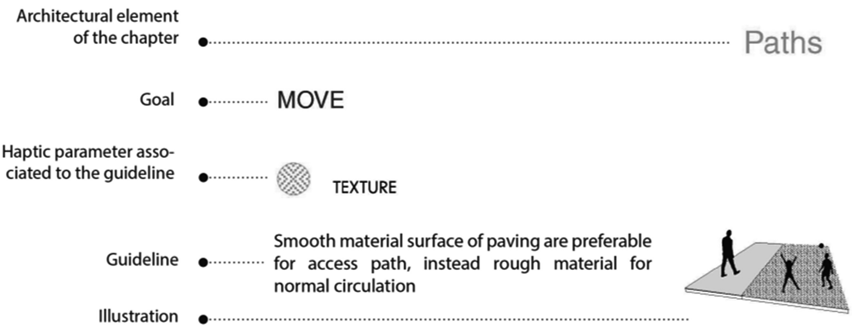


Fig. 1. Example of information's organization in the manual and function of each element specified on the left.

2.2 The Assessment of the Manual

All students who took place in the Universal Design Week workshop in Hasselt were participants and thus involved in the evaluation of our DfA manual. The manual was evaluated from two different perspectives including: (1) a design perspective (architecture students); and (2) a caregivers or healthcare perspective (physio-therapy students). The students worked in teams to collaboratively develop a conceptual project that would ultimately inform the design of St. Katarina Square. In this way, the design process of finding new design ideas were simulated within the workshop, providing the opportunity to evaluate DfA manual's content and performance during the design phase. Although the students did not rely only on the DfA manual towards their solutions, it was hoped that the manual would be used as an integral support to enhance accessibility and usability into their proposed designs.

4 According to Herssens [9] planes can afford certain actions in the built environment and there are three kinds of affordances regarding haptic experience in the built environment: moving, guiding, resting.

5 Haptic design parameters have been developed by J. Herssens to form the Framework of Haptic Design Parameters [8, 9]. Through the framework information are elaborated from the perception of people born blind to give design solutions useful for all architects.

The manual's evaluation was conducted following different steps and related methods of investigation. At the beginning, a PowerPoint presentation about DfA and haptic design was given in order to allow the students to understand the focus of the design guidelines contained in the manual. Then, observation was used in order to evaluate the students' use of the tool during designing, by allowing the researchers to experience the participants' needs and reactions [6]. Multiple-choice questions were submitted during the workshop to discover the participants' first impression of the manual. Finally, follow-up questions were sent by email to the students after they had completed the workshop, in order to know in detail their opinion of the use of the manual during the design project.

The content of the multiple choice questions included themes of disability and accessibility to know the knowledge of the students about these topics for their previous experiences (Q1, 2); contents of the manual (Q3), and layout (Q4). The multiple choice questions were analyzed by placing responses into an Excel spread sheet associated to the respondents.

The email interview questions were sent to all students with 19 replying. The content of these questions included: understanding what students found "simple" or "complex" in the manual (Q1); the use of the manual (Q2, 3); and to understand if students preferred guidelines organized in relation to architectural elements or to users' goals (Q4). Indeed, the manual was developed on purpose with two chapters organized on the first and two on the latter features. The responses to the email interview were as follows:

Q1: "simple": illustrations (by 9 students) symbols (by 5 students), "complex": layout organization (by 2 students), symbols associated to the goals (by 2 students), text (by 4 students).

Q2: most of the students (10) consulted the manual in detail, while 5 did a general and fast consultation and 4 didn't used it, due to the lack of time during the design process.

Q3: some students asked to introduce also references about specific dimension and materials and more information about users' needs.

Q4: surprisingly, this question helps to demonstrate that there isn't one option better than the other one indeed the number of different answers were almost equal. This means it is based on subjective preference and it depends on the way architects think and work[6].

[6] For instance, a student that prefers architectural elements organization asserts: "In this way you can search to something more specific (for example, when you need some more information about a ramp or a stair) while you are designing". While, a student that prefer users' needs wrote: "it is more clear to me because they describe every haptic parameter by the action of the user instead of per architectural elements that might be less clear to people without an architectural background".

3 Findings

As described by the research questions, the main aim of this research is evaluating the DfA manual towards improving and developing a future manual. Thus, this section will focuses on the assessment of the features used to transfer knowledge in the print-based DfA manual used in the workshop. To begin, the application of the manual during the workshop allowed the discovery of important considerations to be taken into account. Figure 2 illustrates the strengths and weaknesses of the DfA manual. Further elaborations on these strengths and weaknesses are presented in relation to the four criteria used to develop the manual.

CRITERIA	MANUAL'S STRENGTHS	MANUAL'S WEAKNESSES
HOW	Illustrations, pictures and symbols capture the attention and help in text comprehension	Problems with the layout's organization of pictures, symbols, and text. Information can't be updated.
WHERE	Topics divided into architectural elements	Fixed and strict structure to choose information
WHY	Design guidelines divided by goals (move, guide, rest) create more insights	More information about the users' needs are required
WHAT	Associate parameters to the guidelines facilitate their comprehension	Design guidelines are still prescriptive and not detailed enough regarding technical information

Fig. 2. Manual's strengths and weakness in relation to the four criteria.

3.1 Strengths

The aim of the tool is to provide a plurality of information to architects in order to enable them to understand design indications related to DfA and to use them as support for the development of their given project. From each of the four criteria we obtained the following positive results:

- **HOW - communicate**: representations in the form of illustrations, pictures and symbols guarantee a visually direct relation with the text that allows quicker comprehension. Above all other features in the manual, the illustration were appreciated most by the students.
- **WHERE - organize**: the division of the topics into architectural elements (parking, paths, green areas, access) were affirmed as aiding the search for information regarding a specific architectural element.

- **WHY - understand**: the division of the design guidelines in relation to the goals of move, guide, and rest [9] are appreciated for ease of comprehension. All the students, including those without a an architectural background, can understand the meaning of the design indications, because each parameter is described in relation to the users' action.
- **WHAT - use**: the manual is used to acquire information on haptic design and the DfA approach, which represents a new way to design for students. Design guidelines were considered useful to be inspired on designing inclusive projects.

3.2 Weaknesses

The application of the manual during the workshop reveals that the design students interpret it prescriptively due to some of its characteristics. There are different reasons for this:

- **HOW - communicate**: pictures should be placed next to the design indications. Symbols of the parameters should be used separately from other symbols so as not to create confusion. A lack of time to complete a project/design is considered the most recurrent barrier limiting the use of the manual[7], so it is necessary to provide information through a more flexible tool that leaves room for interpretation but focuses on information that is highly useable. The manual also needs to be easily updatable.
- **WHERE - organize**: it was discovered that the participants of the workshop have different needs regarding the way they consulted the manual, for instance some of them prefer looking for the goals move, guide, and rest; while others prefer the architectural elements. However, in a print format, the manual reads as a book that implies a beginning, middle and end with a specific order. This means the manual's structure is still too linear and static.
- **WHY - understand**: more inspiring information about the needs of users is required in order to create more insights.
- **WHAT - use**: the design guidelines are still perceived as prescriptive and insufficiently detailed. There is a lack of detdlxailed information regarding measurements and materials.

From these findings, we can assume that the structure presented in the manual to transfer knowledge through the four criteria (e.g. organizing the information divided by architectural elements of the built environment or presenting design guidelines according to the users' goals is useful and they reflect some of the architect's needs. The problem is the inadequacy of tool's which cannot be flexible and able to transfer

[7] Some students pointed out that the short duration of the workshop did not allow them to accurately read all the design guidelines. Indeed, only the students really interested consulted the manual in detail, instead the tool should be easy to use in order to allow everyone to use it.

descriptive knowledge. Indeed, the request for more information cannot be satisfied with a manual, due to the difficulty in managing a wide quantity of information. At the same time, there is no possibility of updated information through a print-based manual. Furthermore, lack of time was another limitation, that is actually a recurrent condition in architecture's firms when designing and consulting external resources [11]. For this reason, only the students really interested at DfA topic consulted the manual in detail, conversely the tool should be easy to use in order to allow everyone to use it. According to Goodman et al. [13], in research that investigates the designers' needs, methods that transfers knowledge to designers should satisfy the following characteristics: "quick and easy to find and use, visual and stimulating, flexible and open-ended, and relate clearly and concretely to design issues" [13].

3.3 Design for All Knowledge Transfer Criteria

The four criteria of DfA knowledge transfer that the manual is developed can be updated according to the new knowledge learned from the manual application and evaluation. New characteristics are associated with the four criteria, based on the previous findings. They are described as follows and showed in the scheme (Fig. 3).

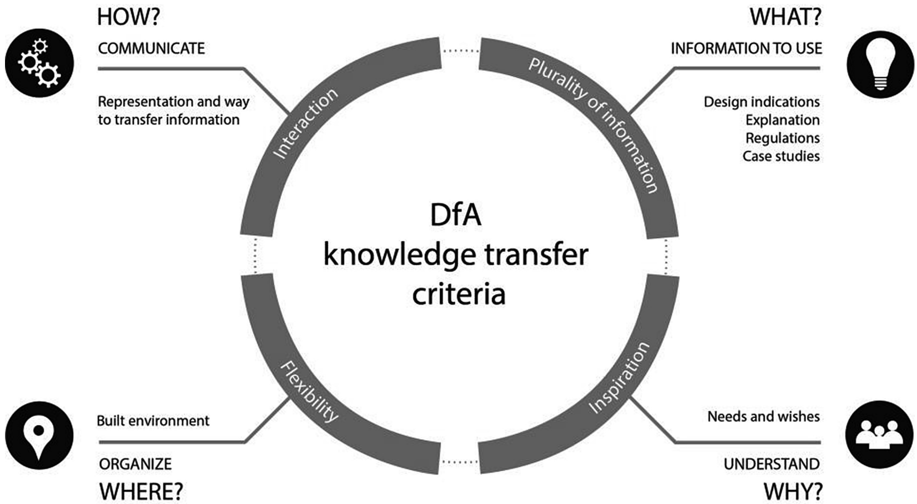


Fig. 3. Scheme of the DfA knowledge transfer criteria to develop tool to support designers into DfA application. Previous contents of the criteria are associated to the new features found.

HOW – interaction: the interaction between the contents of the tool and the users should be allowed through the possibility to update information, by a quick and easy format, and effective visual representation.

WHERE – flexibility: arrange information in relation to outside and inside public space, considering the different architectural elements in a flexible way. Users can choose information without a strict organization, but through different options (for instance a tool could provide two "filters" for choosing design guidelines, one related to architectural elements and another one on users' goals.

WHY – inspiration: creating empathy and inspiration based on users' goals and needs through detailed information both on the reasons design guidelines are provided and on specific user characteristics useful to take into account in particular circumstances.

WHAT – plurality of information: manage a plurality of information, such as design guidelines, information about users' needs, case studies, reference to legislation, and technical information on dimension and materials.

4 Conclusions

Having assessed the manual in the workshop, with the participation of its potential users, the research discovered strengths and weaknesses of the manual used to transfer DfA knowledge to designers and this allowed to better define the four criteria on which it was developed. It is important to note that this is just the beginning to assessing the tool created and that further testing is required to truly understand it's use.

On the one hand, from our limited study, this analysis demonstrates that the use of the four criteria to develop a manual that can transfer DfA knowledge can be considerate an appropriate mean to develop tools to support designers. However, to be more effective, some characteristics of the criteria need to be improved with new features, such as interaction, flexibility, inspiration and plurality of information.

On the other hand, the research reveals that a manual is not the proper tool to transfer knowledge because a book limits the amount of the information and way of accessing to lots of them easily. Furthermore, it complicates the way of organizing contents and updating. For this reason, one option for further research could be to shift to the usage of an interactive and web-based smart tool that may satisfy the new requirements of the discussed criteria, to inspire and sensitize architects in designing inclusive projects. That stated, it is important to conduct further research using the current tool with other groups of practicing architects or students to understand whether it was simply this group that seems to prefer a more interactive tool because they are digital natives with biases towards web-based information or whether this is the case for all groups who would use a DfA manual.

Appendix

Sample of one page of the manual focusing on guidelines. Chapter about Paths.

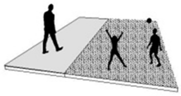
Paths

MOVE

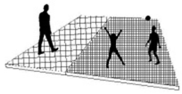
Material

TEXTURE

Smooth material surface of paving are preferable for access path, instead for normal circulation rough material.



Large formats of paving are preferable for access path, instead for normal circulation smaller formats.



ELASTICITY

Contrast between surfaces with a different elasticity (ex. grass and stones slab) is useful to circulate in a fixed direction. (Fig. 5)

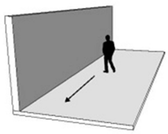
An handrail next to a path can also provide different haptic eperiences for the qualities of its material.

GUIDE

Geometry

ORIENTATION

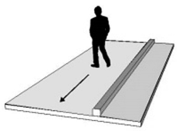
The wall of a building of one side of the path helps in the orientation to go straight. The wall should be free from obstacles. (Fig. 4)



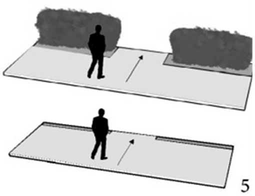
Too much signals to indicate parking or cycle path on the street floor can confuse instead of orientate. Different texture and materials can used as a different option. (Fig. 1, 4)

CONFIGURATION

A kerb on one side of the path, which divides it from the grass, helps also to go straight.



Elements like hedges or tactile lines placed at one side of the path helps to go straight and at the same time, when they stop is clear that there is a change in direction or a cross. (Fig. 2, 6)



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Design for Enabling Technologies. A Framework to Empower Multi-level User Engagement

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Abstract. The Internet of Things, smart devices, connected health and ICT have the potential to enable people, carers and families to improve the quality of health and social wellbeing. One factor that can help people with physical or cognitive impairments to learn new skills and to be connected with the world, concerns accessible interaction with media devices, such as radios, TVs, tablets and smartphones. According to input received from stakeholders of Irish-based communities of people with different abilities, one of the main barriers for users relates to a reduced level of accessibility when controlling media devices. The aim of this work is to improve users' autonomy by providing tools that enhance users' abilities with media device functionalities through the use of configurable prototypes of media assistive controllers. The output of the work is a proof of concept version of a methodology that matches user ability profiles to configurations of the corresponding functionalities of media assistive devices according to the Universal Design approach. This framework enables people with different abilities to independently engage with a media controller, through a multi-level interaction approach. It also facilitates users who become proficient at using a device at one level to improve their capabilities to a more complex level, requiring additional users' interaction. Finally, it provides an example of how the ICF can be leveraged to suggest accessibility configuration parameters for devices of this type.

Keywords: Internet of things · Ambient assisted living · Inclusive design
Smart remote control · Human-device interactions · Learning device
Assistive technologies · ICF · Human factors

1 Introduction

According to the latest data from the 2015 Ageing Report, life expectancy has been increasing in most developed countries worldwide for a considerable time period [1]. While much is known about changes that can be measured in tightly controlled laboratory tasks and environments, less is known about the implications of these changes for everyday tasks and activities, under natural conditions [2]. Not only ageing users

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who experience impairments, but also a wide range of younger people who have a range of physical/cognitive impairments may experience difficulties related to daily activities or difficult health conditions. Functionally impaired citizens, will for various reasons, be unable to complete what others might consider to be simple everyday tasks, such as eating, bathing, dressing, toileting, and moving. All of these activities are collectively called “Activities of Daily Living” (ADL) [3]. When people are unable to perform these actions, they need help in order to cope, either from other human beings or mechanical and technological devices or both [4].

Opportunities for using mobile IoT-based technology to help these vulnerable citizens have improved in the last few years with a growing number of smartphone and tablet users, even among senior citizens [5]. Smart homes and responsive appliances address the promotion of independent living by using assistive technologies for higher quality of daily life, supporting a high degree of autonomy and dignity [6]. This research investigates the idea of a personalised functionality gap for smart media devices that can enable users with different abilities to move towards a more independent lifestyle. In order to profile users’ abilities, the researchers took as a reference the ICF (International Classification of Functioning, Disability and Health) provided by the World Health Organisation (WHO).

The research questions arise:

How can users’ abilities be classified, using the ICF tool, in order to match them with the functionalities of media assistive devices?

How is it possible to develop a framework that provides a multi-level interaction approach to enable more autonomous user engagement with media assistive controllers?

People with intellectual disabilities are often not seen as full citizens of society. Including them in the digital world can help to change this negative stereotype [7]. One factor that can help people with disabilities to learn new skills and interact with the world is related to the accessibility of media and entertainment devices, such as radios, TVs, tablets and smartphones. There are several and varying levels of disability that different users exhibit, from the lack of hand and arm movement, to aural or visual impairments, to the lack of literacy and mental functionality [8]. When a citizen faces both physical and intellectual impairments (for instance following a stroke), even simple tasks such as operating the controller for media devices such as a TV becomes a challenge. The prototype of the Adaptive Remote Control System (ARCS) has been designed as an easily configurable assistive IoT-based learning system that enables users to interact effectively with media devices. The Universal Design approach has been developed with the support of stakeholders of Irish-based communities of people with different abilities, in order to study and develop the prototype of the ARCS.

The ARCS has been used as a test case for developing the framework result that provides a means of representing multi-level user engagement to cater for the usability needs of users with a broad range of physical and cognitive abilities. This framework, is fundamental for developing an improved strategy for configurable and accessible user interface that presents different levels of interaction corresponding to the levels of a user’s abilities. This enabled the creation of an interpolated blueprint of different values, that could be further implemented into a tool to express the personalised functionality gap for users while they are using different smart devices.

2 State of Art: Activities of Daily Living and Cognitive Abilities

Every citizen has particular traits, skills or abilities and equally, may at any point experience severe to mild physical impairments and/or minor to severe cognitive disabilities [9]. Furthermore, such characteristics may be eased or accentuated, depending on the culture, the level of education and the context in which they live. Data from a recent analysis shows that intellectual disability affects about 2–3% of the general population and 75–90% of the affected people have mild intellectual disability [10]. It is not easy to define and measure different levels of ability, because they are related to many Activities of Daily Living, habits and subject-related culture and they involve interactions between the person, environment, objects and devices. It is important to define methodologies that can guide treatment interventions and management strategies for predicting outcomes and prognosis [8]. Understanding user needs and solving the issues related to user satisfaction requires the use of different assessment tools and different design approaches. One of the most commonly used assessment instruments for summarizing the physical and cognitive abilities of different users is the International Classification of Functioning (ICF) that is produced by the World Health Organization (WHO).

2.1 A Tool for Measuring Activities and Abilities: The ICF

According to the instruments provided by the WHO, the Disability Assessment Schedule, which refers to the comprehensive set of ICF items, is a sufficiently reliable and sensitive standardized method for measuring health and disability across different cultures [8]. The overall aim of the ICF classification is “to provide a scientific basis for understanding and studying health and health-related states, outcomes and determinants…” [11]. ICF uses an alphanumeric system in which the letters “b”, “s”, “d”, “e” and are followed by a numeric code that starts with the chapter number, followed by the second level, third and fourth levels [11]. The ICF assessment tool is developed in two different parts: part one is related to Functioning and Disability and the second part concerns Contextual Factors, which comprise Environmental Factors and Personal Factors. Part one that is related to Body Functions and deals with the physiological functions of Body Systems (including psychological functions) and Body Structures that are anatomical parts of the body such as organs, limbs and their components. Activities are the execution of a task or action by an individual and Participation is involvement in a life situation [11]. Part two on Contextual Factors, represents the complete background to an individual’s life and living [11]. They include two components: Environmental Factors and Personal Factors. The Environmental Factors make up the physical, social and “attitudinal” environment in which people live and conduct their lives. Through the logical ICF classification, the rehabilitation process has to be understood as a system of intervention for the development of the individual in terms of physical, psychological, social, employment and educational characteristics [12].

2.2 Hierarchical Task Analysis: A Methodology for Employing ICF Tools in Activities of Daily Living

The ICF assessment tool can be used as a basis for generating a more precise and worldwide accepted terminology to describe design factors and personal attributes [13]. The ICF tool has been used, in this research, as an instrument for summarizing certain users' psychophysiological factors while performing a common ADL such as interacting with a TV, through the use of a configurable prototype of media assistive controller. Due to the quantity of domains and richness of classifications that ICF provides, it has been necessary to summarize and distil only abilities and actions that are usually required for interacting with media technologies. The process used for breaking down different tasks and domains of the ICF, into small sub-tasks, refers to the Hierarchical Task Analysis methodology. In its most basic form, the Hierarchical Task Analysis provides an understanding of the tasks that users need to perform in order to achieve certain goals [14].

Hierarchical Task Analysis has the potential to allow a comparison of different groups of abilities and activities to support a defined goal (for example controlling the TV using an IoT-based remote control) in terms of the numbers and types of steps the activity requires. By using the configurable prototype and collecting feedback, it has been possible to narrow the number of ICF Body Functions, Body Structures and Activities that feature in the task of controlling a TV. This "scoping" action represents a

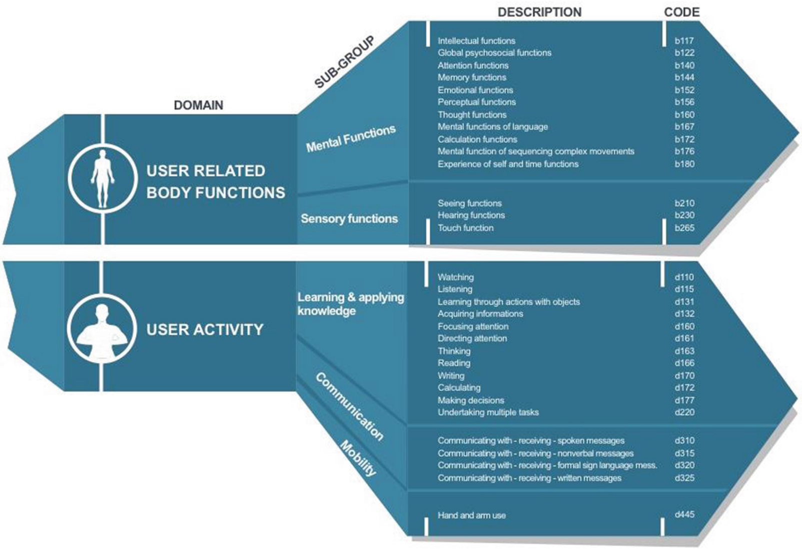

Fig. 1. Summary of ICS domains, related to the user action of watching the TV, by using a general media system.

useful step, in order to restrict the research field and to provide a hierarchy of tasks that users need to perform. The image in Fig. 1 shows how it has been possible to use the ICF domains for defining different sub-tasks or sub-groups for people with different abilities. This approach provided the opportunity of capturing multiple features that can be useful in developing a multi-level user engagement framework that facilitates users in interacting with media technologies.

3 Developing an IoT-Based Media Assistive Controller

One of the intended applications of the ICF is to provide a consistent and internationally agreed classification and terminology to represent design concepts [13]. Through the application of the Universal Design Approach [15], awareness is usually referred to a broad-spectrum of ideas meant to produce products and environments that are accessible by different groups of people. The term Universal Design was originated by the architect Ronald L. Mace to describe the concept of designing products and built environment in a usable and aesthetic way, to the greatest extent possible, by everyone, regardless of abilities, age or cultural context Mace et al. [16]. The report on Universal Design expounds the following principles [17]: Equitable use; Flexibility in use; Simple and intuitive; Perceptible information; Tolerance for error; Low physical effort; Size and space for approach and use. A prototype media assistive controller has been developed as a system incorporating the above mentioned principles, in order to embrace and satisfy the need for improved autonomy of a relatively diverse targeted user group. The extract of the ICF groups and domains and the UD approach, has been helpful to define different levels of actions that the chosen system would include in order to meet the needs of the widest group of users from the community. Depending on the level of abilities of the users, the system is designed to adapt accordingly and this results in a lower psycho-physical effort being required. The proposed scheme has domains from the specific ICF classification codes (b117, b152, etc.), associated with a scale that quantifies the level of impairment and the degree of accessibility and usability following the principles dictated by the Universal Design. Level zero refers to the absence of physical or mental problems that would restrict the use of an assistive media device, level one indicates mild usage problems, level two moderate, level three severe and level four profound issues in using an assistive media device [13]. The multi-level features developed for the ARCS derive from the needs of a sample group of user personas, based on the ICF classification, that display differing levels of interaction.

4 ARCS - Adaptive Remote Control System

When a person with physical and intellectual disabilities wishes to engage with technology, there are often many barriers to overcome including difficulty with learning how to use a new device, an inadequate level of flexibility provided for using the device and a low tolerance of error. But, as developed in this case study, an accessible, adaptive remote control system has the potential to empower people with different abilities and improve the execution of certain Activities of Daily Living [18] while also stimulating mental or physical effort that is appropriate and beneficial to the user from an OT (Occupational Therapist) perspective. This project provides an adaptive ARCS, developed as a configurable platform providing multiple levels of assistance for the user, which can be tailored individually for different end users. The system is designed to enable such users to cycle between a personalised set of preselected TV channels.

At system configuration, the caregiver selects, for each user,

– One of four levels of system access tailored to the user;
– The three channels in a channel listing that the user will initially have access to.

At runtime, the system is used by the user and engages with him/her at one of four levels, A1 to A4, each of which is outlined in the next section.

4.1 The Multi-level Learning System

ARCS allows for personalised use by providing multiple levels of user engagement corresponding to various combinations of user abilities as suggested by the ICF tool. The caregiver or an OT, using the ICF tool for guidance, preselects the most suitable level at which a user will access the system. In order to facilitate engagement with the system as a learning and enabling tool, the carer can change the level for a user as he/she becomes more proficient in his/her use of the system. The higher the level of access is, the more adaptive the system becomes. The system can accommodate users with a range of physical and cognitive abilities as outlined in Table 1 below.

A1 – The system reacts to a user's button press by cycling in a "round robin" fashion through each of channels in the user's personalised channel listing. It records for each user's viewing session how long that user views each of the channels. It uses this information to prioritise the ordering of the channels in the channel listing for that user such that at that user's next viewing session the channels will be in order of most to least watched channel based on the previous viewing. This level requires minimum interaction between the system and the user, simply requiring the user to press an

Table 1. The four levels of interaction for the ARCS.

Level	Physical ability required	Cognitive ability required
A1	Dexterity to press the interaction button	Minimum: system adapts the settings automatically based on user usage pattern
A2	Dexterity to press interaction button, hold interaction button to feel system feedback in the form of a vibration	Follow basic audio/visual instructions and be able to make a choice to enable a recommendation system
A3	Dexterity to press interaction button, hold interaction button to feel system feedback in the form of a vibration	Follow basic audio/visual instructions and be able to make a choice to enable a recommendation system and accept/reject the output of the recommendation system
A4	Dexterity to press interaction button, hold interaction button to feel system feedback in the form of a vibration, double click interaction button	Follow basic audio/visual instructions and be able to make a choice to enable a recommendation system, accept/reject the output of the recommendation system and delete a channel from the channel listing

assistive switch to cycle between 3 pre-set channels (e.g. Sports channel, News channel, Soap channel). The system is capable of recording user activity and adapts the settings in a non-invasive way thus customising it to enhance user experience and increase user engagement.

A2 – As in A1 the system prioritises the ordering of the channels in the main channel listing depending on user's context data. Before toggling from the first (most-viewed) channel to the next channel in the list, the system prompts the user both visually (for those who can read) and orally (for those who cannot read) to choose if they would like to view a channel with similar content to the current one (e.g. another news channel). The user is then required to press and hold the switch, or in this case a button, until a vibration is felt for "yes" or press and release the button as normal to skip this stage and move onto the next channel in the channel listing. If the user chooses "yes", the system will use an online recommendation service to find another channel with similar content to the current one and this will be added automatically into his/her channel listing. This information will be stored in the user's record and will be available each subsequent time the user uses the system. This level requires basic user interaction between the user and the system. In particular, the system requires the user to be able to read/listen to the prompting to engage/reject the recommendation service and be able to make a decision about whether to use it or not. In addition, the user must have the physical dexterity to use a long and a short button press.

A3 – In this level, before the content suggested by the recommendation service is added to the channel listing, the user is asked to agree (by pressing and holding the button until a vibration is felt) or not (by pressing and releasing the button) to the recommendation. In addition to the characteristics in common with those found at level A2 this level prompts the user to make a decision at two points in the system use and the system responds by giving the user a more customised level of control.

A4 –This level augments the functionality available at A3 by allowing the user to delete any of the channels in the listing by double clicking when that channel is selected. In order to ensure that the user has not inadvertently double clicked on a channel, by referencing to the principles of Universal Design concerning errors tolerance, the system will prompt the user with visual and audio prompts to confirm their intention before the action is completed. In addition, it will not be possible to delete a channel if it is the only one remaining in the channel listing. This level is characterised by providing the user with maximum control of the channel listings. In addition to the skills required at the other levels it also requires that the user is able to double click and understand the implication of deleting a channel from the listing.

4.2 Design Details of Adaptive Remote Control

The system can be adapted to different user profiles. The user cycles between his/her preferred TV channels by pressing an accessible interaction button that is part of the media interactive controller. A database is used to store the user system settings as well as to record for each user's viewing sessions which channel the user watched and for how long. From A2 level up the system forms a recommendation based system, where channels are suggested to the user based on records of the user's preferences and viewing patterns. To be capable of performing the tasks intended with a defined group of user's abilities, the system is designed to:

– Store each user's context data (e.g. the user preferences and channel viewing pattern) according to the General Data Protection Regulation;
– Connect with an online TV scheduling service to determine what program was viewed by the user in an anonymised way;
– Use a TV recommendation service to search for and make suggestions based on matching a user's historical viewing records with the schedule of upcoming TV programs.

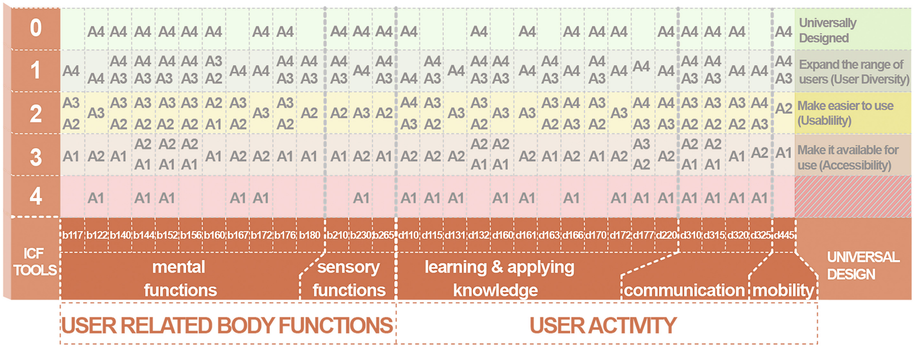

Fig. 2. Blueprint of ICF domains, linked to the levels of the ARCS and Universal Design principles.

5 Conclusion

This research project conducted a first feasibility study on how an Adaptive Remote Control System can improve users' autonomy. This has been possible by using a set of information provided by the overlap of specific ICF information with the principles of the Universal Design.

In particular, the use of the ARCS prototype, allowed the creation of a proof of concept of a methodology that employs the ICF to match users' abilities for matching users' abilities with configurable smart media assistants that can be fostered in the future design of new adaptable devices.

The prototype requirement consists of developing a general architecture following the Universal Design approach to enable people with intellectual and physical disabilities to have access to controls for media devices. As shown in Fig. 2, it has been possible to match the ICF classification domains with the ARCS levels using the Universal Design approach, in order to develop a blueprint of the possible combination of functions for a smart remote control.

The first user interaction study has shown that when a person with intellectual disabilities engages with our adaptive technology there is an improvement in their engagement and autonomy when interacting with a TV media device. The design of the system that followed the framework, matching ICF and UD principles, allowed for an accessible design of a low technology solution. This type of framework and associated technology that adapts to user needs can have a big impact in broadening the access to the information society for everyone in the future development of media assistive devices.

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Anthropometric Data Collection of Portuguese Overweight and Obese Children Using a Kinect Body Image System: Preliminary Results

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Abstract. This paper presents some preliminary results of an anthropometric research, part of an undergoing Ph.D. study at the Department of Textile Engineering of the University of Minho, Portugal. Data was collected using a 3D body scanning technology - Kinect Body Imaging (KBI), and carried out in public and private schools, of the first cycle of basic education, located in the cities of Braga, Guimarães, and Vila Nova de Famalicão, in the north of Portugal. Preliminary results are presented aiming the development of adequate measurement tables for overweight and obese children, respecting their anthropometric and ergonomic needs. Final considerations regarding the challenges of conducting anthropometric studies are presented.

Keywords: Data collection · Anthropometric studies
Children with overweight and obesity

1 Introduction

In Portugal, as in other countries, children's clothing manufacturers are not prepared to offer products to overweight and obese children [1]. In addition, it is important to highlight that measurement tables used by companies for designing children's clothing are based on the average population. Further, such tables are often outdated, not following the body changes in the last three decades, which have increased considerably [2]. Although there is a need for adequate clothing for overweight and obese children, few studies are focused on that [1]. A limited offer of appropriate clothes leads this population to wear clothing for other age groups and body shapes.

Scaling the pattern blocks and measurements tables is not a proper solution to face the problems of fitting and comfort [3, 4]. Anthropometric studies should be carried out [2, 5–7], in order to collect measurements of body proportions and body shapes [5, 7],

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to design clothing according to ergonomic needs and psychological aspects of such children.

The objective of this research is to propose a methodology for designing appropriate clothing for overweight and obese children. Therefore, it starts with the development of measurement tables adequate to such population. To reach that, an anthropometric study with children from 2 to 12 years old, was conducted. Such study was supported by a 3D body scanning technology.

2 Methodology

The Ph.D. research is organized into 5 main stages (Fig. 1): literature review, data collection, data treatment and analysis, prototype development, and thesis writing.

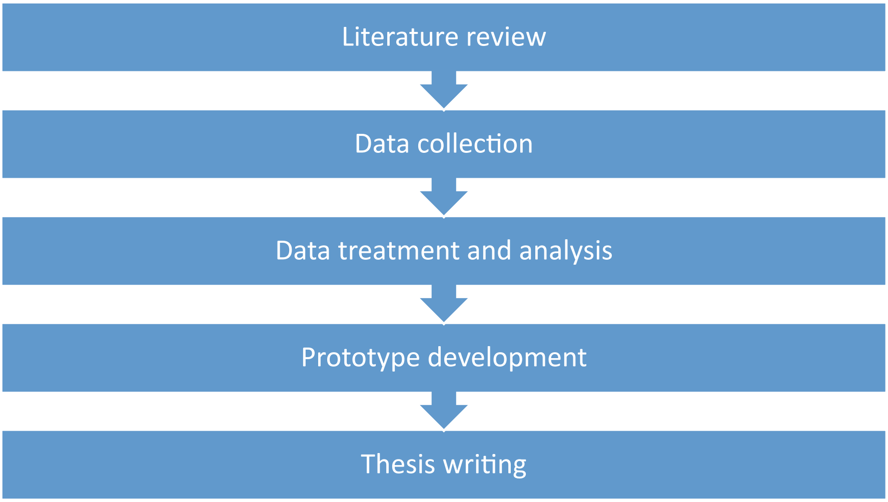

Fig. 1. Ph.D. research stages.

Thus, this paper is focused on the 2nd and 3rd stages (Data collection and Data treatment and analysis) as following described.

2.1 Anthropometric Data Collection

The anthropometric data collection lasted 6 months, starting in June 2016 and ending in November 2016. It involved 816 children between 2 to 12 years old (434 boys and 381 girls). It is important to note that not all of these children belong to the target population of the study, which is further described.

Gaining Data Access and Sample Selection. Three cities located in the north of Portugal were selected for the study: Braga, Guimarães, and Vila Nova de Famalicão. About 25 schools (both public and private schools) were invited, and 10 schools accepted to take part in the study (1 private school located in Braga, 1 private school located in Guimarães, 5 public schools located in Guimarães, and 3 public schools located in Vila Nova de Famalicão). After school approval, a Parental Consent Form was sent to parents, in order to obtain their authorization to proceed the study with the respective children. Even with the parental consent, each child was asked whether they wanted to participate in the study. In the same sense, all children who had parental consent and accepted to participate were measured regardless of whether they were in the study target population or not. Considering their well-being and aiming to avoid abuse by peers, children were not informed about the focus of the study on overweight and obesity.

Equipment. Data was collected using a 3D body scanning technology named Kinect Body Imaging (KBI), available at the Textile Engineering Department at University of Minho. Such system was developed by researchers from the University of Texas at Austin and University of North Texas in Danton (USA), in order to respond to measurements needs of the apparel industry. The KBI system is comprised of a hardware and a software for image capture and visualization. Its scanning system makes use of Kinect sensor technology and is formed by four Kinect devices. The combination of the four devices allows an acquiring area of 4 m depth with an angular field of view of 30° to the right and to the left. The devices capture the image in three dimensions as are able to identify automatically body landmarks, providing the most important measurements to the software for data analysis and body image visualization on a computer screen. The KBI system provides automatically 110 body measurements and body image is captured within a 1/4 s time frame. A booth is necessary to assemble the devices and ensure a correct system calibration. For performing data collection, the equipment was assembled in each one of the schools that participate in the study, or in a library, auditorium, or in a classroom.

Data Collection Protocol. Two researchers were involved in data collection, and a protocol was adopted to ensure confidentiality and privacy for participants. Each researcher was in charge of some specific activities: while one was responsible for operating the KBI, other was responsible for manual measuring (height, weight and head circumference). In order to avoid system errors, a marking was created for the correct feet position. Children were invited to enter the booth and stand in the orthostatic position: hands closed and facing backward, arms and legs further away from the body. Due to the fact that children may have difficulty in stay standing in the same position, the collection of the 3D images was repeated five times as suggested by Bragança et al. [8]. The time required to perform data collection for each child was about 10 min, including the time required for child undressing, perform manual measuring, operate the KBI, and child dressing. To facilitate the collection of measures, children were measured in pairs: while one child was within the booth, other was being manually measured.

2.2 Anthropometric Data Treatment and Analysis

This stage comprised 6 phases. In each phase, specific treatments and analysis were performed, aiming to verify the data pertinence and quality. Also, different software was used, according to each phase goal. Figure 2 illustrates such phases. From the total of 816 children initially measured, only 205 comprised the final sample, as it is following described.

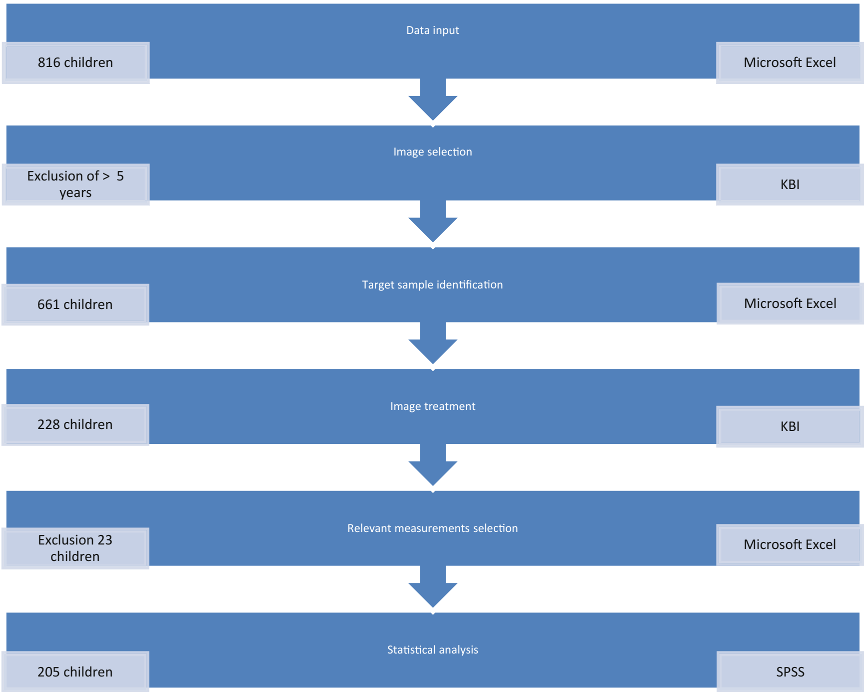

Fig. 2. Phases of the anthropometric data collection and analysis.

Phase 1 – Data Input. This phase started with tabulation in a Microsoft Excel spreadsheet of manual data collected for the 816 children that participated in data collection stage. The following variables (p) were considered: sample identification (represented by code), city, school type, sex, age, weight, height, and head circumference.

Phase 2 – Image Selection. In a subsequent phase, all 4.080 images (816 children x 5 images of each child) generated by the KBI were classified according to their quality level. Although the initial research goal was to analyze all the age range invited to participate in the study (from 2 to 12 years), the images obtained for the youngest children were poor. In order to guarantee the quality of the study results, the children from 2 to 4 years old were excluded from the initial sample. From the initial sample of 816 children, 155 were excluded, remaining, at this point, a sample of 661 children.

Phase 3 – Target Sample Identification. As mentioned before, all children from the 10 schools were invited to participate, and once they had their parental consent and wish to participate, were measured. In order to identify the study target population, the nutritional status of the 661 children in the sample was calculated, using the BMI – Body Mass Index as a reference. The percentiles curves and nutritional status classification was performed. Different classifications were considered: WHO – World Health Organization, IOTF – International Obesity Task Force, and CDC – US Centers for Disease Control. Children were classified in: Thinness, Normal, Overweight, and Obese, according to each international organization. Using the WHO criteria, 228 children were considered over the normal weight, as will be described in the results.

Phase 4 – Image Treatment. A datasheet containing measurements and images (back, front, and profile) was created for each overweight and obese child. After, the best image for each child was treated using the KBI software, to remove shades and adjust the guided lines. This image treatment is important to ensure that measurements provided by the KBI system are correct. After, each datasheet was saved in a .txt file, to be exported to the data analysis software. At this phase, data of 23 children were excluded from the sample, because the .txt file was not generated. After image treatment, a final sample of 205 children with overweight and obesity (Fig. 3).

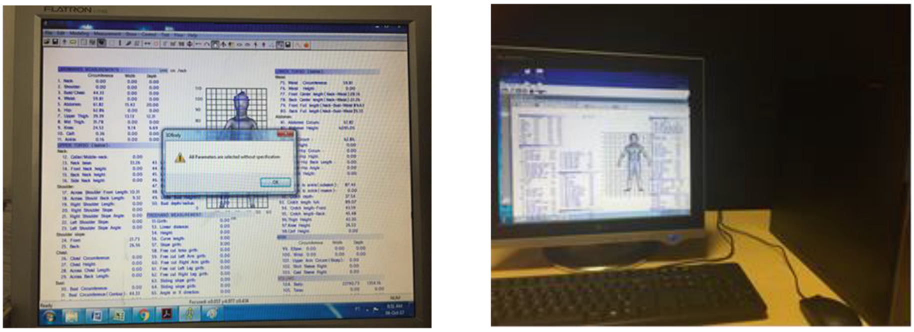

Fig. 3. Image treatment using the KBI system.

Phase 5 – Relevant Measurements Selection. After image treatment phase, measurements provided by the KBI software from the 205 children in the final sample were exported to a *Microsoft Excel* worksheet. From the 110 measurements provided by the KBI, 25 were selected. These 25 measurements are the most relevant to children's clothing design: 13 circumference measurements (neck, bust, waist, abdomen, hips, upper thigh, thigh, knee, calf, ankle, biceps, elbow, wrist) and 12 length and height measurements (arm, shoulder width, shoulder depth, bust, waist, abdomen, hips, thigh, knee, calf, front neck to left bust, front full length). In this worksheet, the head circumference (manually collected) was also included. Later, data were exported to the SPSS 21 (Statistical Package for the Social Sciences) for performing the statistical analysis.

Phase 6 – Statistical Analysis. The data collected was analyzed in the SPSS 21 software, using basic statistics, mean and standard deviation to evaluate the anthropometric characteristics of the girls and boys in the target population. Differences among age, gender, and school type were verified. In all analysis, the level of significance considered was 5%.

3 Results and Discussion

3.1 Sample Characterization

The initial sample of 816 children was characterized as shown in Table 1. Girls represent 46,7% of the initial sample, while boys represent 53,3%. The age ranged from 2 to 12 years old, and the average age was 7,2 years (2,7%). Weight varied from 10,2 kg to 72,8 kg, and height from to 69 cm to 175 cm.

Table 1. Sample characterization of 816 children.

		Total (816)
		n (%)
Gender	Girls	381 (46,7)
	Boys	434 (53,3)
Age range		2–12
Average Age		7,2 (2,7)
Weight range (kg)		10,2–72,8
Average Weight (kg)		28,6 (10,7)
Height range (cm)		69–175
Average Height (kg)		126,4 (18,2)
School	Private	422 (51,7)
	Public	394 (48,3)
City	Braga	126 (15,4)
	Guimarães	560 (68,6)
	Vila Nova de Famalicão	130 (15,9)

Considering school types, 51,7% of the sample was from private schools, and 48,3% from public schools. The city of Guimarães (6 schools) corresponded to 68,6% of the sample.

3.2 Overweight and Obese Rate

The classification of nutritional status followed the criteria proposed by the WHO: thinness, normal, overweight and obese. The gender differences were considered, as it is further described.

Table 2. BMI classification (WHO).

	Thinness	Normal	Overweight	Obese	Total
n	7	426	102	126	661
%	1,07%	64,44%	15,43%	19,06%	100,0%

The final BMI percentage for the sample of 661 children is shown in Table 2. 4 children were classified as Thinness, while 426 as Normal. The total of overweight and obese children is 228:102 (15,43%) overweight and 126 (19,06%) obese.

3.3 Gender Difference

After excluding 23 children from the sample, because it was not possible to generate the .txt file, the final sample of overweight and obese children comprised 205 children.

When comparing the difference between genders in the final sample, it is possible to conclude that the number of overweight and obese children is higher for boys (n = 120) than girls (n = 85). Therefore, considering the two groups (overweight and obesity), boys represent 58.5% and girls 41.5%.

Table 3. BMI (WHO) according to gender.

		Gender		Total
		Boys	Girls	
Overweight	n	58	40	98
	% BMIPercWHO	59,2%	40,8%	100,0%
Obese	n	62	45	107
	% BMIPercWHO	57,9%	42,1%	100,0%
Total	n	120	85	205
	% BMIPercWHO	58,5%	41,5%	100,0%

Comparing only the overweight children, boys represent the majority (n = 58/59.2%) compared to the girls (n = 40/40.8%). Regarding obesity, the difference between the genders was slightly smaller, being 57.9% (n = 62) boys and 42.1% (n = 45) girls (Table 3).

It is important to highlight that this classification considered the differences between boys and girls, as proposed by the WHO. Figures 4 and 5 show the BMI percentiles curves for boys and girls, according to their age.

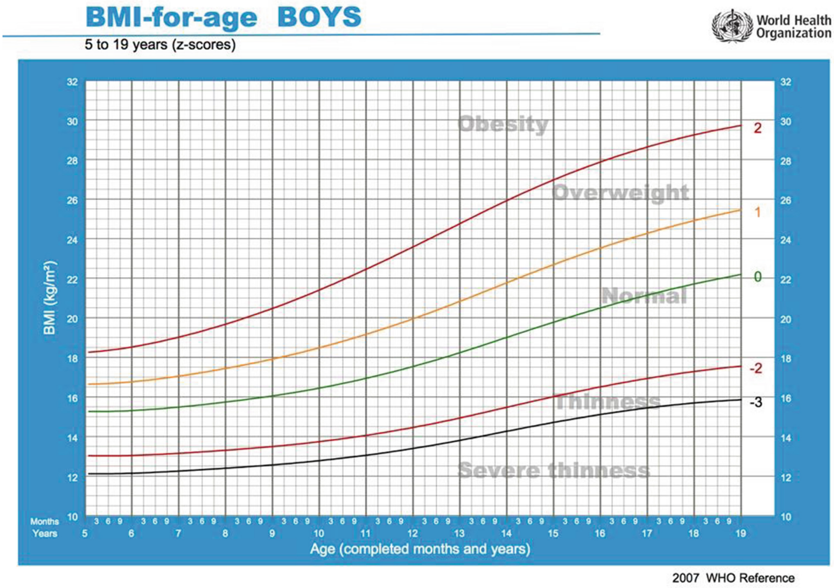

Fig. 4. BMI percentile curve for boys [9] (WHO, 2007).

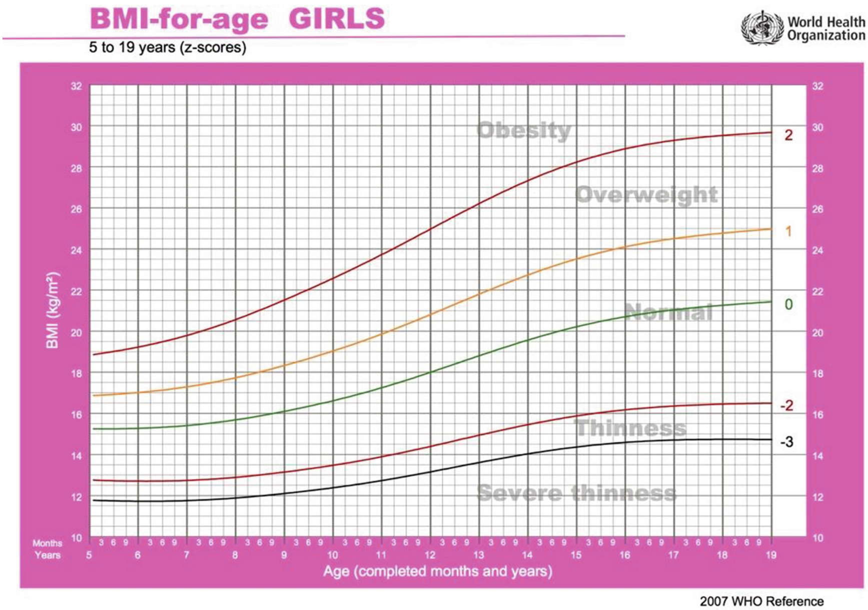

Fig. 5. BMI percentile curve for girls [9].

3.4 Age Difference

Regarding age, the 7 years old children was the most frequent among the overweight and obese (n = 36), followed by the ages of 6 years old (n = 35) and 8 years old (n = 34). This age range represents 51.2% of overweight and obese children. The least representative ages are those of 5 and 12 years (Fig. 6).

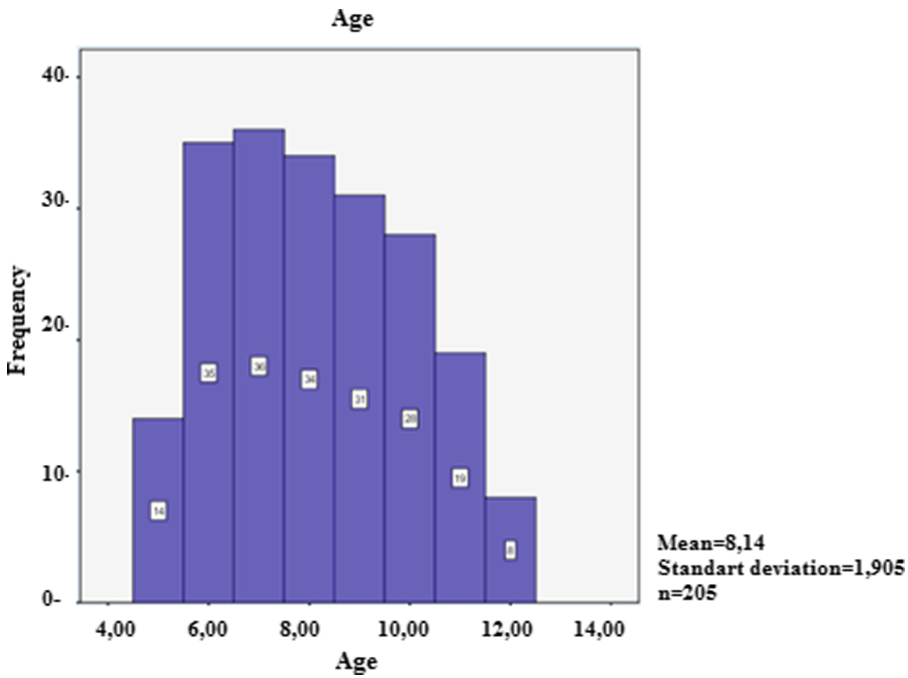

Fig. 6. Overweight and obese distribution according to age.

3.5 School Comparison

In the city of Braga, the study was conducted in a private school and represents 15.4% of the children. In Guimarães, the study was carried out in 6 schools, representing 68.6% of the children in the study. Vila Nova de Famalicão represents 15.9% of the children and the study was carried out in 3 schools.

Comparing results between the public and private schools, the overweight and obese rates were higher in public schools (65,37%) than in private schools (34,63%). However, the two types of schools do not have the same pattern between the overweight and obese: while in private schools the percentage of overweight is higher than the obese, in the public schools, the obese children were more prevalent than the overweight ones (Fig. 7).

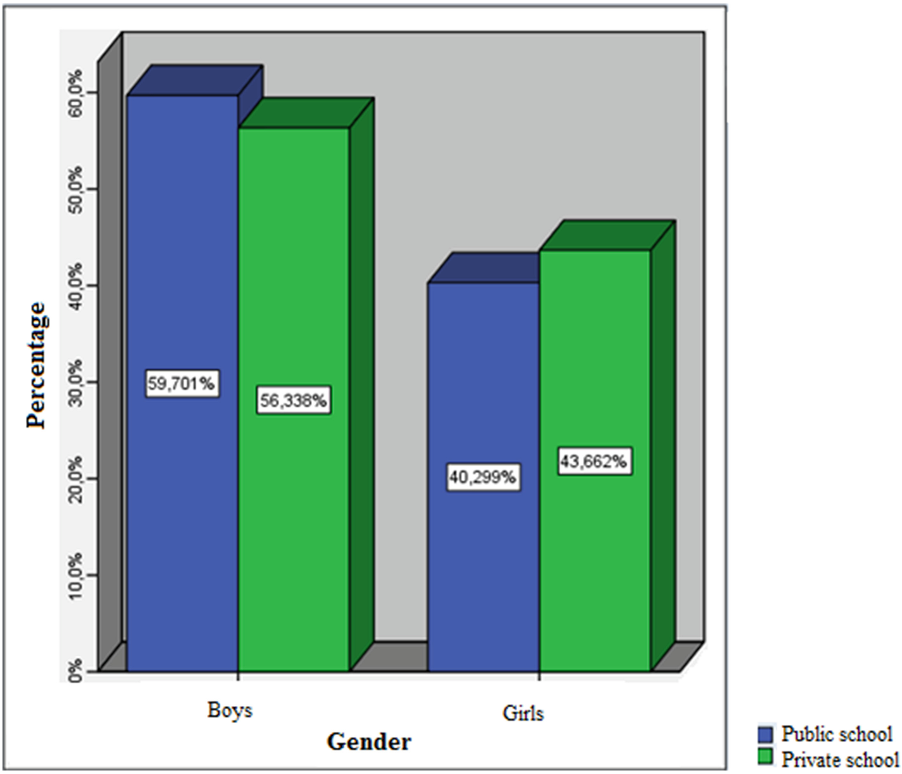

Fig. 7. Overweight and Obese children percentage according to school type.

4 Final Considerations

According to the WHO studies, childhood obesity has reached epidemic proportions. However, children's clothing manufacturers are not prepared to offer products to overweight and obese children. Although there is a need for designing adequate clothing for such children, few studies are being conducted. To develop appropriate table measurements to support such industries, anthropometric studies should be carried out.

This paper describes the methodology stages and the preliminary results of a Ph.D. research focused on the development of appropriate clothing for overweight and obese children. Both quantitative and qualitative analysis were performed. The presented preliminary results show the percentage of overweight and obese children from public and private schools located in 3 cities in the north of Portugal. Considerations regarding the age and gender differences are described, as a comparison between public and private schools.

Although 3D scanning system have been contributing to clothing industries, anthropometric studies are time-consuming, and adjustments for obtaining a valid and representative sample are needed. In this study, from an initial sample comprised of

816 children, only 205 were considered. During data collection, some children didn´t want to participate, especially the youngest ones, fearing the booth structure. Even not being informed about the study focus, some overweight and obese children refused to be measured, feeling ashamed. Also, the time allowed by schools to keep the equipment was reduced, hampering data collection.

During data treatment and analysis, the images from children from 2 to 4 were not considered by being poor, mainly because of the difficulty in keeping the children in the same position while being measured. Data from children that are not in the target group (overweight and obese) were excluded. Data from 23 children in the target group was excluded due to a software problem. However, such difficulties must be viewed as part of the learning process for conducting anthropometric studies. Such studies are of paramount relevance to the clothing industry, in order to support the design of appropriate clothing to specific populations.

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Assessment of How Inclusive Are Shopping Centers for Blind People

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Abstract. Due to the difficulties experienced by blind and weak-sighted people within shopping centers, these people often avoid to visit these spaces, being excluded from the same experience as sighted people. The aim of this study was to determine the current situation of Guadalajara's shopping centers and to address guidelines to enhance inclusivity for people with visual impairment in shopping centers. Nine subjects, with sight disabilities, took part in a semi-structured interview to register their previous experience visiting shopping centers. After that, each subject executed a Verbal Protocol Analysis while walking through a shopping center. Data were transcribed and thematically analyzed. The results from this study suggest that Guadalajara's shopping centers do not have an inclusive design for users with visual impairments. The participants of this study think their experience in shopping centers could be enhanced if, at least, people around them had an "inclusive culture" and offered them any help.

Keywords: Human factors · Inclusivity · Shopping centers
Visual impairment · Blindness

1 Introduction

"A visual impairment is a defect of sight where there is an eye disease, or damage to the eye, which influences the function of the eye. This can mean that a person is actually blind or partially sighted" [1]. According to the World's Health Organization, an estimated 253 million people in the world are visually impaired [2]. It is important to mention that, in Mexico, 467 thousand people are blind, being blindness the second cause of disability after mobility [3]. In Jalisco, a Mexican state, 18.3% of people with disability approximately are visually impaired [4].

Some consequences triggered by visual impairment are being more likely to be unemployed, to be involved in a motor vehicle collision, to suffer depression and anxiety disorders, and to fall while walking [2]. These consequences may increase or decrease depending on the visual acuity of the person.

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A person's visual acuity is measured by a comparison between the distance a person with normal sight sees an object and the distance needed for a person with visual impairment to see the same object. For example, a visual acuity of 6/18 means that objects seen at 18 m with normal sight will only be identified by a person with visual impairment if they see it at 6 m or closer.

Visual acuity is the factor used to divide visual impairment into three categories: low vision, blindness, and total blindness. Anyone with low vision, also called partially sighted, cannot correct his or her sight with treatment or spectacles. People with this kind of visual impairment have a visual acuity between 6/18 and 6/60. When their visual acuity is less than a 6/60 in their best eye is called blindness. The last category, total blindness, is the complete lack of sight in which no light or shadow is perceived [1].

Visual impairment represents challenges for the person who suffers it, such as the complexity to deal with an environment which is not adapted to their needs. The *International Classification of Functioning, Disability, and Health* (CIF by its Spanish acronym) considers that the not inclusive public places lead to consequences in which the person's activity, participation, and productivity could decrease [4]. Also, when an environment is not thought to be inclusive, the user's health, or even his or her life, could be in risk.

Nowadays, we may find a great variety of accessibility aids which help people with visual impairment to move from one place to another. Unfortunately, almost none of them is applied to Mexico's shopping centers. Some examples are podotactile rails and braille signs, which are the most popular. In the case of other Spanish speaking countries, we may find innovative aids like the Saki project in Bogota, and the Beepcon from Spain.

Saki was a multimedia module with a braille keyboard in which blind people had access to digital assistance. The module provided verbal instructions to arrive at the desired store [5]. On the other hand, the Beepcon provides sound information that allows blind people to know what is in their surroundings and guide them to their destiny. It has the place's map preloaded so it does not depend on Wi-Fi. The Beepcon was conceived to be used at hospitals, airports, museums and shopping centers [6].

However, the most commonly used in Guadalajara are podotactile rails and braille signs, which are mostly used at the subway station and some public roads. Unfortunately, they are rarely used in shopping centers, and their application could be enhanced in many ways. It is important to mention that the Article 58 of the Mexican Federal Law for Protection of the Consumer says:

> Suppliers are obliged to provide the facilities or have the indispensable devices so that people with disabilities can use the goods or services they offer. Such facilities and devices cannot be inferior to those determined by the legal provisions or applicable official norms, nor can the provider establish conditions or limitations that reduce the rights that legally correspond to the disabled as a consumer [7].

This law is not fully respected and most of the people have no knowledge about it.

The aim of this study was to determine the current situation of Guadalajara's shopping centers and to address guidelines to enhance inclusivity for blind and weak-sighted people in actual and future shopping centers, considering the perspective of people with visual impairment.

2 Method

2.1 Subjects

At first, shopping center management was invited to participate, but none of them showed interest. Therefore, it was decided to focus on the users, considering their experience would help to get more relevant information.

Nine volunteers between 22 and 49 years old participated in this study. The four women and five men were all blind or weak-sighted. In Table 1 is shown each subject's age, sex, the degree of visual impairment (DVI), the onset of visual impairment (OVI), the strategy they use and the frequency in which they visit a shopping center.

People with visual impairment make use of different strategies such as guide dogs, canes, or people who accompany and guide them (Fig. 1). When the person is accompanied it is easier to know about their surroundings. Whatever the strategy, solid orientation and mobility skills are required for a safe and effective travel. One of these mobility skills is memory, which becomes difficult for the subjects because they need to memorize the route as a whole, and once they start moving along the route, they have to remember where they are and where they need to go [8]. When one considers that shopping centers are not designed to a particular standard, then memorizing them could be difficult and cause memory overload.

Table 1. Subject's information.

S	Age	Sex	DVI	OVI	Strategy used	Visits frequency
(1)	28	M	TB	A	Cane	2 per month
(2)	39	F	B	C	Guide dog/cane	1–2 per month
(3)	22	F	B	C	Cane	5 per month
(4)	40	F	TB	A	Cane	1 per month
(5)	40	M	TB	A	Companion/cane	1 per 2 months
(6)	42	M	B	A	Cane	3 per week
(7)	49	F	TB	C	Cane	1–2 per month
(8)	27	M	B	A	Cane	1 per month
(9)	49	M	LV	C	Cane	4 per year

Notes. S = Subject; DVI = degree of visual impairment; OVI = onset of visual impairment; TB = totally blind; B = blind; LV = low vision; A = acquired; C = congenital

2.2 Experimental Procedure

The experimental methodology was divided into the following 3 stages:

Stage 1: Semi-structured interview
A semi-structured interview was designed to obtain the subject's previous experience in shopping centers and to understand the context from which they developed their activities and their perception of the things that represented an obstacle or an aid.


(a) (b)

Fig. 1. (a) Subjects using cane and companion strategy, (b) subject with guide dog.

Stage 2: Verbal Protocol Analysis (VPA)
VPA is used to derive descriptions of the processes, cognitive and physical, that an individual uses to perform a task. VPA has been used extensively as a means of gaining an insight into the cognitive aspects of complex behaviors [9]. Subjects were asked to go to a shopping center of their preference since initial findings pointed out that persons with visual impairment prefer to move in a close perimeter near their home. Once in the mall, subjects moved by themselves through the corridors, to arrive at a specific store as an ordinary day. Subjects expressed their feelings and opinions during the activity, which was observed and recorded for further analysis.

Stage 3: Analysis
Data were transcribed and thematically analyzed. The gathered information was divided into two main fields: environmental and personal factors. Within environmental factors are social and physical environment factors, which include employees and strangers; as well as noise/sound, amount of people, smell, airflow, type of floor, architecture and store distribution, objects distribution and facilities accessibility; respectively. Personal factors include navigation strategy, familiarity with the shopping center and personality. After being divided in fields, answers were compared between each subject and the most important and reiterative ones were highlighted as part of the results.

3 Results

3.1 Social Environmental Factors

Employees. Consumers expect good customer service when going shopping, but for the visually impaired it's a necessity. When there is an interaction between employees and people with visual impairment, help is usually given, and sometimes employees really dedicate themselves to assist them with everything they need. These dedicated employees also offer their help voluntarily when they notice a blind customer, and they look for the best way of aiding them. Sadly, it is very rare for the shopping center's personal to count with a special training about how to treat blind customers. This causes uncertainty and even fear on employees when they are asked for help from a blind person, and they end up not giving an adequate attention or they choose to ignore them at all to avoid the situation. An example is when they try to give directions to the customer by pointing with their finger the direction of the place or when they say the direction but not the distance you need to walk to get there. The instructions could be clearer if they include references that incorporate more than one sense (smell, hearing, touch, etc.) so they can corroborate they are going in the right way.

Unfortunately, this training is not given because there is a lack of inclusive culture, which is also demonstrated by a few managers who even punish their subordinates for helping blind customers. Also, it was discovered that many management officials are ignorant of the laws regarding the visually impaired. For example, guide dogs users are frequently asked to leave because "pets" are not allowed. The fact is that guide dogs are not considered as pets but as part of the person, and the law supports them. A subject mentioned that once she explained the situation to some managers, part of them understood, but others did not care. A manager said: "Laws also say I can deny the entrance and I deny your entrance." However, the law he was referring to, demands an objective reason for denying the entrance, and he did not have one.

Strangers. When subjects and other customers interact, different reactions emerge. On the one hand, some people try to help and sometimes are actually very nice and helpful (Fig. 2). They approach the subject even though help was not sought. Some others notice them and move from their way, and even encourage others to help them or at least to do not obstruct their way. For example, the case of people who use guide dogs is pretty interesting. Guide dogs arise curiosity in bystanders, especially in kids, but almost anyone knows how to act around them. A lot of them want to pet the dog, but they do not know the guide dog should not be distracted because they are doing its job. It is understandable that people get curious, but they should ask, or read the sign on the dog's back in order to respect its job. It is important to highlight it has become more common to find people who ask about the right way of approaching a guide dog.

On the other hand, customers frequently stare at blind people, and some others do not notice them because they do not pay attention and end up hitting them by accident. Also, it is worst when they get to ignore intentionally a blind person because they do not want to help. Some subjects comment how some strangers even kick their cane.

In short, it is uncertain if a stranger would help or not a blind person, but certainly, there is not a factor of age, gender or employment which could determine or predict if someone is willing to help. The only considered factor is each person's inclusive culture and manners.

3.2 Physical Environmental Factors

Noise/Sound. Most of the information received by sighted people is visual, but blind people have to rely on their other senses. Among these, hearing becomes the principal

Fig. 2. (a) Employee helping the subject to get to another store, (b) stranger obstructing the subject’s way

sense that most of the subjects develop, but their acute hearing actually produces advantages and disadvantages. Some benefits are that noise helps those with sight issues adjust to and navigate their surroundings. For example, noises help them to notice if they have something in front or close to them. Also, specific sounds like music and voices help them to figure out the kind of store they are in. On the other hand, excessive noise, like accumulated conversations and loud music, may distract and/or hinder them to locate themselves or their surroundings.

Amount of People. As mentioned before, one of the sources of excessive noise is the accumulated conversations. Usually, there is a proportional relationship between the amount of people and noise level. Also, crowds are generally not orderly, so it gets more difficult to walk through the hallways because spaces get smaller. The positive side observed in this study is that most of the people end up clearing the way around a blind person. Also, as the number of people grows, the chances of getting help from others also increases. It is very important for a blind customer to have someone around them in case they need to ask for something. Certainly, the crowds, people, and noise can affect a blind person’s experience while in a commercial space, but the most important factors are having an educated and cooperative populace as well as a supportive infrastructure, which remain critical to the sight impaired people experience while in a shopping area.

Smell. Another sense that blind people have got to develop more sharply is the smell. Aromas help them to know what kind of things they have around them, and by this, they can perceive what kind of store they are in front of. This is because their smell has developed enormously to the point where they do not just notice smelly things like food or perfumes, but they also recognize neutral things like clothes or shoes. These aromas they recognize are so helpful that they guide their way to the entrance of the different stores.

Airflow. Airflow is a considered factor which can affect how blind customers locate themselves. We mean by airflow the lack or the presence of wind currents, which can suggest if they are in an open place, corridors, or near an entrance. Some subjects mention how they recognize the direction of the wind currents and use it to figure out their path, which is the reason why open places are preferred. Also, they may know how big a space is by feeling the wind.

It may be mentioned that airflow is not a relevant factor for every subject. Most of the shopping centers on Guadalajara are closed buildings which have almost no wind currents, triggering blind people to rely on other senses such as smell and hearing.

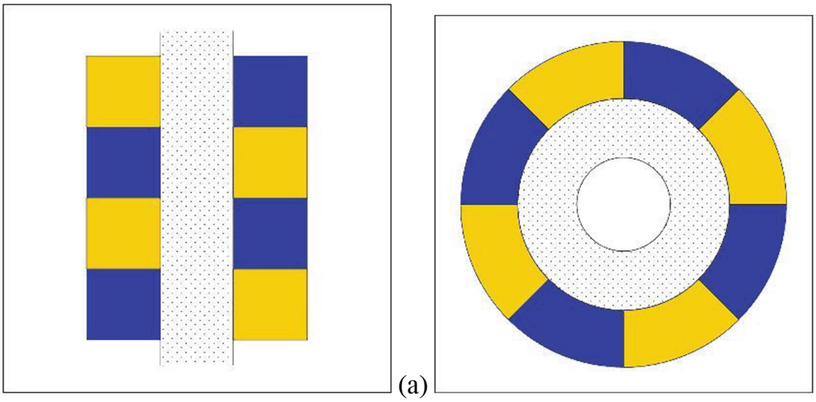
Type of Floor. Subjects have favoritism for floor types that have acoustic characteristics that amplify the sound because they can locate things by detecting the closeness of sound (echolocation). The texture of a floor surface is very important to the subjects. It was clear, flat floor types with friction are preferred since they provide security by a better grip. Additionally, this kind of floor facilitates the sensing with a cane. Just like slippery surfaces, floors with irregular features were disliked, because it is easier to trip on them and to confuse the location of podotactile rails. Podotactile guides are well accepted by the blind people, but usually, there are only used on public roads such as the subway. The interviewed subjects assure podotactile guides could be a great option for shopping centers, as long as they are well applied (Fig. 3). They should take you to every place in the shopping center, and as a subject said: "People should be capable of telling you to follow a specific guide to get to your destination." A few people preferred to have a low relief guide than a jumped one. Ultimately, the most significant strategy for choosing a floor type is to have changes in it, either on texture, relief or both, indicating important elements on their surroundings, such as stairs, entrances, hallway intersections, and others.

Architecture and Store Distribution. All shopping centers are different from one shopping center to another. Most of the participants pointed out that distribution was not a critical factor because they can learn the different structures of each plaza and

Fig. 3. Subject using podotactile guides at a shopping center.

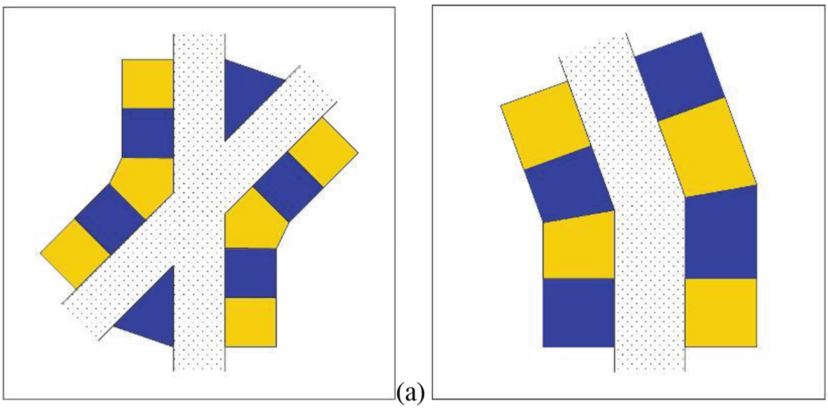
what it makes each place unique. Nevertheless, it was mentioned that shopping areas or plazas should consider the following characteristics: a long unique hall and a round/ring type of arrangement are some of the favorites (Fig. 4 show an example respectively). Having two or more levels is almost not an issue, but escalators can be a challenge. Multiple halls, intersections, and/or sudden shifts on the corridors should be avoided (Fig. 5 show an example respectively). Also, having together stores with the same kind of items would be appreciated, but it is not seen as something essential. All these characteristics would enhance blind people's self-location and movement around a shopping complex.

Objects Distribution. Apart from shopping center layout, it is critical to have wide halls obstacle free. However, if they are too wide, you can lose your way. Trash cans,



(a) (b)

Fig. 4. (a) A long unique hall (*white doted*) with stores (*the 2 darkest colors*) at its sides, (b) a round/ring hall (*white doted*) with stores (*the 2 darkest colors*) around it.



(a) (b)

Fig. 5. (a) Halls (*white doted*) intersecting with stores (*the 2 darkest colors*) at its sides, (b) hall shifting (*white doted*) with stores (*the 2 darkest colors*) at its sides.

fountains or benches are obstacles if they are placed in the middle of the way (they are better placed on the sides). Though, if there must be an object in the middle of a wide space, it is recommended to have a sound in it to advert there is the object. This should be also applied in the mall kiosks, which could be not considered as an obstacle if there is enough space in the hall and you can notice them by the sound.

Facilities Accessibility. Consumers should be able to access easily to every single service the place offers. The services should be adapted for everyone, including blind people, to enhance its use. Two of the places which also present issues of accessibility are parking lots and bathrooms.

Parking lots are hated by almost everybody because they do not have clear pathways to cross them. In most of them, there is a long way from the parking lot to the entrance and it is very easy to get lost. Therefore, it is preferred if they are narrow and right next to the building, so you can walk through them quickly and easily to get in or out of the mall (Fig. 6).

In the case of the bathrooms, most of the subjects said they ask for help to find them, and also when they are already inside because sometimes they are difficult or tricky to find. It is preferred if bathrooms are not at nooks and if there are no other doors near the bathrooms because subjects get confused and may enter to other room. Also, there are no tactile/auditive signs inside of the bathrooms and that's the reason why they ask for help.

Talking about signs, most of the shopping centers in Guadalajara do not have braille signs, but many of the subjects think they would be useful as long as they were well applied all around the mall. They should be placed at an ergonomic height and each dot should be big enough and well separated to distinguish between each character. However, they do not see them as a priority or as the best solution because not everyone knows how to read it and technology has become a better instrument.

Fig. 6. Subject walking through a parking lot.

3.3 Personal Factors

Navigation Strategy

According to the participants in our study, most people use the cane as their navigation strategy. Guide dogs are not as popular because getting them is complicated in Guadalajara and they are expensive to maintain. Nevertheless, every subject likes being accompanied by someone who guides them. Actually, if they are in a new place, sometimes it is indispensable for them to be accompanied, even having a cane or a guide dog. On the other hand, when they really know a place, they manage to travel around without cane or company, though this is rare in public places.

Another strategy used is the echolocation, method of generating sounds and using their echoes to identify surroundings and move around [10]. Also, many people use special GPS apps for blind people, e.g. "Lazarillo", but unfortunately these kind of apps are only used to travel around the city, not in closed places. The majority of the participants agreed it would be really helpful to have an aid like this inside shopping centers, and it would be interesting if all the users could use that same platform to put their comments about each place.

Familiarity with the Shopping Center

When taking the decision of going to a shopping complex or not, it is a very common and important factor to analyze if you previously know the shopping center. When blind people are accompanied it is not an important factor, but when they are alone, they have to go to places they are already familiar with. Familiar shopping centers are preferred than unknown ones because knowing the place helps them to feel more secure and to need less help.

Personality

Personality is a really meaningful factor and goes along with each person's motivations. The incentives that motivate users could be positive or negative: the user would move towards the positive and would avoid the negative [11]. A person would classify this incentive as positive or negative depending on how open he or she is and how secure he or she feels.

It was found with the interviews that some of them feel really insecure about unfamiliar places and they need company to go there. If they are not accompanied some of them were not shy at asking questions to people around them, but others prefer to be with an acquaintance to ask.

On the other hand, a group of the subjects interviewed was determined to enhance the development of their senses to depend less on external help and be more independent, to the point of going alone even without a cane to some places (Fig. 7). Additionally, these subjects want to enforce their rights as human beings and as people with disability by working in associations and campaigns about it, or others on daily life activities.

(a) (b)

Fig. 7. (a) Subject avoids escalators and uses stairs instead, (b) subject uses escalators even with her guide dog.

4 Conclusion

Guadalajara needs to create an inclusive culture and apply it in public places such as shopping centers. There are many factors to work on, and it would be a great option if the city had an organism that regulated the inclusivity of public places. This inclusivity should be for every person, including all the types of disabilities, not only visual.

If regulations were applied equally and forcefully, people with disabilities would enjoy more and might participate more in public spaces, specifically in shopping centers. In case young people created the habit of going regularly, it would transcend to other generations. Actually, if blind and weak-sighted people visited more frequently shopping centers, it would be easier for other people to recognize the importance of inclusivity.

There is a strong relationship between a public place´s attendance and its inclusivity, in which they form a virtuous circle. This virtuous circle involves inclusivity, motivation for attendance and people's awareness of inclusivity importance/inclusive culture.

A good starting point for enhancing shopping malls inclusivity is increasing people's culture. It is not necessary to do very complicated things, being kind and having a good sense and judgment is a key advice.

We hope this study could help to motivate Guadalajara's actual and future shopping centers to implement accessibility items that will benefit people with visual impairment.

Acknowledgments. We express our sincere regards to our family and every person who collaborated in this study.

Appendix: Sample of the Semi-structured Interview Questions

1. What is the most frequent reason why you go to a shopping center?
2. What strategies do you use to guide yourself within a shopping center?
3. Have you been into a mall with adjustments for the blind?
4. If the shopping centers had adaptations, would you visit them more frequently or with greater pleasure?
5. What do you think about braille signs, podotactile guides, and auditive guides?
6. What kind of adaptation would you suggest for a shopping center?
7. Which the shopping center you visit the most? Why?
8. Which the shopping center you visit the least? Why?
9. What bothers you the most about a shopping center?
10. Mention any your positive or negative experiences in shopping centers.

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Game for the Digital Inclusion of the Physically Disabled with Reduced Mobility

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Abstract. Floating Wheels is a serious game created and developed with the goal to assist and integrate the physically disabled in the digital environment. The software brings issues of accessibility, mainly in what refers to the urban mobility present in the daily lives of the target audience in question. The results showed that any person may make fair use of the game, attesting to its content inclusive. The users will be exposed to the rights and public policies related to accessibility, therefore, both the learning and fun will be present.

Keywords: Serious game · Inclusion · Physically disabled

1 Introduction

The digital entertainment industry has been growing continuously, directly proportional to the new types of emerging technology. Despite this progress, the gaming market does not offer a total motor, cognitive or physical adaptation of their products to consumers who have some type of disability. In addition to the limited offer of these games (given the variety of computers, consoles and other devices currently available), notice that the products are targeted at specific disability types (only games for the blind or deaf, for example), disregarding the use by others audiences, who end up classifying the games as uninteresting. This fact causes even more social exclusion.

The idea is to bring serious games to be used as facilitators in the process of teaching and learning of the physically handicapped, providing involvement in the accomplishment of activities, and, at the same time, offering as much as possible, the development or improvement of their motor skills, contributing even more so in their personal autonomy. This example of game use is called digital therapy, which can provide stimulation or even rehabilitation of disabled persons [4]. The software will be directed to children in the age range between six and ten. Given this age, the educational function of the game will not only make users aware of their rights but will also allow them to claim them in the midst of any discomfort in the urban area. The game brings the mechanics of one-touch gameplay, in which with only one touch, the user is able to control all the movement of his character. In this way, the game becomes easier to be played by people who do not have full control over the movements of their hands.

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2 Methodology

In order to achieve the goals proposed in the project, a bibliographical research was carried out to establish a theoretical basis for inclusion of the physically handicapped, both in society and in the virtual world, in view of the modern digital world, as well as accessibility for the same ones and electronic games already existent so that they could be used as base of improvement.

In addition to the research, the target audience was studied for a better use of the subject, and also a better search for problems and their due solutions, regarding the digital world, regarding technologies, and also in society with regard to the their daily lives and problems faced. After the research and studies the implementation phase was started.

3 Results and Discussion

To suit the target audience of the game and get a positive return, the design was based on the principles of universal design that seeks quality of interaction and fair use by all, without restriction of age, skill or situation. There are seven principles [3]: (1) equitable use; (2) flexible use; (3) use simple and intuitive; (4) noticeable information; (5) error tolerance; (6) low physical effort; (7) size and space.

The GDDs (game design documents) are registrations of all the characteristics that form a game project and indicate several essential components that go beyond the issues of operation or usability in general. There is a history, concept, context, scenarios, characters, structures, differentiating elements, conflicts, controls and flows. Some of these elements denounce the design and creative complexity of a digital game [5].

3.1 The Game

Floating Wheels is a game that tells the story of two main characters, Malu and Doug, both people with special physical needs who need a wheelchair to get around and go through constant problems due to lack of accessibility. These problems are of a realistic nature that aims to extract the maximum of situations faced in the daily life of a disabled person, for example: non-adapted buses, objects that prevent passage on the sidewalk, irregular sidewalks and the lack of ramps. The player when colliding with some of these obstacles, besides losing a chance of three, will also have contact with the public policies and rights of the handicapped who were inflicted at that time, so during their execution time, the educational purpose of the software will be emphasized.

For each obstacle overcome, the player will accumulate points related to accessibility solutions that will compose a list of suggestions. At the end of each race the player will arrive at school and will present the list of solutions to the problems encountered during the course to the mayor of the city that will be in the school.

3.2 History

Malu and Doug dream of one day achieving autonomy, and for that they need to carry out simple tasks of everyday life such as being able to move around the city, the environment in which the game is played. However, it's very difficult without the presence of accessibility.

The characters met after Malu moved to the house next to Doug, with the proximity and growing friendship, the two were discovering themselves. They both study at the same school and have this daily difficulty to reach it, because they need to cross a city that does not have any support for urban mobility.

The most frequent problems in the way they do are the lack of adapted public transportation, steep or irregular sidewalks, holes and cracks, stairs, prejudice and even lack of inclusive education. These drawbacks are faced every day during round trip to school and even within it.

After a while they found out that the mayor would go to school to participate in a lecture and then they decided to create a proposal for accessibility suggestions to present to him. This was a unique opportunity to show their problems and present solutions according to their point of view, helping all, both individuals with some type of disability and those without it, with a proposal of a better city, more inclusive and with the adequate urban mobility.

3.3 Characters

Malu was born with poor formation of the lower limbs and only achieved partial autonomy at the age of nine. She is female, with congenital physically handicapped and wheelchair. Doug acquired the deficiency of the inferiors due to a traffic accident at the age of four. He is male with physical disability and wheelchair, and faced great difficulties of adaptation. Both characters will be moved in the game by the same mechanic and both have attributes shown in Fig. 1 below.

Fig. 1. Characters

The wheelchair of both will move forward and have the same capabilities, the differential will be present in the additional bonuses found by the player along the way, which can either benefit or hinder their performances in the race.

3.4 Entertainment

A serious game is still a game, so the fun has to be present in all stages of the software. The user will be able to learn while playing, without the educational side overriding the fun, being essential the balance of both parties. During the gameplay the user without disability will have no advantage as to the user with, so the competitiveness will be induced equally, the game becomes fun and playable for both. A solution found for a problem widely seen in the gaming market for the disabled. For users who identify with the main target audience, (wheelchair or someone who does not have full control of their upper limbs), the game tends to be even more efficient and educational, aiming not only at awareness, but especially the fun. Since the same is already often aware of their problems though not entirely, it will focus more on having fun overcoming obstacles and reaching their final goal.

3.5 Interface

The interface of a game is the element that provides the connection between the player and the software, since the two could not connect directly. An interface well developed won't result in the rejection of a system and either in activities badly executed. It's responsible for doing the communication among the user and the tasks that he wants to execute, in other words, it is the visible part.

The interface can facilitate the handling and understanding of the software, especially for the disabled, which gives design a great responsibility. For Salen and Zimmerman [2], one of the central aspects of game design is playful interaction, in other words, giving good experiences with meaning to the player and the game.

User centered design approaches [1], usually applied to digital games and interactive systems, consider iterativity as an effective way to understand players' behavior and improve their experiences. In order for the user to experience a connection with the game, the interface was developed aiming at interactivity. Therefore, the protagonists were designed as physically handicapped to seek a better experience, identification and acceptance of the proposed universe (Fig. 2).

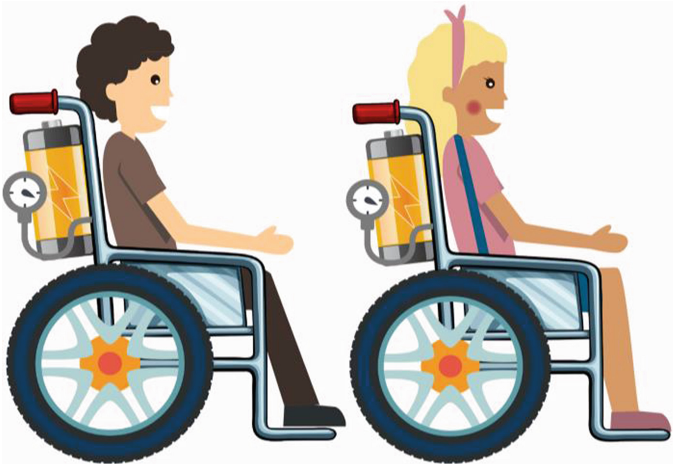

Fig. 2. Characters in wheelchairs

All areas of the user interface can be accessed using the same input method as gameplay (keyboard), making this user-software communication. The design is simple and intuitive, so the player understands how to access and make use of the game without complexity, counting on home screen, options menu, pause, game over and victory. The scenery is composed of flashy colors and that play an important role in the distinction of obstacles in the urban route (Figs. 3 and 4 below).

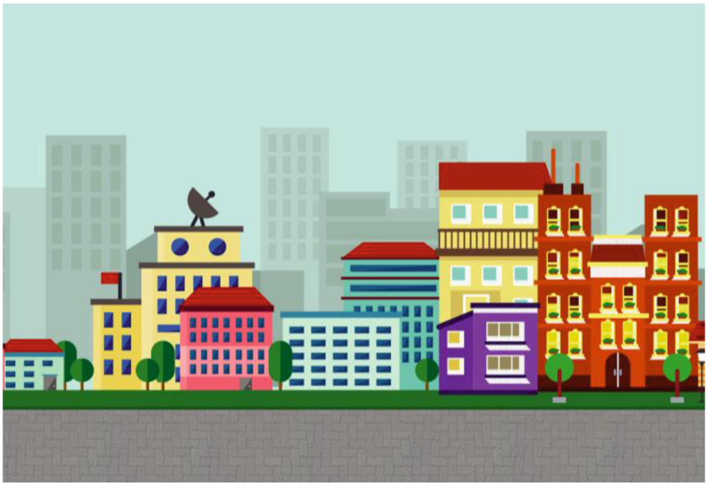

Fig. 3. Scenery

Fig. 4. Obstacles

3.6 Inclusive Strategies

The game is Running style and considering the target audience in question, the set of rules of the same has flexibility of use whereas, the difficulties proposed regarding the starting time and speed of the character will be gradual, therefore, the user will have their time adaptation to the rhythm of the game as well as will be able to make use of the software accurately. From this it is assumed that the more further, the more committed the user will be to beat his own record, keeping the spirit competitive and instigating him to continue. Such obstacles will be easily discernible regardless of the skill and environment in which the user is found, so everyone will be able to differentiate and to contrast the elements of the scenario, differentiating what will need to be diverted or not.

The tolerance to the error will be respected and maintained with three chances that the player will have, so the adaptation will be present without it losing its progress, being able to also compare among the attempts which was more successful and also evaluate its gameplay, trying not to commit the same error the next time the user is playing. The educational messages during the phase are short and objective to avoid overshadowing the scenario and prevent the player from noticing any barriers along the way, besides being absorbed more easily by the children.

3.7 Gameplay

At the start of the game, the player will be presented to a screen where the main character chosen will be shown in front of a street and will automatically run to the right where the obstacles that the player will overcome will be shown. By pressing the up arrow button it'll divert from the obstacles. When overcoming or hitting an obstacle the player will receive a message showing that the goal has been added to the list of proposals. The objective of the game is to accumulate enough rights to show the proposal to the mayor. At the end of each race the player will arrive at school and be presented to the current list that he has, thus reinforcing the game's proposal at all times. To finish each match the player must arrive successfully to the school, without hitting 3 obstacles. Otherwise, the player loses and must restart the match, so that with each match the difficulty increases a little, but it is never too difficult because the target audience of the game is limited, leaving them at all times able to play without giving advantages for those who do not have special needs.

3.8 Conclusion

Since the game was developed aiming at the highest range of objectives, the software is easy to handle and education is transmitted. The satisfaction of the users can only be evaluated later, to finally have their performances analyzed, therefore, the game has been completed with all the proposed requirements in the development stage.

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Playgrounds for All: Practical Strategies and Guidelines for Designing Inclusive Play Areas for Children

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Abstract. To date, outdoor game equipment and playground facilities worldwide are increasingly oriented towards a wide range of solutions in support to gaming activities for children of any age, independently from their motor, cognitive and social impairments. However, due to the complexity of variables interplaying between product demands and user capabilities, many efforts are still needed for making games and playgrounds as much as possible inclusive. The present work proposes a novel methodology useful to designers and other stakeholders for predicting the degree of user exclusion when performing play activities. User trials, focus groups, interviews together with the analysis of accessibility standards, disability descriptors by ICF, and Task Analysis were used for cross-correlating the required tasks with user capabilities. This led to creating an evaluation tool useful to get an immediate feedback and reliable information on the level of inclusiveness of any type of game equipment and user disability. It revealed to be also effective for assessing personal and environmental factors of interest and identifying design requirements.

Keywords: Playground · Inclusive play · ICF · Disability · Inclusive design Social innovation

1 Introduction

Designing inclusive public open-air playgrounds is an issue of foreground and strategic relevance within the contemporary society, as it can have significant implications on the social dimension of children, especially for that of exerting the right to play. The United Nations Convention on the Rights of the Child (commonly abbreviated as the CRC or UNCRC) provides the following definition regarding the right to play and to play with the others peers: "every child has the right to play, regardless of age, nationality, gender, skin color, social and religious status, physical and intellectual capacity" [1]. Within public play areas such a right is often undermined by the presence of games that are not suitable and inaccessible or even more by the presence of restrictive play solutions for humans. For instance, it is not enough to put ramps in existing games or choose games for disabled children, but we must guarantee the

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possibility of playing for all children in total safety, regardless from any impairments and discrimination [2].

Basically, playing in its widest meaning foresees physical, sensory and relational activities. To date, existing outdoor game equipment and playground facilities worldwide offer a wide range of solutions in support to the above mentioned activities. However, despite the advances achieved in this field, we are still far from making thoroughly inclusive playgrounds. As an example, what are the levels of acceptability of current playground facilities in relation to user needs and their abilities? How is it possible to objectively assess the degree of inclusiveness? What are the variables and the knowledge that the designer must consider to realize inclusive concepts? Surely, the answer to these queries is not immediate and how the contribution of design can foster the implementation of such systems-services is an open question that still deserves further investigation. As reported in the literature, the inclusive design knowledge base involves mainly two distinctive areas. On one hand, understanding end users from many different perspectives (not only in terms of ergonomics), on the other hand, understanding the information needs of the many groups involved in promoting and delivering inclusive design solutions, from politicians and campaigners, through business, design and marketing to strategic planning [3, 4]. A crucial aspect is undoubtedly that of identifying an analytical strategy for understanding the diversity and the release of useful designing inputs in order to satisfy user needs transversally, by considering a plurality of physical, psychic and social conditions in an integrated way. As a matter of fact, the Inclusive Design Cube, which was initially proposed for understanding the link between product demands and user capabilities, was reformulated in the area of playgrounds by adding the social dimension [5, 6]. Nevertheless, whenever facing with the development of playing areas or a single game, the identification of user needs, user abilities, environmental factors together with the analysis of activities to be performed during a specific gaming are key factors for achieving inclusiveness. The representative sketch displayed in Fig. 1 illustrates and summarizes all aspects to consider whenever designing inclusive playground facilities.

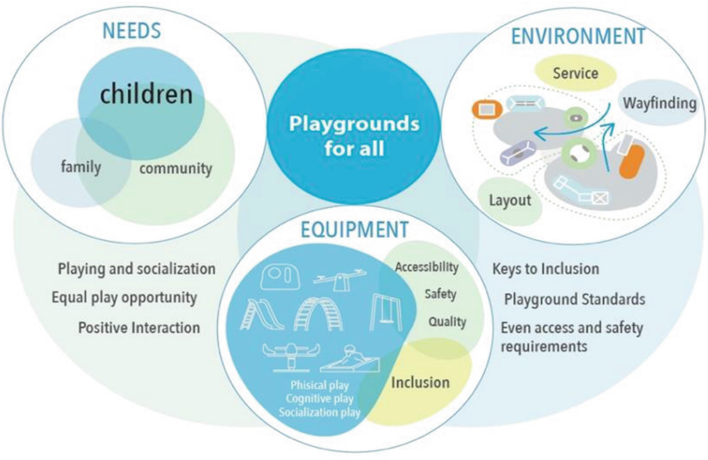

Fig. 1. Key elements for designing inclusive playground facilities

In this work, part of the outcomes presented were achieved during the PIU research project – *Urban Innovation Project*, within which the Laboratory of Ergonomics and Design (LED) of the University of Florence was actively involved. In detail, thanks to a multidisciplinary approach, focus groups, interviews and many other, all the information gathered during the PIU project were used for providing to designers and public institution a methodology to collect keys for designing inclusive playgrounds. The aspects related to those children who use wheelchairs or others scaffolds for mobility, or who have cognitive and sensory disabilities were considered of meaningful importance. The work is therefore finalized to outline practical solutions and specific guidelines, whose objectives are:

- enhancing the children's abilities on the basis of an attentive analysis of user needs
- fostering socialization and collaboration between disabled and non-disabled children;
- promoting communication among relatives and children, even in the presence of early disabilities.

2 Research Stages

On the basis of the main research goal to be achieved, the work was organized according to the four steps illustrated in Fig. 2. The first phase was dedicated to critically reviewing the reference literature and technical standards in order to get preliminary information on playgrounds (i.e. dimensional and safety requirements, inclusion parameters, layout, type and quality of equipment). In the step 2, user needs including physical, sensory and social activities were identified through a series of specific methodologies, especially focus groups and interviews. These information together with the use of ICF taxonomy and Task analysis allowed estimating the level of user exclusion (point 3). In the step 4, the whole process was then translated in a smart evaluation tool which allows to the designer and other stakeholders to put immediately in relation children's abilities to tasks required during play activities. More details about each research step are explained in the following sections.

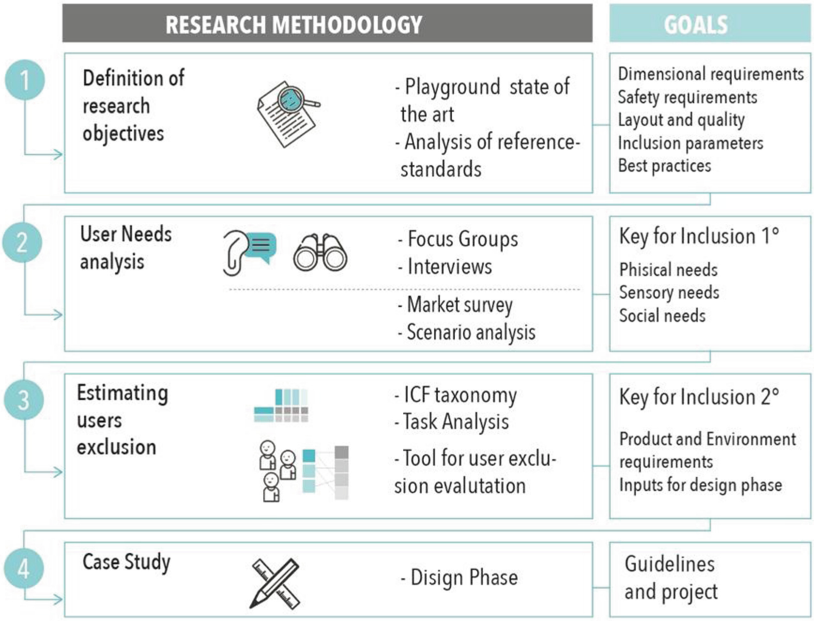

Fig. 2. Sketch showing for each stage the applied methodology and correlated research goals

2.1 Definition of Research Objectives

The research objectives were formulated by carefully reviewing the reference literature and the sector regulations. In detail, the following European and American safety standards related to public playground environments, playground equipment and surfacing standards were analyzed [7–11]. Among the most accredited guidelines one may find: Me2: 7 Principles of Inclusive Playground Design™ [12, 13], Inclusive play design guide by Playworld's [14], Let's play Toolkit [15] and Public playground safety handbook [16].

During this phase, the best design practices along with technical and environmental specifications regarding safety, mobility (accessibility and use of equipment), and compliance requirements of gaming activities were identified. According to the dimensional and safety requirements, a detailed classification of all the activities related to each type of play (i.e. physical, sensory and social activities/interactions) is proposed in Fig. 3, and it includes also a further subdivision for age groups. This classification was useful for evaluating the game equipment present in playgrounds and in market worldwide. Moreover, it was exploited to draw and plan the following user needs analysis phase and hence designing a method for assessing the degree of exclusion.

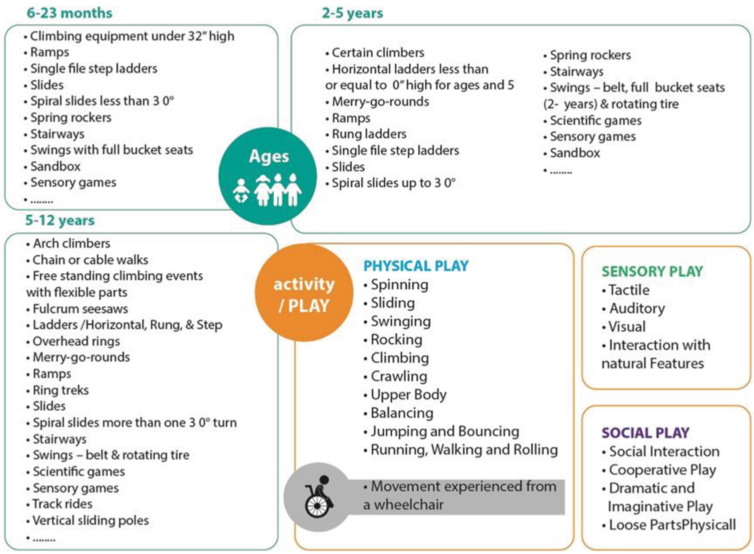

Fig. 3. Classification of gaming activities for age groups and for different type of play Public Playground Safety Handbook [16] Inclusive Play Design Guide by Playworld's [15]

2.2 User Needs Analysis

With aim of assessing user needs, focus groups and interviews were conducted within the PIU research project framework. The main activity of the LED group of University of Florence was that of outlining design guidelines for accessibility, urban ergonomics, and wayfinding for the school village of the city of Cecina (Tuscany, Italy). Basically, focus groups and interviews were attended by citizenship, design experts, educators and individuals involved in social assistance to families. The focus groups were planned by targeting general issues including public space, safety, current services, and the problems mostly related to the needs of relatives of children with physical and cognitive disabilities. Subsequently, a set of interviews were conducted with families of disabled children, and the team of designers who designed one of the most popular inclusive playgrounds in Italy: "All aboard Rimini". The interviews were focused on to understand the level of acceptability of the spatial and environmental elements that characterize an inclusive playground. In particular, it was requested to tell the experiences that children and their families have experienced in the use of traditional games, and which elements of the analyzed park have actually amplified the level of access and inclusion for children.

2.3 Estimating User Exclusion

Generally, for estimating the level of exclusion the following steps revealed to be essential: (1) understand the capability demand made by a product within its operating environment; (2) define a specification for and collect new population based capability data; (3) calculate levels of product exclusion and difficulty; and (4) present such data in an accessible and useful way [17–19]. Here, to make predictions about the product exclusion we defined the type of disability according to the ICF classification, the international standard to describe and measure health and disability (World Health Organization 2001). The ICF provides a classification of body function and disability composed of three lists called Body Functions, Body Structures and Activity and Participation (see Fig. 3). Furthermore, to classify contextual factors, it offers another two lists called 'Environmental Factors' and 'Personal Factors'. Each domain is structured into chapters where each item can have up to four levels of depth. Thus, the ICF offers about 1500 descriptors in its taxonomy [20]. Besides the tree-like structure of ICF, Fig. 4 shows some of the reliable disability descriptors which were selected for assessing exclusion when practicing play activities.

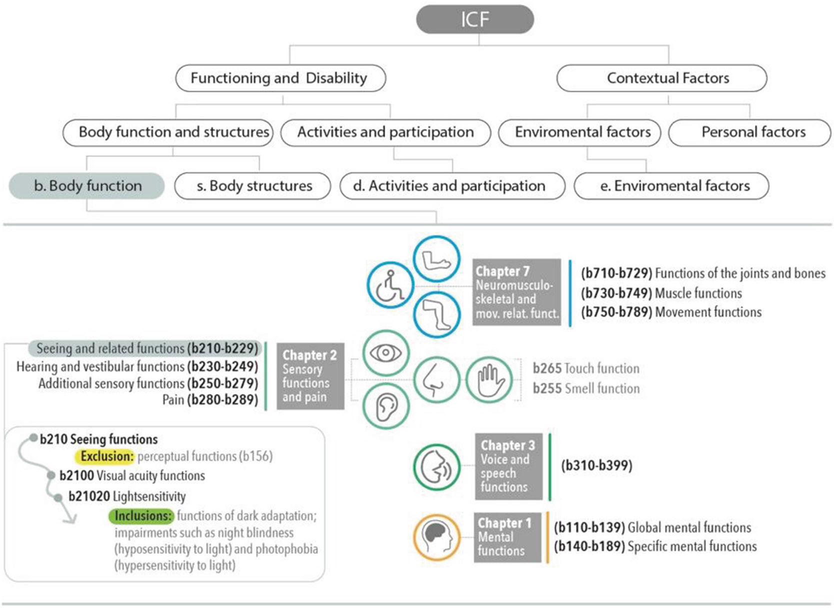

Fig. 4. Tree-like structure of ICF and disability descriptors related to physical, sensory and communication functions

The disabilities taken into consideration were those corresponding to the highest levels of impairment, thus between 96 and 100% of the ICF functions qualifier. This choice was adopted to consider the most extreme level of the exclusion scale (low capability), which means designing for all.

The level of interaction between the game and the group of users analyzed were assessed through the systematic analysis of individual games (i.e. physical, sensory and social plays). For each of them a Task Analysis was developed and for each test and sub-task identified were analyzed the levels of potential interaction, referring to specific users' physical, cognitive and sensory conditions [21, 22]. As an example,

Fig. 5 put in correlation the macro-tasks related to the traditional swing and sensory games, with the level of interaction required to accomplish a specific task (Physical, Cognitive, Social).

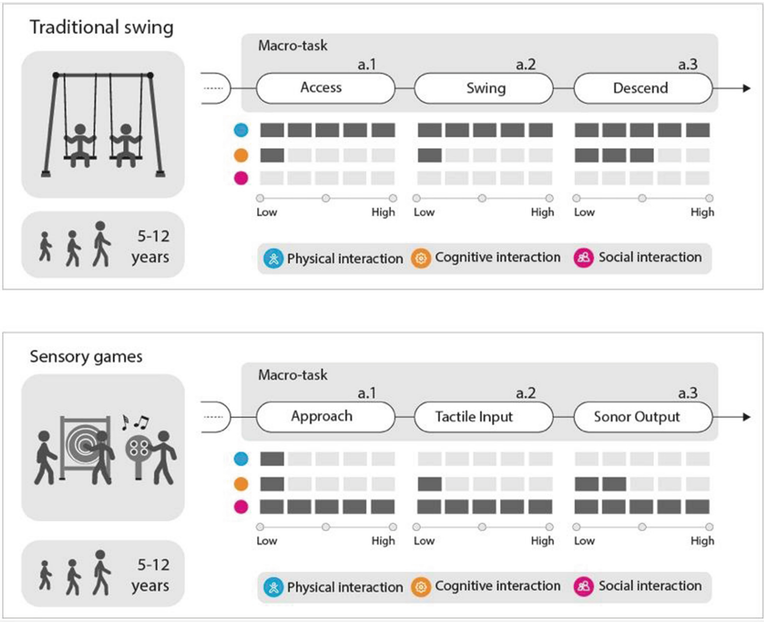

Fig. 5. Level of physical, cognitive and social interaction respective to the tasks required when using traditional swings and sensory games. Age group considered 5–12 years.

The cross-correlation between macro-tasks and the levels of capability, as quantified by ICF descriptors, allowed to create an evaluation tool for predicting the degree of user exclusion when performing play activities. The exclusion was evaluated in relation to the following items: (1) the user, (2) the product, (3) the environment or context (4) the activities and tasks that constitute the interaction over time.

3 Results and Discussion

The assessments carried out within the PIU project and the subsequent developed methodology allowed the creation of an experimental cross-correlation system between the product demands/tasks and user capabilities identified through the ICF taxonomy.

The tool provides an immediate feedback on the level of inclusiveness of any type of game equipment. As an example, Fig. 6 shows the degree of exclusion of 5 games, 4 different types of swings and a sensory game.

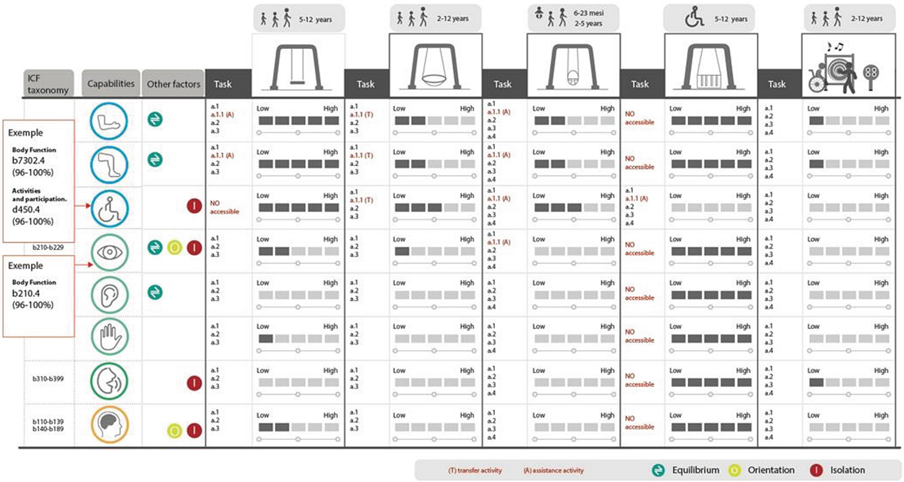

Fig. 6. Cross-correlation diagram illustrating the degree of user exclusion during gaming activities

In the case of the swing evaluation, the analysis of the related tasks (i.e. access, swinging, descending phase) shows, in reference to the first four columns, the need for support activities by an accompanying persons, especially in the presence of the physical disabilities shown in the first four lines of the Fig. 6. In the case of limited or complete body functions disability (upper/lower limbs, wheelchair users), the participation of an accompanying person is strictly required for the transfer and/or for assistance activity. During the swinging phase (a.2), if there are children with severe visual and cognitive impairments, assistance and physical contact with an accompanying person is needed. However, the level of exclusion for wheelchair-bound children which can not be transferred on remains high.

The cage swing (play in the fourth column) designed for children in wheelchairs, is certainly accessible for them but turns out to be a dedicated solution that excludes the participation of other children in the game activity. Moreover, these systems are dangerous and require block systems to prevent improper use of other children.

For children aged between 2 and 5 years, to increase the level of socialization, it is recommended the installation of solutions that allow the activity of swinging together with parents. Some solutions are the double seat, with the possibility of looking at each other, or the types of swing implemented with child restraint systems equipped with a backrest and side supports and safety front panels.

Therefore, the results of cross-correlation show that the most suitable swing is the shape of a basket, especially regarding the issue of socialization. This type of swing offers play opportunities to children with disabilities, who can sit or lie down, swinging alone or with other children.

For what concerns the sensory games, always illustrated in Fig. 6 (column 5), it has been found that they make it possible to work simultaneously on several levels, so as to better satisfy inclusion. These games help children to become aware of their senses and develop them further. These aspects are therefore of fundamental importance for the growth of cognitive, tactile, sensory-motor, social and linguistic abilities. A further positive aspect of sensory games is also due to the interaction between parents and children, as there may be cases in which the parent may reside in the disabled condition. Also, think about the activities that grandparents may want to undertake with their grandchildren.

In the category of sensory games we also find sound games. In this type of games, the attention must be paid to subjects with cognitive and/or autistic disabilities. These subjects may be bothered by such games, so it is advisable to use not too high sound tones or to place, where possible, elements/materials that act as acoustic isolators. According to recently published studies [23–25], almost half of the children with autism spectrum disorder (ASD) try to move from a safe and controlled place to more open areas. In the absence of places to shelter, half of these children tend to get lost. Therefore, solutions with shell structures or small houses may be more suitable in cases of ASD. In fact, these last solutions can have a double function, the first one concerns the possibility for ASD subjects to isolate themselves in order to observe the environment. By doing so, they can decide the most opportune moment to open up to relationships and any socialization activities. The second reason concerns the need of these subjects to identify in these structures a safe place and protection.

Another fundamental aspect for ASD subjects is to look for playgrounds that have a wide pathway around the playing area. The perimeter path is often requested by ASD children because it offers a quiet space away from the game action. It may therefore be useful to install protection systems, such as houses, tunnels or domes, near the perimeter areas. Another disturbing factor for ASD children, and in general for all children, is the presence of saturated and bright colors of the games. In addition, the flooring is important to allow the child in a wheelchair to easily reach the game and make any task required by the game. The child in a wheelchair must be able to approach the game effectively and perform the necessary actions. Moreover, the possibility of using the game by children of different height must be provided. Usually, these games are used for learning activity, in a fun and engaging way. For instance, some fundamental notions of dynamic physics, optics and other categories of scientific knowledge can be learned. In particular the latter category of sensory games gives an active role to the player who, depending on the game, can act individually in collaboration with other players.

Finally, the proposed methodology and the related considerations allowed to formulate new project scenarios and specific guidelines. This phase was followed by a planning phase, within which the LED group and the public administration of the city of Cecina are currently working on the creation of the "playground for all".

4 Conclusions

The approach adopted in this work has provided a reliable strategy to take proper ethical choices during the designing phase of playgrounds, by accounting for human diversity, social inclusion and equality. User trials, focus groups, interviews together with the analysis of accessibility standards, disability descriptors by ICF, and Task analysis were used for assessing the product demands and user capabilities. In particular, the cross-correlation between macro-tasks and the levels of physical, cognitive and social capabilities allowed creating an evaluation tool for predicting the degree of user exclusion when performing play activities.

The proposed methodology allowed to get immediate feedback and reliable information on the level of inclusiveness of any type of equipment. It was also useful for assessing personal and environmental factors of interest and identifying design requirements (regulatory and procedural). In particular, the methodology presented will be further validated within similar experiments as an evaluation tool for the verification of the executive project. At the current state of research, the work has shown that among the types of games analyzed, the category of sensory games is the most inclusive, as it favors collective and collaborative modes of play, valorizing individual diversity and the exchange of knowledge and experience diversified.

Acknowledgments. The present work was supported by the PIU project - Progetto di Innovazione Urbana Comune di Cecina - financed by the Tuscany region (D.R. n. 3197 del 10.07.2015). The interviews were conducted as part of the collateral activities of the LED laboratory of the University of Florence, in collaboration with the designer Sebastian Lecca. The "Tutti a Bordo" project was created by the designer Fabio Casa Dei which is kindly acknowledged. For the interviews, a special thanks is dedicated also to Claudia Protti and Raffaella Bedetti, the responsible of the Parchi per Tutti Blog.

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Preprocessing the Structural Optimization of the SPELTRA Robotic Assistant by Numerical Simulation Based on Finite Elements

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Abstract. This project will structurally optimize the robotic assistant SPELTRA (Robotic Assistant for Speech and Language Therapy) that serves as pedagogical support to children with and without disabilities who are benefiting through the UNESCO Chair and Assistance Technologies (GI-IATa) of the UPS. This process would be carrying out through the study of different geometries and materials considering certain aspects technical and economic that will help to define by weighting parameters the optimal geometry and two possible materials for the design and creation of the new structure of the robot. After, will be defined all the variables and restrictions affecting the SPELTRA during the manipulation to which it is subjected in the robot-human interaction, thus establishing the structural model. For its analysis, CAD-CAE computational tools based on finite elements will be using and it will can to observe the possible deformations, efforts and safety factor to which would be subjected.

Keywords: Special education · Finite elements · Structural design
Children with disabilities · Pedagogical robotic · SPELTRA
Simulation by numerical methods · Communication disorders

1 Introduction

Knowledge is giving by different symbolic means such as graphics, numbers, music, writing, computer science among others. The latter, the computer science, is innovative and enriching for a student, since it allows a continuous relationship between the student's actions and the answers of the hardware, that is, the interaction of human-computer facilitates the children to build the morphology of their knowledge, considering its capacity to receive and relate the symbolic means. In general, this makes it more difficult for children who have different types of disorders and disabilities related to language and communication. To reach their full development, which is why the Research Group on Artificial Intelligence and Assistance Technologies (GI-IATA) and the UNESCO Chair, Support Technologies for Educational Inclusion, from the Salesian Polytechnic University (UPS), for provide support in speech and language therapy

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(SLT), created the SPELTRA robotic assistant. Which is then improved, changing its initial structure, platform, to a structure that can be covered by multiple disguises capable of providing support during the treatment of speech and language pathologies (SPL) and managing information from the electronic brain to speech pathologists (SLP) [1–3].

However, the robotic assistant SPELTRA has presented deficiencies in its physical appearance before the manipulation during human-robot interaction, being necessary to increase the strength of its structure, without affecting the essence of it.

For this reason, it is intended to develop a mathematical model that includes the variables that intervene during the manipulation and possible accidents that may occur during the interaction with children with and without disabilities, using for this purpose analysis of the enveloping, geometric structure and/or material that protects the mechanism of the robotic assistant SPELTRA [4, 5]. Once an optimal geometry has been determined, the two possible materials, more variables such as loads and restraints are included in the mathematical model. And the effect of all the variables and conditions is simulating in programs based on the element method Finite, which will serve to observe the possible deformations that, would suffer the robotic assistant with each material and the determined geometry.

Consequently, three phases can be identifying pre-processing, processing and post-processing; but in the present, there will be a detail of the first phase, pre-processing.

2 Pre-processing

The pre-processing phase consists of:

- Compilation of technical information about the therapies and needs of children with Autism and Down Syndrome.
- Studies of possible materials and forms for the SPELTRA robotic assistant, that, meet the requirements to help with language and learning therapies.
- Definition the geometry, the material, the loads and the restrictions for the robotic assistant and its discretization.

2.1 Compilation of Technical Information

Robotics is basing on the progress of electronics and computer science, as well as new disciplines such as the recognition of forms and artificial intelligence. In the latter, we can see how in recent years various types of artificial assistants of an anthropomorphic, zoomorphic, caricature and/or functional appearance, known as robots have appeared [1, 5].

There are many kinds of robots that differ according to their internal architecture, size, materials with which they are made, the way in which these materials have come together, the types of sensory systems they possess, their locomotion systems, the microprocessors that use, etc. However, the construction of those with a certain degree of intelligence is still an open problem, because a robot considered intelligent should be an autonomous machine able to extract information from its environment and use the knowledge of the world around it according to certain intentions of utility; how we can observe in the following studies [6–8]:

(a) Galán et al. indicate that according to the World Health Organization (OMS), one of every 160 people in the world is diagnosing with ASD. However, in low and middle-income countries, this situation becomes more complex, given that the prevalence of ASDs is not adequately estimated, or unknown. Therefore, they propose to provide mobile tools and robotic assistants in the diagnosis and intervention of children with ASD. Establishing two stages: The first is to treat the functionality and appearance of the robot, while in the second are the system services that are based on ontologies and the semantic web. Concluding that an avatar with a friendly appearance should be created that interacts with children, their families and therapists from the host institution or their home, allowing the feedback of language and other related pathologies [8].
(b) Timbi et al. provide an educational support based on ICT, especially for children suffering from speech disorders or similar pathologies through tools based on virtual worlds that help the interaction of children, their families and therapists, based on audiovisual stimulation and verbal. This tool, by interacting with those involved during therapy, creates feedback in situ or later, which helps to analyze their children's progress. Similarly, the authors recommend studying the possibility of using techniques to assess cognitive development, as well as the abilities of patients using toys that interact with mobile devices [9]. The right toys for a child with autism will depend on the level of development of the child; it should be simple, because bringing them closer to complex elements can cause frustration. In addition, the toys must be compact that resist falls and blows, that help their motor skills and sense in special visual, auditory and tact [10].
(c) On the other hand, Kidd and Breazeal point out the importance of human-robot interaction and the active participation of people with robots to the point that the robot becomes a useful tool for health care or behavior change, deducting that the appearance or physiognomy must be gentle, attractive and affable, to be considered sociable [7].
(d) Sony launched the electronic pet AIBO, which is a dog-shaped robot capable of evolving from a puppy to an adult dog, learning and adapting to life with its owner. In addition, Sony created QRIO, an abbreviation of QuesT for curiosity. It was a 60 cm humanoid robot and weighed 7.3 N, but it was not developed in 2006 [11].
(e) González et al. presented in 2015 to SA3M, a robot whose geometry or physical aspect is similar to a small humanoid. Based on an autonomous support system with a fuzzy controller, facial recognition, voice response and the use of several sensors to prevent or alert dangerous situations and respond effectively to real life situations to support the elderly and improve their quality of life [12].

According to the annotated, we can see that the different studies are basing on mobile ICT tools, the game and robots. Where their appearance, geometric structure and their coating is of great importance so much that visually conquers, like, call to interact with the same and that does not provoke fear, allowing feeling its texture and contributing to the tactile audiovisual therapy of the patient [8].

Reason why Robles et al. Through the UNESCO Chair Support Technologies for Educational Inclusion and the Research Group on Artificial Intelligence and Assistive Technologies (GI-IATa) of the UPS, they developed the SPELTRA robotic assistant to help children with disorders of the communication. This robot is based on therapeutic activities, mobile ICT tools, in six main areas of speech and language: hearing, voice, receptive language, expressive language and articulation, oral structure and function and linguistic formulation. Each one of these areas allows to define the skills, milestones of development, knowledge, evaluations and tests that should be considered during the rehabilitation process of people with communication disorders, concluding that SPELTRA would not only serve for the therapy of children with therapy. Speech and language- SLT but could also help patients who have Down syndrome, intellectual disability and attention deficit disorder, and recommend for patients with ASD [1].

This prototype initially its appearance was a platform that included a screen; but SPELTRA is improved by changing its structure or image to anthropomorphic caricature – functional. That is, its structure consists of an oval head, rounded cubic body and extremities without the human or animal form but a square drawing that is covering by various costumes of Friendly appearance, attractive, with movements of head and/or arms that express your mood and pleasant sounds see Fig. 1, [2, 3]. This aspect achieves a more natural interaction, increases the child's audiovisual confidence, stimulating it to discover new symbolic means by means of touch, inducing an inclusive education of children with speech and language disabilities or similar pathologies such as autism, Down syndrome, intellectual disability, etc. [8, 9].


a) b)

Fig. 1. Structure of the SPELTRA robotic assistant: (a) initial (b) current.

Therefore, we have seen the need to improve the structural design of the SPELTRA robotic assistant at the level of resistance to manipulation, treatment and possible accidents due to the human-robot interaction, whose objective requires both mathematical and computational knowledge. With the identification of the quantitative measurements of the studied system that is the structure of the robotic assistant SPELTRA whose characteristics are called variables and are subject to several conditions called constraints to be analyzed and studied by the finite element method (FEM) [13]. The variables to consider is the combination of the geometric and material form that must meet multiple conditions by presenting at least three alternatives of the form and several materials that will be analyzed by various parameters with a degree of relevance or action with respect to the assistant's index robotic SPELTRA. That is, the function of quality transforms the demand for the variables in design quality in order to obtain an optimal form and two tentative materials that make up the model [4, 14].

2.2 Studies of Possible Materials and Forms

Studies of Possible Materials

The science of materials presents the balance between the scientific foundations and engineering to select the appropriate materials in modern technology based on the investigation of behavioral modeling, degree of innovation (new material) and its physical-mechanical properties that includes its life cycle [13–16].

The existing materials by the engineers in practice are dividing into five types:

- Glass ceramics: they are rigid materials, they resist high temperatures, light, hard, do not suffer wear; but they are fragile they do not bear impacts and according to the distribution of their atoms they vary of color until being crystalline [14].
- Semiconductors: Materials whose capacity to conduct electricity is intermediate. Constitute a boundary between metallic and nonmetallic elements. The most important electrical material is silicon [15].
- Metals: are inorganic elements that have a regular crystalline matrix that allows making mixtures between them and alloys. The most outstanding properties are: high density, high to medium resistance, good ductility and conduction, suffer corrosion, have the capacity of permanent deformation and can have metallic substances such as iron, aluminum, titanium and non-metallic materials such as carbon, nitrogen and oxygen [14–16].
- Polymers or Plastics are using in everyday life and technology. These synthetic materials formed by molecules whose main component is carbon are easy to access, cheap, ductile, low density, have greater chemical reactivity than ceramics, easy to shape, corrosion resistance, thermal and acoustic insulation, less resistance that metals, however, polymers with advancing technology have improved in strength and stiffness to the point of replacing certain metals [14].
- Compounds are whose chemical bond contains metallic materials, ceramics, semiconductors, polymers and/or new materials product of the different combinations between the five groups. The components of these materials are easy to identify because generally one material serves as filler or reinforcement and the other as a binder resin to obtain the required properties. according to the function to be performed and pure or compound nanomaterials [14–17].

According to the annotated, the common materials used in the manufacture of toys or robotic assistants for children with SPL are within the categories of compounds, metals and polymers. The latter is the material in vogue of the technology. Allowing greater practical and playful contact of the child with the toy, providing for his therapy moments of joint attention between children-parents or therapists for their color, texture, shape and other characteristics of the material. Through the learning, stimulation and play by providing opportunities to teach social and communication skills, especially if it is in the first stages of life, [14, 18]. However, with 3D printing, the parametric design allows to improve the distribution of any material only where it is necessary for the object to resist regardless of its properties, reducing the waste of resources, time, environmental impact and costs, see Fig. 2, [15].

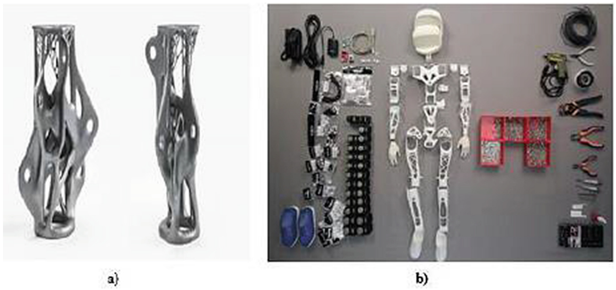

Fig. 2. Structures realizes in impression 3D; (a) Node of acer Source www.cosasdearquitectos.com; (b) The Poppy Components Source www.poppyproject.org.

Study of Possible Forms

A continuation, the geometrical schematics of possible prototypes of the SPELTRA robotic assistant, see Fig. 3:

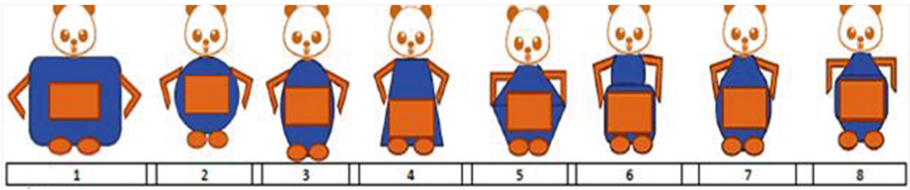

Fig. 3. Geometric scheme of: 1. Current structure, 2. Horizontal oval, 3. Vertical oval, 4. Truncated pyramid, 5. Rhomboid, 6. Guitar, 7. Drop and 8. Mixed.

- Oval consists of the body taking the form of a horizontal or vertical ellipse where the widest part of this protects the electromechanical system of the robot adjusting its orientation to the best aesthetics and functionality of this robotic assistant.
- Truncated pyramid: The housing that makes the body function has a rectangular base of dimensions superior to the electromechanical system and covers the wheels of movement of the robot while the upper base that will be the men is of dimensions similar to the diameter of the head and all the edges or tips will be rounded.
- Rhombus: its body is the union of two truncated cones of different dimensions in height and truncation, but of equal bases.
- Guitar this prototype structure of the robotic assistant consists of two base prisms rounded laterally. In the lower part is the prism of greater width and height that will wrap the electromechanical system of the robot and in the upper part the smaller to

the lower but slightly larger than the diameter of the head and its lower to lower but slightly higher than the diameter of the arms.

- Drop: this body consists of the union of a sphere with a truncated cone. The lower part of the body is form by three quarters of the sphere that will cover the electromechanical part and the robot's travel wheels and the truncated cone covers the upper part.
- Mixed: this prototype consists of three parts: an inverted dome that will cover the wheels of the robot that is coupling to the cylinder that protects the electromechanical system followed by a truncated cone whose height and truncation will be slightly greater than the diameter of the arms and the head, respectively.

Requirements of the Material and Form

Material

In general, the selected material must respond to the needs of the function of the component (physical and mechanical properties), production method available at a prudent cost, with a friendly, and solid and/or light appearance, and must be recyclable. Consequently, the possible materials of the structure of the robotic assistant must have characteristics superior to the PLA in: Resistant to fire, to impacts, to wear, Workability, Durability, Safety, Easy transport, Easy to clean, fast, economic and Aesthetic.

Form

The possible forms of housings, structures or prototypes of the SPELTRA robotic assistant must comply with: Prototype of simple form, of clean appearance, It should help to develop its gross motor skills, easy manipulation, it must be anthropometric, of adequate ergonomics, The shape of the wrap or shell should be attractive, Lightweight structure and Stable structure.

Analysis Technical and Economic

Evaluation criteria for designs in the concepts or projects phase:

- e: score from 0 to 4
- p: is the weighted weight and is given according to the importance of the evaluation criteria from 5 to 10 (low to high)
- Scale of values according to VDI 2225: 0 = Does not satisfy, 1 = Acceptable to jousts, 2 = Sufficient, 3 = Good and 4 = Very good (ideal)

A survey on the shape of the prototype was carried out on 40 children from 8 to 12 years old, which provided the children's preference for the rounded shapes that represent 60% of the total of the survey, predominating the Gota prototype and according to the technical analysis and economic for the possible prototype of the robotic assistant SPELTRA we have that the optimal prototype is the Drop since it is closest to the point (1, 1), with a technical value xi = 0.936 and economic value yi = 0.943, [16, 18].

As for the material, the analysis of 35 materials was carried out; but from the technical and economic analysis we can conclude that the possible materials are: ASA-PEEK-SILICONE with a technical value of xi = 0.90% and economic value yi = 0.84%; since they are closest to the point (1, 1), see Table 1 and Fig. 4, [14, 16].

Consequently we have the optimal geometry to adopt is the prototype drop with the materials to simulate: PLA, ABS, ASA, PEEK and SILICONE.

Table 1. Technical and economic values obtained in the material analysis

Materials	Analysis technical xi	Analysis economic yi
ASA	0,905	0,840
PEEK	0,902	0,840
PEI	0,883	0,798
MADERA	0,881	0,798
RESINA EPOXI	0,856	0,750
SILICONA	0,901	0,840
ALUMINIO	0,851	0,739
IDEAL	1,00	1,000

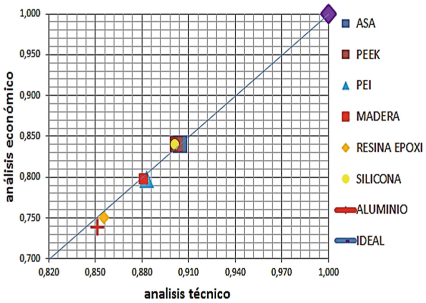

Fig. 4. Resulted of analysis technical & economic of the materials

2.3 Definition of the Geometry, Material, Charges, Restrictions of the Robotic Assistant and Their Discretization

Computer-aided engineering-CAE is the application of computational engineering programs to evaluate the object of study through three phases pre-processing, processing and post-processing [19].

The identification of the objective, variables and restrictions or model is the beginning of the pre-processing phase where CAE's main application is CAD-computer-aided design alongside the FEA-finite element method, which allows an approximate numerical solution to be obtained. a continuous medium in which the equations of motion that characterize the physical behavior of the problem are defined; whose results, to a certain extent, depend on the size of the finite element mesh used [20].

For pre-processing in ANSYS, the type of analysis in this structural case is chosen, then the properties of the materials to be analyzed are entered: PLA, ABS, ASA, PEEK and SILICONE; followed by the import of the geometry carried out in a CAD tool, in this case Inventor. Then enter the different types of variables and restrictions to which the structure to be analyzed is subject.

3 Results

According to the properties of the materials we have in Table 2 that:

- The current structure weighs less if the body is printed on ASA with a similar value of 0.808 N, decreasing the weight by 15.58% with respect to the weight of the body in PLA and 6.7% with respect to the entire weight and by changing the shape it decreases its weight by 25.5%, from 3 kg to 2,235 N.
- In addition, when printing the body drop shape in PLA has a total weight of 2,331 N decreasing by 22.3% with respect to the current structure.

The prototype Drop was then optimize with two alternatives:

Type A: the shape of the head and limbs is preserve but the material is change as well as the screen, battery and a speaker is increased, the latter will be place one on each leg. And type B: differs from the previous one is that in addition to changing the material and internal components the shape of the head and limbs is changed. See weights in Table 2:

Table 2. Summary of weights of the different structures with the optimal materials and their combination.

Simulations del assistant Robotic/weights (N)	Structure actual	Structure witch body of drop	Structure prototype drop type A	Structure prototype drop type B
PLA: weights (N)	3	2,331	2,178	2,152
ABS: weights (N)	2,815	2,242	2,141	2,008
ASA: weights (N)	2,799	2,233	2,127	**1,996**
PEEK: weights (N)	3,062	2,361	2,363	2,393
SILICONA: weights (N)	3,309	2,479	2,585	2,2
ASA – PEEK: weights (N)	2,8	2,233	2,161	2,024
ASA – **SILICONA:** weights (N)	2,8	2,233	2,193	2,053
SILICONA – **PEEK:** weights (N)	3,31	2,48	2,553	2,362
ASA-SILICONA-PEEK: weight (N)	2,8	2,233	2,307	2,118
ASA- **ABS**- **PLA** weights (N)	2,8	2,233	2,157	2,021
ASA- **ABS** weights (N)	2,8	2,233	2,152	2,018

- The prototype drop type A and B the best alternative to be printed the robotic attendant is in ASA because it has less weight, easy handling, exists in the market and has a similar price to PLA and ABS.
- The best alternative in combination is the Drop B prototype in ASA-PEEK has a lower weight of 2.024 N that represents two thirds of the current weight of the robotic assistant, that is, with this combination the 32.5% that represents to 0.976 N less than the current weight. In addition, the weight of the internal components of 1,149 N, this represents more than 50% of the total weight of the robotic assistant. However, another tempting alternative is the prototype Drop type A in ASA-ABS-PLA with a weight similar to 2.16 kg, decreasing by 28%, that is to say almost one third of the weight.

4 Conclusions

- Seven prototypes were analyzed with a simple, clean and appealing appearance for children with SPL or patients, then the robotic assistant SPELTRA adopted the prototype Drop form as result of the survey carried out on children between 8 and

12 years old and, the economic and technical value because the rounded forms generate trust and empathy.

- The current robotic assistant SPELTRA is made of PLA, a material that observed some wear due to the interrelation exerted during the therapy. As result of which 35 materials were analyzed that have a lower coefficient of friction, lower abrasion coefficient, lower coefficient of moisture absorption, a lighter material, with a higher resistance to impact, greater resistance to wear, greater tenacity, with a good resistance to bending, that is not toxic, be insulating, recyclable, among others resulting in possible materials ASA, PEEK, SILICONE.
- The ASA is one of the thermoplastics that can be combining with most polymers available in the market and is economical. Additionally, it is easy to print 3D, optimal for complex molds.
- The PEEK and SILICONE are thermoplastic with some physical and mechanical characteristics superior to the ASA as well as their cost; however, their analysis by weighting placed them in similar condition to be simulate.
- The Drop prototype in PLA is for the immediate future since it only changes the shape of the body square by drop, decreasing its weight to 2,331 N, facilitating its displacement, handling, transport, safety, empathy during the therapies.
- For the near future, the prototype drop type A with the possible materials ASA, ABS, PLA, PEEK, SILICONE was simulated, optimizing its appearance, being the best alternative ASA-PEEK with a weight of 2.161 kg and as a second alternative giving priority to weight we have the combination of ASA-ABS with a 2.156 kg weight.
- For the medium-term future, the Drop Type B prototype was simulated: a robotic assistant with a caricatured appearance with: bear head, drop body and extremities with joints to facilitate handling, transport, functionality, etc., The best alternative is to print it on ASA, this reduces the weight by 34%, which represents more than a third of the weight, 1,996 N, and can be printed on a 1.75 mm filament without affecting the safety of the structure. Regarding the color of the filament in the survey with the highest score, 18 of 40 surveys, is magenta, and then red; but in the last question, what little animal do you like? The color that predominates is the combination of pink, magenta yellow, coffee resulting in a color like reddish or terracotta coffee.
- For a long-term future, it is possible to take as a basis the study of the materials carried out and take advantage of their properties, for example, a graphene battery can be printed, which has a longer life, easy to recharge, lighter and less space, servomotors light, smaller and greater torque in this way would stylize the prototype body Drop type B, decrease volume, decrease weight, improving its appearance and its functionality. In addition, the disguise of a bear, dog, owl, lion, cat, duck and rabbit are the animals that had the highest score in the survey.

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Device Design for the Learning Processes of Children with Cerebral Palsy

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Abstract. Both, practice and education in design in Latin American countries such as Colombia, have been centred in stylistic production of forms directed towards accelerated consumption, under the premises of fashion trends. Consequently, different social problems centred in the relation body-device are left behind, especially those from minority groups, like the children population considered disabled, which require an approach from design that addresses not only the operational and functional aspects, but also those linked to an understanding from the intuitive, affective and emotional factors of their surrounding world. This talk presents the results of the project "LÚ: a system for daily life abilities learning and decision making for children with Cerebral Palsy", carried out by the class of Design for the diverse functionalities from the Faculties of Costume Design and Industrial Design at Universidad Pontificia Bolivariana in Medellín, Colombia.

Keywords: Daily life abilities · Learning · Clothing design · Children Cerebral palsy

1 Introduction

Both, professional and educational fields in design in Latin American countries – Colombia included-, have been centred in stylistic production of forms directed towards accelerated consumption, under the premises of fashion trends. Consequently, different social problems centred in the relation body-device are left behind, especially those from minority groups, like the children population with cerebral palsy, which require an approach from design that addresses not only the operational and functional aspects, but also those linked to an understanding from the intuitive, affective and emotional factors of their daily lives.

As a result, the aforementioned approaches find a place in the reflections of affective and pleasurable design. Among the founding guidelines of this design line are found – in respect of emotional design- the postulates of Donald Norman (1990), who suggests it consists of the design of services and products that are, not only functional and understandable, but also pleasurable – as evidenced at the moment of

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consumption/use. As stated by Norman, said perspective requires an analysis of all the factors related to the Object-Man-Environment triad, as well as an expansion of its users and its own questioning range concerning the perception, emotion, sensation and experience fields, which answers are subjective [1].

Relative to affective design is also the Kansei engineering. It was created in the 70's at Hiroshima University and it is presented as a methodology towards the development of new projects which objective is to facilitate the emotional expectations translation. According to this particular approach, these emotional expectations can be impressions -or stimuli- understood to be the consumer's judgement about a product and which take form, mentally, as luxurious, natural, and remarkable, to characteristics and technical design specifications. Thus, Kansei engineering joins feelings and emotions with the engineering discipline aiming at letting the designer gather the emotional needs of the user which can be transferred to the developed product while satisfying the consumer's expectations. [2].

In addition to the aforementioned, Patrick W. Jordan's (2000) design proposal, suggests that products and services should satisfy three needs in a particular order, as follows: Level 1, functionality: it solves a specific problem; level 2, usability: the product is comfortable, easy and safe to use; level 3, pleasure, besides fulfilling its functional and usability needs, it provides emotional benefits [3]. This classification refers to Abraham Maslow's (1943) postulate, which suggests that human needs are set in a pyramid shaped hierarchical organization and are targeted in an ascending way. This, meaning that once the lower level – the base – needs are met (physiological needs such as homeostasis and nutrition), the other level's needs will also begin to be met, reaching the top of the pyramid where needs related to self-actualization (morality and creativity) are located. Furthermore, Jordan [3] claims that if a product is nor functional, it will not be easy to use. Hence being unappealing and unable to reach the consumer's emotional aspects.

From the previous stances it is clear that affective, pleasurable and emotional design is located on top of the pyramid, as the highest of human needs, as long as basic needs such as nutrition, health and work are resolved.

Nonetheless, in Colombia there are populations as the children with cerebral palsy, whose needs include multiple issues that engross a large spectrum of conditions and that go from daily life basic needs to emotional expectations of the individual. This, meaning that the emotional, affective and pleasurable aspects also aim at meeting those needs that have been considered as basic and fundamental for their everyday life. This statement will be illustrated through the results of the project LÚ: a system for daily life abilities learning and decision making for children with Cerebral Palsy, carried out by the class of Design for the diverse functionalities from the Faculties of Clothing Design and Industrial Design at Universidad Pontificia Bolivariana in Medellín, Colombia.

1.1 LÚ Project

LÚ project was developed with Lupines foundation. This institution is in charge of the habilitation and rehabilitation of children with cerebral palsy in Medellin, Colombia and seeks to provide the environment these children and teenagers need to learn. This, though a comprehensive education, that is based on meaningful experiences which foster their participation in the different aspects of daily life.

Cerebral palsy is considered an abnormal alteration of movement or motor skills. It is a disease of the psycho-neuromuscular nervous tissue, caused by a cerebral motor injury that occurred before, during or immediately after labour. Depending on the type of disorder it could be: Spastic, where muscles are rigid and contracted showing great resistance to movement and affecting motor functions such as walking, object manipulation, food intake, balance and speech; dyskinetic, with alterations in the muscle tone and movement, causing involuntary and sudden movements that can be repetitive, shaky, with alterations in posture control and coordination deficit; ataxic, with weakness and flaccidity of the muscles, generally affecting the lower extremities, causing trouble to walk, sit, as well as balance and coordination, along with making precise movements, key to developing writing skills.

Among the cognitive and behavioral characteristics observed in this research, it is found that children with cerebral palsy have limitations developing speech, short-term and aural memory deficit (trouble remembering heard sounds), auditory processing difficulties (trouble differentiating individual complex sounds and keeping the order of sounds in their short-term memory, affecting the phonological awareness), problems regarding storage and processing of information, deficit in numerical concepts, expressive language, grammar and speech, and limitations in motor skills and social abilities as well as autonomy in different actions of the everyday life.

For these conditions, Lupines foundation offers programs for the development and strengthening of different cognitive processes (such as perception, memory, abstract reasoning, language and execution) through different pedagogical strategies that aim to migrate these lessons from the classroom to the daily life of the individual. One of them is the training program for executing functions, which emphasizes on the following factors: setting tasks' complexity, dividing said tasks in different components, giving clear and simple instructions to help structure and execute the task, using accessible resources, and considering activities that can be carried out from the natural environment of the individual towards the learning of daily life abilities and decision making, all which are included in the courses "Thinking skills", "Daily life abilities", and, "Intimately".

The aforementioned courses are lacking didactic specialized material to address the variety and complexity of the formative situations that convey in the classroom. Therefore, the students and teachers from Design for the Diverse Functionalities from the Faculties of Clothing Design and Industrial Design at Universidad Pontificia Bolivariana, developed a project with the objective of designing didactic material for teacher support in the course "Daily life abilities" which main purpose was to optimize autonomy transfer via decision making exercises, which can be extrapolated and practiced in any situation of the daily life of each child with cerebral palsy.

2 Methodology

The development and results of this project were a co-creative job among the therapists, children in the foundation, parents and teachers from the faculties of clothing and industrial design. All participated in the different design stages, among which it is worth mentioning (Fig. 1):

Fig. 1. Design process used in the project

Research Stage. With the objective of understanding the psychophysical, sociocultural, emotional and technological needs (requirements and restrictions), it included literature review, experts, teachers and parents interviews, participant and non-participant observation, audiovisual register, population statistic study and users' characterization, didactic material analysis (interaction, and operation inside the classroom), class environment analysis, among others. The properties that were determined in this stage are the ones concerning the tensions between the users – in all his/her human dimensions – and the objects, the others and his/her context. It was this stage where the issues to be addressed in the project were identified.

Conceptualization and Conformation Stage. It is this stage where the form becomes tangible through models, mock-ups and prototypes, suggested to each of the tensions that form the users' needs in relation to their context and the others. This aiming at decrease said tensions from functional, operative and morphological dimensions.

Materialization Stage. Here is where the result of the conceptualization process becomes a product. It goes through a testing process to verify functional, emotional, technological and security aspects to, subsequently, be handed over to the Lupines foundation to be used.

3 Results

The result of this project was a system that encouraged the autonomy in daily life decision making, all through games, shapes and figures perception, haptic and proprioperception relations, self-abilities and contextual relations with the devices.

3.1 System's Composing Elements

Lú is an articulated dummy similar shapes and dimensions as the ones of children with cerebral palsy. It facilitates the development of physical and cognitive competences, such as the spatial-visual intelligence related to the orientation ability, from which a child gets to see and identify the parts of the body and relate them to geometrical shapes and sizes. It also allows the child to develop the kinaesthetic intelligence through the control of automatic and voluntary movements, through object manipulation and perfection of fine motor skills. All above, through a series of intelligence and clothing bits that are added to the dummy's body and structured in directed actions (Fig. 2)

Fig. 2. The Dummy.

Why getting dressed?

Getting dressed is chosen from all everyday life activities for it gathers multiple and various actions that take form on our own body and prepare it to be shown in the society [4] This includes, on one hand, operations that encourage proprioception, hand-eye coordination and development of gross and fine motor skills; and on the other hand, a conscious action of choosing while relating to the weather, use occasions and self-image, all actions that aim towards autonomy and independence growth through decision making in the daily routine.

Said activities were divided in four levels: level 1 allows for teaching the sequence of getting dressed and the recognizing inner and outer wear; level 2 allows for generating a relationship between the different parts of the body, their shapes and the clothing; level 3 allows for teaching the use of the different kinds of zippers, mechanisms and accessories found in the clothing; level 4 allows teaching children how to select the most appropriate clothes according to the occasion, the weather and the individual's own identity.

Intelligence Bits. They are a tool that is proposed in the Glenn Doman method that involves cards with graphic information (28×28 cm) corresponding to clear images of the objects, animals or any other concept that needs a representation. In Lú's case, they are words related to the act of getting dresses and daily life activities. The images are high quality photographs that represent reality so that the brain of children with cerebral palsy do not have the possibility to just guess the answer. Its methodology is based on the display of concise and fast visual and aural data, through information cards, for short stimuli are more efficient that those long ones. For this reason, said bits change repeatedly with great enthusiasm in several short sessions to attract the attention and motivation of children.

Following the previous process is how children learn new classified and structured terms and meanings that help him/her develop and expand language, vocabulary and memory. It is a method that significantly favours all stages previous to this one Fig. 3.

Fig. 3. Intelligence bits related to daily life activities (frontal and posterior).

Wearable bits are the tridimensional, device-shaped variation of the intelligence bits. Their purpose is to represent concepts related to clothing and their relation with body segments. They are presented as follows: (1) Geon-like wearable bits. They are simple volumetric elements that allow children establish a direct relationship between the shapes of both, the piece of clothing and body Section. (2) Clothing bits. They allow children to dress the dummy or themselves after understanding the connection there is among the shape of both, the clothes and body segment and the use of the clothes. (3) Mechanisms bits. These allow children understand and operate the different devices – such as buttons, zippers, brooches, different accesses, among others – present in the clothes to guarantee its functioning.

These bits aim to support practically the art of getting dressed. Their name uses the name first coined by Glenn Doman 'Intelligence bits' which refers to them as learning tools to be utilized in the act of getting dressed (whether it implies getting the dummy or oneself dressed) (Figs. 4, 5 and 6).

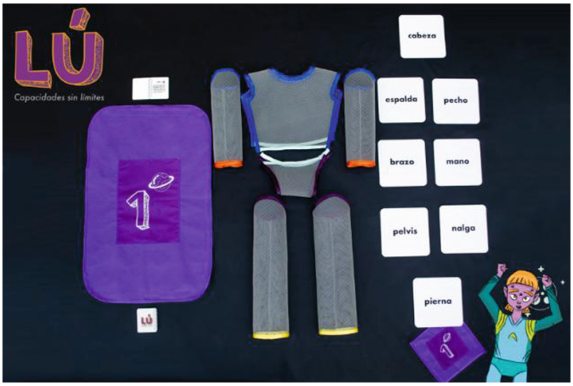

Fig. 4. Wearable bits, geon type

Fig. 5. Wearable bits, clothing

Fig. 6. Device wearable bits

Base and Rack. These are different parts which function is to keep the system in a vertical position and store its different elements. The base serves the purpose of a container for the bits. The Rack is formed by a metal structure that comes from the middle of the base and is in charge of holding the dummy (from the waist) and the wearable bits (which hang from clothes hangers and are protected by dress-covers) (Fig. 7).

Fig. 7. Complete Lú system

Manuals and Use Guides. We suggest two types of instructions: the first ones indicate to the teacher or therapist every step of the activity and include a narrated fiction guide in which Lú is one of the characters. The second type is a manual that compiles the technical information such as usability recommendations, device care, among other important aspects for a correct use to guarantee durability.

4 Conclusion

A person with a disability will be more autonomous and will be able to lead a normal life if their physical/material world – objects included – is adapted to them. It is, then, on this dimension where the designer can act, controlling those incapacitating external factors that condition the level of social participation of these minorities. For design, inclusion is an opportunity to focus on other products' categories that go beyond the idea of accelerated consumption and, instead, become a possibility to improve daily life activities, the execution of habilitation and rehabilitation processes, and, in general, to promote skills' development in groups with a disability. All this, leading to social processes of inclusion and the education of individuals more and more autonomous and independent that are no longer in a disability situation.

To create a product that is able to positively impact the reaching of a high autonomy level, it is necessary to count on an interdisciplinary team that comes together around the design process. Disciplines such as psychology, pedagogy, physiatry, etc., will allow the identification of contextual element – learning styles, contents – and the definition of the interactivity according to the chosen pedagogical and didactic strategies – Lupines Foundation and its work model based on the Glenn Doman method.

The concepts of accessibility and inclusion are being studied by the Design faculties in Colombia. This implies taking into consideration multiple design discourses and theories, like the Human Centred Design. Critical Design, Autonomous Design and Design for Behaviour Change, which invite to create a compromise among the design professionals and the people in their contexts and particular situations.

The aforementioned brings along multiple considerations about design teaching in Colombia that promote projects highly contextualized. This means, projects that answer to specific needs, which implies leaving the classroom to face different daily life situations and sharing with people in order to design not only for them but also with them. Hence, introducing to said projects different discourses and research tools that will help unveil social issues and translate them into design problems.

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Design for Inclusive Environments, Materials and Multisensory

Design for the Sensitive Experience: Inclusive Design in Historical-Archaeological Contexts

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Abstract. The Research Project deepens objectives, tools and methods of a design sensitives to human perception and senses and it's finalized to the acquisition of Community involvement, basing on an agreement with a public administration, the Municipality. The range of city_users involved are people with special needs or disabilities who, thanks to a dedicated platform and a help desk at Municipality offices, can give a contribution to the research and to the city plans of outdoor archaeological paths, heritage sites, adaptive-ergonomics urban furnishings and sustainable mobility. The ouputs expected from the research are the Creation of a map of accessible itineraries and a consequent mobile systems application; in addiction the creation of connections of "mental topographies" generates a new layer of the map, an emotional map of the city users. In Europe contexts, the possible developments are the publication of Guidelines and a recognized certification mark.

Keywords: Environmental psychology · Community involvement Emotional map · Sensitive experience · Emotional barriers · Human-senses Accessible tourism

1 Introduction

The sight reveals what the tact already knows[1].

Architecture reinforces the human experience and elicits multiple interconnected reactions that go beyond the *five senses.*

The space determined by the architecture is not lived solely with the common senses; the architectural space stimulates not only the sight, but also the memory, the sense of balance, the sense of movement, the language and the thought.

The architectural space embodies an experience made of multiple sensory.

The hands want to see, the eyes want to caress[2].

All the senses, including the sight, are extensions of **touch**; as Juhani Pallasmaa said, *senses are specializations of the epidermal tissue and all sensory experiences are ways of touching*. Therefore, experience the space is has always be connected to tactility.

[1] from The Eyes of the Skin, Juhani Pallasmaa.
[2] A notion of Johann Wolfgang Goethe.

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Tactility, moreover, creates a precious *sensorial memory* in user's mind. The perception of materiality, distance and spatial depth, would not be possible without the help of the **tactile memory**. Many of the contemporary architectural experiences, in the most recent exhibitions, installations and displays where senses are involved, sometimes risk to divert the attention from tangible architecture, that of the present, that of the past.

The architectural space frames, strengthens and focuses our thoughts, avoiding that they are lost. *Outside we can feel and perceive our existence but we need the architectural geometry of a room* (see Footnote 1).

The measure of civilization and democracy of a country is how it treats its weakest members[3].

Academic researches allow to the voice of the few to be heard by many.

The Design expresses the contemporary, but desires the future. It can represent people dreams and emotions, something that doesn't exist yet, but that lives in the future. Research is the tool to reach it, it aims to the change.

The European Commission for Economic & Social Committee of The Regions within the European Disability Strategy 2010–2020[4] has remarked how it's important that people with disability can be involved in all the cultural activities, and that can benefit of artistic heritage. The EU has encouraged the investments in projects that promotes an inclusive design able to make *people with diversity* feel treat as part of the community, as "common" users.

Design for the sensitive experience[5] focuses on a study that **starts from the importance of diversity** in the perception of the space and the architecture, as well as in the design process.

The goal is to find out the principles who take in count both the discipline of human psychology and the environmental psychology and the architectural project design. These are the objects of examining human reactions, behaviors and perceptions in contexts such as contemporary cities (crowded spaces, pedestrian areas, attractive poles, city segmentations), residential places, institutional spaces, orientation and exploration of cultural places and museums.

Colors, lights, affections and elements connected to the places are investigated as elements able to determine the well-being of the user.

Thanks to the agreement with a Public administration the Research experience has the possibility to have a direct comparison with the city users: the "experts" of the space able to deepen the connection between architecture, installations of exhibits and

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[3] A notion of Gandhi, from the website Associazione Design for all Italia: http://www.dfaitalia.it/.

[4] European Committee on Culture and Education, Rapporteur Mircea Diaconu, *Towards an integrated approach to cultural heritage for Europe* (2014/2149 (INI)).

[5] Phd Student Startup Project: "*Progettare per l'esperienza sensibile. Accessibilità, facilità fruitiva e chiarezza comunicativa nel progetto urbano. Il caso del centro storico di Roma: abitazioni, servizi e spazi pubblici, luoghi di interesse culturale*", funded by Ateneo Sapienza, Università di Roma in 2017.

paths through the study of their experience. The historical city space is investigated starting from the analysis of objectives data, tools and methods of a design sensitive to a *human parameter*.

The Research compares the reality of a historical Center as the one of Rome, and its archaeological areas, pre-existing naturalistic-monumental sites, and other assets of cultural interest, through the examination of national and international cases.

2 Community Involvement

A designer who does not possess physical or cognitive characteristics, who doesn't have particular needs that characterizes all the *weak users*, needs a support during the design process by these persons who detain the knowledge of what's needed and what's not.

People with disabilities are, in fact, experts in the field of accessibility. The support in the design phase by citizens as users of areas of public interest, is a determinant factor for the success of the project. The research promotes the Community Involvements in the Design process, to study the sensitive experience, the senses of men and their role in the spatial experience. In particular, the perception of users of Rome city and the role of communication in shared areas and the principles of the *Design for All*.

In the Phd Research activities citizens have been actively involved, through a link activated with the Municipality of Rome in the PhD student's 2017 Startup Project. Thanks to pictures and videos taken in the city center, during meetings organized in collaboration with the Municipality, the Research investigates the *state of the art* in the specific context. Meetings are planned with the daily care centers for people with disabilities, seniors, frail elders and persons with Alzheimer's disease.

Users needs and perceptions are identified through the activation of *participatory processes* and through the surveys and direct experiences, especially of the "weak" users.

The research aims to demonstrate how emotional factors generated by a context are decisive in the behaviors, judgments and choices of people; especially for people with specifics diseases. This is why these people are *key elements* in the development of cities and in the valorization of the historical heritage.

3 Case Study

The research compares national examples, the Italian historical centers in comparison with the case of Rome, and in particular we examine cases of accessible archaeological areas. A second part is dedicated to International examples and testimonies of prominent personalities in the field of accessibility. The setting up and the narrative paths in the historical fields are examined, and the *Performing Media* art in exhibit contexts, evaluating in particular experience offered by tools, strengths and limits, operative elements, outlining the methods.

3.1 Rome

The city of Rome presents many public areas of cultural, social, historical and naturalistic interest, spread all over the territory. The accessibility to these areas has became an integral part of the shared space. To guarantee accessible accesses, routes, clear informations and indications, a good relation with the environment is fundamental as much as the view points, able to make feel welcoming the city users (Fig. 1).

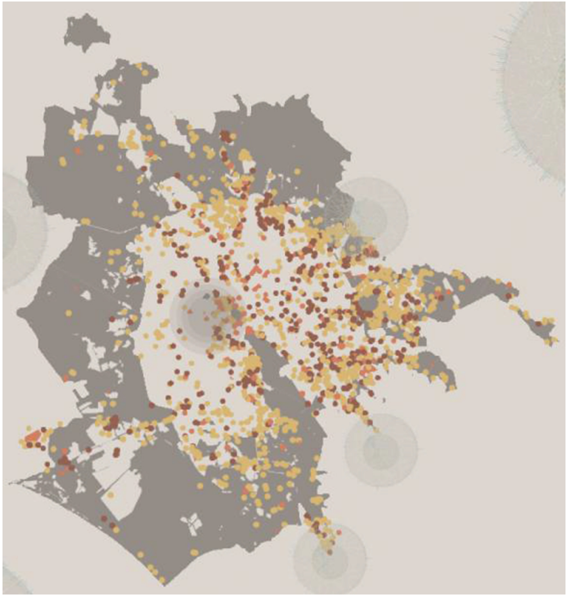


Fig. 1. The widespread historical roman areas.

3.2 Parameters

The space is investigated according with the following parameters:

1. **Physical state of the space.**
   Objective factors that can define the accessibility of:
   - roads
   - pavements
   - steps
   - accesses of the main buildings
   - historical and archaeological spaces
   - adaptive ergonomics of furnishings
2. **Invisible factors of the space.**
   Subjective, emotional reactions in relation to the perception of space - the *city user*:
   - subjective perceptions

– personal sensorial stimuli received by the context, able to influence the user's level of well-being in many ways (Fig. 2).

Fig. 2. Research Experience in historical sites and Rome's roads together with a person with motor difficulties.

Design for sensitive experience highlights the narrative potential of the cultural contexts of a historical city, investigating its "hidden" values in continue interface between the human being and the space of *urban crossing*.

What is important to define is how to "extract" the sensitive indications, and inclusive design guidelines useful to elaborate a code - a convention - an agreement - of an empathic design equipment, to exceed the common practical commitment of the *simply* "breaking down" of barriers.

The experiment, linked to the aforementioned objective, focuses on the definition of inclusive itineraries and outfittings dedicated to *the person* and to its perception, besides the usual historical context.

4 Research Process and Method

Analysis and study of the disciplines related and of the representative models are the starting point of the research.

Reports of accessible archaeological paths, are drawn on a cartographical support and the parallel study of exemplary solutions created in the best Inclusive Design Projects (nationals and internationals) support the action of the investigation of different objectives, methods and techniques of intervention.

Research Process:

1. Surveys and documentation of the state of the art.

2. Active participation of citizens in the examination of accessibility conditions of the main roads and the analysis of space perception together with the related stimulation of the senses.
   Data are collected through:
   - **Questionnaires**
   - **Interviews**
   - **Pictures, audio and video records of *Cultural Promenades* with citizens organized with the Municipality**
3. Experimentation of the last technological tools for the examination of the emotions
4. Studies and analysis of the emotional state thanks to a detection equipment
   - **Workshops**.

4.1 Questionnaires

The Phd student has elaborated five formats of Questionnaires uploaded on the Municipality website[6], that people can download, fill out, send it back and receive a feedback and a personalized Design Advice, free of charges (Table 1).

The five surveys are different, specific for each user:

1. Users with physic problem/impairment
2. Blind Users or with a law vision
3. Deaf users or hearing impaired
4. Users with cognitive problems
5. Tourists.

4.2 Interviews

The interviews work in parallel to the other activities and aim to investigate the following topics (Fig. 3):

- The Sensible Experience.
- Perception of space and the relationship between environment and person.
- Stories and narratives: experiences in the foreground.
- Environmental sounds - the “voices” of the historical center[7].
- Views on the context: characteristics of observation points, perceived effects, views, perspectives in motion.
- “Chromography”: the colors of Rome.
- The olfactory parameter in the city.
- Proxemics and personal user space.
- Nature stimuli of the senses.

[6] See the website: https://www.comune.roma.it/pcr/it/newsview.page?contentId=NEW1830175.

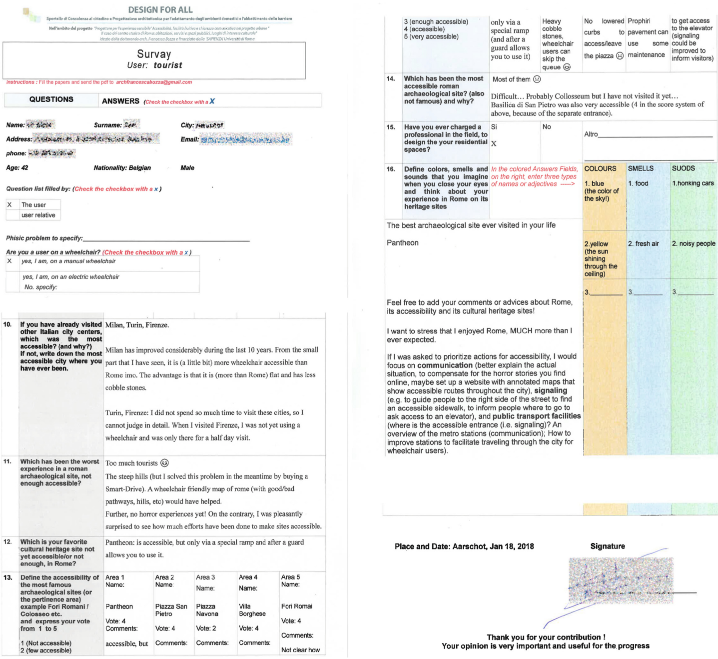
[7] “Human being still enjoys variety, including variety of sound.”, Rasmussemìn, S.E. Experiencing Architecture.

Table 1. Few examples of the questions parts of the questionnaire for people with motor-releted difficulties

	A	B	C	D	E
Has the roman accessibility level influenced your decision to go out?	Always	Quite	Few	Never	Other
Has the organization of the visits to the historical heritage sites stressed you?	Always	Quite	Few	Never	Other
Which has been the worst experience in a roman archaeological site?	____________________ ____________________ ____________________				
Vote the accessibility of the most important archaeological sites visited (1 not accessible 5 very accessible)	Site 1 Vote:	Site 2 Vote:	Site 3 Vote:	Site 4 Vote:	Site 5 Vote:
Does panoramic point parapets allows you to have a good landscape view?	Always	Often	Sometimes	Never	Other
Close to the principal cultural sites, are the information located at the proper hight?	Always	Quite	Few	Never	Other
What do you think about the accessibility of the main roads connected to the monuments that you've visited? Write down here the monuments/sites 1. ____________ 2. ____________ 3. ____________ 4. ____________ 5. ____________	accessible	quite accessible	For an half accessible	Definitely not accessible	Only the following site was totally accessible ________ ________ ________ ________
Define colors smell and sounds that you imagine when you close your eyes and think about your experience in Rome on its heritage sites	Comments: ____________ ____________ ____________ ____________		Colors	Smells	Sounds

4.3 Surveys and Cultural Promenade

The identified Paths are highlighted on a **cartographic support** and put in relation through the elaboration of a "network" of archaeological areas and main points of interest. Objective and subjective data are examined, proceeding towards the definition of a graphic elaboration, developed on different layers.



DESIGN FOR ALL

Sportello di Consulenza al cittadino e Progettazione architettonica per l'adattamento degli ambienti domestici e l'abbattimento delle barriere

Nell'ambito del progetto "Progettare per l'esperienza sensibile" Accessibilità, facilità fruitiva e chiarezza comunicativa nel progetto urbano" Il caso del centro storico di Roma: abitazioni, servizi e spazi pubblici, luoghi di interesse culturale" ideato dalla dottoranda arch. Francesca Bozza e finanziato dalla 'SAPIENZA' Università di Roma

Survay
User: *tourist*

Instructions : Fill the papers and send the pdf to *archfrancescabozza@gmail.com*

QUESTIONS	ANSWERS (*Check the checkbox with a X*)

Name: [redacted] *Surname:* [redacted] *City:* [redacted]
Address: [redacted] *Email:* [redacted]
phone: [redacted]
Age: 42 *Nationality: Belgian* *Male*

Question list filled by: (Check the checkbox with a x)

X	The user
	user relative

*Phisic problem to specify:*__________

Are you a user on a wheelchair? (Check the checkbox with a x)

X	*yes, I am, on a manual wheelchair*
	yes, I am, on an electric wheelchair *No. specify:*

10.	**If you have already visited other Italian city centers, which was the most accessible? (and why?) If not, write down the most accessible city where you have ever been.**	Milan, Turin, Firenze. Milan has improved considerably during the last 10 years. From the small part that I have seen, it is (a little bit) more wheelchair accessible than Rome imo. The advantage is that it is (more than Rome) flat and has less cobble stones. Turin, Firenze: I did not spend so much time to visit these cities, so I cannot judge in detail. When I visited Firenze, I was not yet using a wheelchair and was only there for a half day visit.
11.	**Which has been the worst experience in a roman archaeological site, not enough accessible?**	Too much tourists ☺ The steep hills (but I solved this problem in the meantime by buying a Smart-Drive). A wheelchair friendly map of rome (with good/bad pathways, hills, etc) would have helped. Further, no horror experiences yet! On the contrary, I was pleasantly surprised to see how much efforts have been done to make sites accessible.
12.	**Which is your favorite cultural heritage site not yet accessible/or not enough, in Rome?**	Pantheon: is accessible, but only via a special ramp and after a guard allows you to use it.

13.	**Define the accessibility of the most famous archaeological sites (or the pertinence area) example Fori Romani / Colosseo etc. and express your vote from 1 to 5** 1 (Not accessible) 2 (few accessible) 3 (enough accessible) 4 (accessible) 5 (very accessible)	Area 1 Name: Pantheon Vote: 4 Comments: accessible, but only via a special ramp (and after a guard allows you to use it)	Area 2 Name: Piazza San Pietro Vote: 4 Comments: Heavy cobble stones, wheelchair users can skip the queue ☺	Area 3 Name: Piazza Navona Vote: 2 Comments: No lowered curbs to access/leave the piazza ☹	Area 4 Name: Villa Borghese Vote: 4 Comments: Prophiri pavement can use some maintenance	Area 5 Name: Fori Romai Vote: 4 Comments: Not clear how to get access to the elevator (signaling could be improved to inform visitors)
14.	**Which has been the most accessible roman archaeological site? (also not famous) and why?**	Most of them ☺ Difficult… Probably Collosseum but I have not visited it yet… Basilica di San Pietro was also very accessible (4 in the score system of above, because of the separate entrance).				
15.	**Have you ever charged a professional in the field, to design the your residential spaces?**	Si X	No	Altro__________		
16.	**Define colors, smells and sounds that you imagine when you close your eyes and think about your experience in Rome on its heritage sites**	*In the colored Answers Fields, on the right, enter three types of names or adjectives ----->*	COLOURS	SMELLS	SUODS	

	COLOURS	SMELLS	SUODS
The best archaeological site ever visited in your life	1. blue (the color of the sky!)	1. food	1.honking cars
Pantheon	2.yellow (the sun shining through the ceiling)	2. fresh air	2. noisy people
	3._____	3._____	3._____

Feel free to add your comments or advices about Rome, its accessibility and its cultural heritage sites!

I want to stress that I enjoyed Rome, MUCH more than I ever expected.

If I was asked to prioritize actions for accessibility, I would focus on **communication** (better explain the actual situation, to compensate for the horror stories you find online, maybe set up a website with annotated maps that show accessible routes throughout the city), **signaling** (e.g. to guide people to the right side of the street to find an accessible sidewalk, to inform people where to go to ask access to an elevator), and **public transport facilities** (where is the accessible entrance (i.e. signaling)? An overview of the metro stations (communication); How to improve stations to facilitate traveling through the city for wheelchair users).

Place and Date: Aarschot, Jan 18, 2018 **Signature** [redacted]

Thank you for your contribution !
Your opinion is very important and useful for the progress

Fig. 3. A questionnaire filled by a tourist.

Each corner of space is reported on a map, highlighting

- Pavements,
- Any presence of steps
- Path safety level

Topics investigates:

- Discomforts deriving from physical, perceptive and sensorial disabilities are expressed in particular in historical urban contexts.
- Sampling of "differences" and related specific issues.
- Identification of "hidden differences": potentiality - opportunities.
- Material and emotional obstacles: from physical barriers to emotional barriers.
- The link with **Neuroscience**[8] and Neuroaesthetics.
- The environmental psychology

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[8] Zeki, S.: Con gli occhi del cervello. Immagini, luci, colori. di Renzo Editore, Roma (2011).

- The importance of the green, colors, smells, and pleasing sounds for people mood and well-being
- The importance of an Ergonomic Design in the furniture and in the interactive set-ups for the relations between citizens
- **Soft mobility** - the urban transformation
- **Wayfinding** orientation systems.

The study structures the analysis on many layers, creating *a multiple "maps"* syntheticl to define, through their overlapping, a **walkable map** that highlights sensory pathways able to stimulate the emotional state and well-being of users (Fig. 4).

Fig. 4. A Picture taken during a cultural promenade. The photograph represents a good pavements made in the historical centre, with a smooth surface.

4.4 Workshop

The agreements with Municipality, has also considered, together with the cultural promenades, a couple of workshop experience, to organize within the meetings with the citizens.

Title: ***The game of senses***

The plan of the workshop develops the activities in 60 min and aims to encourage a discussion about the re-education of people as part of the community, as **city users** positively open, with own opinions, roles, competences, needs, feelings, perceptions.

−10 minutes: The dialogue starts from the research reports, reflecting on videos, pictures of promenades conducted with citizen in the historical city.

−25 minutes: GAME. While part of participants write down considerations on a furnished map, a group of them start to experience the space focusing the attention to sensations received by the environment:

- One with eyes closed, walks around the space.
- Second one moves on a wheel chair.
- Third one will closes his eyes trying to connect with the sounds and smells, records the audio
- Another will step away from the group observing the rest of people, unable to hear their words, investigating the body language and the environment. Participants will exchange the roles until the end of the hour, drawing a sensorial map, included tracks crossed with closed eyes, sounds perceived and the ones recorded. They will obtain a new kinds of map…

−15 minutes: After that, participants draw and write down informations, reflections about the impressions received by the experiences.

−10 minutes: Display of easy-walk/info_maps drawn! Participants will try to define difficulties observed and suppose tools and strategies of a dedicated Inclusive Design appropriate for cities centers.

5 Output Expected and Research Products

The first expectation is that the thesis allows to define ex_novo:

- Thematic and Inclusive itineraries able to connect the "affections" to the places
- Decrypt and connect the various "mental topographies" to each other
- Create an "atlas of emotions" in continuous movement.
- Draw up an **interactive** map of historical narrative paths, developed on multiple levels of perception, defining a map based on the principle of spatial cognition and determining the needs and expectations of the users.

The interactive map will be designed on a software application, so that it can always be implemented, as a Walkable Map of a network of historical and archaeological areas of Rome, in the definition of an emotional map constantly evolving. A subsequent development of the walkable might be an application in an **Open Source network.**[9]

The second expectation is to elaborate Basic standards formulation of **Guidelines** that aim to:

- enhance the narrative paths of the historical city
- promote the multi-sensory urban experience
- promote accessibility in the urban sharing spaces
- expanding the Design for All principles to historical and cultural contexts.

Third, to identify the **parameters** necessary for the definition of a ***certification*** based on the different level of inclusion of the sharing spaces, especially in cultural and historical contexts. In addition to the elaboration of a new concept of city map, *the emotional map,* are the drafting of exemplary designs and **Guidelines** for a network of accessible cultural sites: a *historical city for all*, suitable for obtaining a new type of **certification: an inclusion certification**.

[9] Ratti, C.: Open Source Architecture towards an open design. Giulio Einaudi Editore, Turin (2014).

5.1 The Walkable Map

The output of the research is a walkable user_map, an interactive map as a rewriting of space through "bottom-up" participation. The different cartographic levels represent sensorial, motor, perceptive and emotional aspects of cultural areas, both punctual and widespread. As for the explication of acquired acquisitions, on the basis of the experiences of the neighborhood promenade we will proceed to the drafting of different "layers", each related to different objective parameters (physical, spatial, environmental and natural parameters) and subjective (perceptual, sensory, cognitive…) that allow, through the overlapping of graphic data, the possibility of their synergic communication "collaboration".

With regard to the mapping system, the different layers will be differentiated:
Physic accessible map | perceptive map | sensory map | cognitive map

- These map layers will define an additional one:

the emotional sensitive map.

5.2 Guidelines

In order to be able to give an attribution of the level of inclusion, the project manager, the designer, the technicians have to know how to design an inclusive space.

For an inclusive design of cultural paths, the project have to follow sensitive and emotional parameters, basing on users needs and their perceptions, especially in the public buildings, sites of cultural interest, particularly archaeological (the most difficult), as well as historical paths, dedicated to soft mobility.

A depth development of the Guidelines will be presented to the European Commission that will be able to mach and implement the tools and the research results, in order to establish a:

certification of accessibility

The research intends to carry out a systematic collection of data - elements relating to the motorial, mental, perceptual and emotional experiences of places and things belonging to the reference context.

The idea of laying cartographic bases and standards, is preparatory for the elaboration of a Map of the accessibility of a historical center, built through a census of the users' sensibilities.

5.3 Open Source Platforms

Mapping an area can have multiple functions, to acquire data, to plan an urban area; it's an action that requires analysis and cartographic representations of the reality.

There are multiple ways of representing and graphing a context, also thanks to the advent of new softwares that allow infinite developments, readings and design actions.

Currently there are many Research Departments of Architecture in several Italian universities (Turin, Milan, Ferrara, Bologna, Naples) that have published an Open Source **platforms** for the mapping of cities, activating a "bottom-up" process in collaboration with the municipal administrations.

However, these projects still have to be defined, but there is the potentiality to determine the basis for the development of new standards that include the *diversity* as part of the ordinariness.

The map can be shared in an open source network system because users can add their impressions, experiences and advices, helping to improve citizens' life, together with the development of the accessible tourism, that's allow also an economic profit.

The research would like to spread an important message.

What's considered the best solution for people with disabilities, does not imply that it's not also for people without disability, actually it might satisfy both with the same intensity.

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Inclusive, Active and Adaptive Design as Approaches to User-Centered Design

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Abstract. The paper analyzes the evolutionof user-centered design in a variety of approaches that have been established in the history of architecture. It leads up to the current tendency to consider the designed environment as a physiologically prosthetic phenomenon inasmuch as it favors behavioral objectives while maintaining certain requested states that are physiological and behaviorally prosthetic due to the fact that the designed environment intentionally configures specific behavioral topographies. Therefore, the degree of a design’s quality and the various scales to which it is referred follow from its ability to interrelate on a human scale; that is to say, the capability of physical elements to confront the factors that characterize a design focused on well-being: inclusive, active, and adaptive.

Keywords: Human factors · User-centered design · Anthropometric approach
Anthropocentric approach · Prosthetic space · Inclusive design
Active design · Adaptive design

1 User-Centered Design

Design is one of mankind’s fundamental actions. Through our interactions with the natural or artificial environments we enact strategies that allow us to improve our living conditions. Suh [1] posits that design is an essential activity that determines the creation of systems; that is to say, it associates the needs of the user with a system capable of responding to those needs with appropriate solutions [2]. Design done correctly should therefore adopt an anthropocentric view in observing the relations that are established among people, systems, and the environment, in order to design the latter in a manner that serves anthropometric, physiological, cognitive, social and cultural needs. “Design on a human scale” is a motto that has entered into the vocabulary of architectural planning, although it has almost always limited its reference to human subjects to certain particular aspects in the interaction between people and systems. This concept is sometimes linked to issues that are purely anatomical or metric, and on other occasions connected to the sphere of perception or cognitive processes. Throughout the history of architecture it is possible to highlight two primary tendencies in the approach to user-centered design. Although these two share the objective of improving people’s well-being in accordance with the environment, they differ in their meanings and in their strategies of human-space relationships (Fig. 1).

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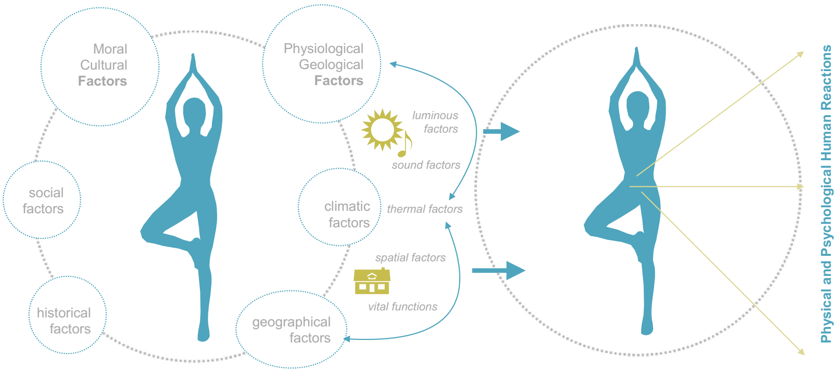

Fig. 1. Representation of the human-environment interaction according to Olgyay. Human reactions are related to the physical elements of the environment. Graphic reworking by V. Olgyay, Designing with the climate, Muzio, Padova, 1981, p. 13 and p. 30.

2 Anthropometric Approach

When we use the term "measurement," we refer to the dimensional measurements of the individual. These measurements are not seen as static but rather in terms of potential movements in space within which the user (with his/her body) can assume an infinite number of positions capable of being measured and suited to defining compatibility between the individual and space. The first approach deals with architecture as a "measurement" of human activity and therefore aimed at seeking out forms and proportions capable of ensuring a correlation between architectural structures and human characteristics. It involves the study of the relationship between human measurements and the spatial measurements that individuals inhabit on various scales. Ancient civilizations designed their structures on the basis of abstract units of measurement, setting the framework of their structures in relation to the dimensions of the human body in the conviction that good form developed out of the study of anatomical proportions was one in which man could "live better" [3]. The precepts of the reign of the pharaohs, the time of Ptolemy, and that of the Greeks, Romans and Polykleitus have reached our modern age. For example, the treaties of Polykleitus were long held to be a fixed standard; the same is true for the theories of medieval figures such as Alberti, Leonardo da Vinci, Michelangelo, and foremost for the well-known work of Dürer [4]. In all of these theories, the human body is measured on the basis of the length of the head, the face and the feet. These measurements of length are then divided and put into relation with one another, thus bringing about standards of general use. From the Greeks until the modern movement, the interaction of human-systems has been linked to a purely aesthetic discourse, where anatomy and metrics are used to define a system of proportions that make up the measurement needed to shape architecturally perfect forms. Through his use of the philosophical stances of Plato and Aristotle, who had placed man at the center of the universe's measure, Vitruvius himself designed in proportion to the human body [3].

With the advent of the modern movement, the issues of functional optimization, ergonomics and organizational efficiency emphasized the necessity for the best possible planning of the architectural space to serve the living needs of those who used a given space. Although it continued to prioritize the individual as reference point in designing buildings and structure, rationalist thought focused its attention on the need to face hygienic and epidemiological features that had been aggravated by phenomena of urban migration caused by the industrial revolution. This approach to design, called Optimized Design, refers to an ideal user model that results from an abstract average of the characteristics of the real population. The same is true of Le Corbusier's modulor, which appears as an articulated system of harmonic dimensions related to the human scale and a universal instrument for the proportioning of all designed systems [5]. The subject to which architectural design relates continues to be a standard individual with his/her functioning and uniform, predictable behavior from which it is possible to prefigure his or her life spaces. That being said, optimization involves the choice – among comprehensive alternatives – of the best design solution to satisfy a specific objective. We might say that the Optimized Design approach renders the system more reliable, or rather that the system will most likely achieve the task for which it was designed [6]. It is no coincidence that the principle of *exisistenzminimum* reduces living areas to sizes that are more suited to the "development of the primary vital functions, which are considered the same for everyone and thus capable of producing optimum living spaces" [7]. This sort of approach has then evolved toward "exclusive" forms of design planning that are aimed at optimizing design in relation to specific categories of use (youth, couples, the disabled, the elderly etc.), thus making them no longer optimal for other categories [8]. This is also true of Barrier-Free Design, which sees architectural barriers as the main hurdle to be overcome. Further elaborating on ideas linked with Optimized Design, it sees the wheelchair-bound user as the reference, who becomes the new standard for "exclusive" design [9]. Once again, we find the concept of measurement set between the user and the space as an instrument to define dimensions and universal rules (Fig. 2).

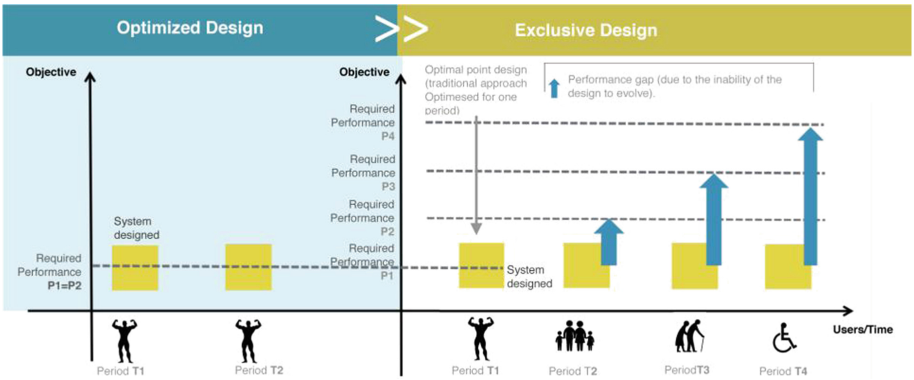

Fig. 2. The first generation of user-centered design, from Optimized Design to Exclusive Design.

3 Anthropocentric Approach

Alongside the anthropometric view in the modern movement, a second user-centered approach has developed in parallel with organic architecture. This approach involves a growing attention to physical-psychological features in the designing of space. The constructed environment is developed in relation to the experiential dimension of human beings. Consequently, Wright states that “a building consists not in four walls and a roof, but in the space enclosed, in the space where one lives”. These ideas give rise to an anthropocentric model where the individual is no longer simply measured in proportional and three-dimensional terms but rather in metabolic and physiological ones through the consideration of the physical and psychological reactions caused by environmental stimuli. These stimuli occur through the use of constructed spaces and may be in light, sound, spatial or biological forms. The design of the habitat is thus no longer limited to physical-formal features but is now also focused on the immaterial determinations of the design [10]. It is oriented toward environmental design, aimed “at the management of the invisible, of immaterial phenomena that often contribute to determining the quality and character of a place” [11]. New “need-fulfilling territories” emerge, meaning places of singular relation between the user and the space, “a sense of belonging, a sense of inclusion and personal involvement, which in anthropological terms renders the space we inhabit the humanizing context of individual beings” [12]. According to this systemic, organic approach – which connotes the research of a variety of scholars starting from the 1950s [13–19] – the object of design is a “system-organism”. This idea raised by Ciribini [20] states that the object is no longer form/essence but rather the result of the interactions of the elements resulting from the internal organization of the conditions, pressures, and limitations of the environment [21]. Furthermore, “in its original vision, though with different nuances and with a different awareness”, Environmental Design’s objective was “the well-being of the human being in his/her life environment” [22], exploring, understanding, and systematizing the expectations of the inhabitant and adopting design solutions based on cognitive input referring to a plurality of disciplinary fields (anthropometrics, ergonomics, proxemics, physiology, sociology, psychology etc.). With the arrival of ecological challenges, however, this complex view of environmental design as an integration of knowledge underwent a progressive leveling off into issues of energy saving, losing its essential connection to the relationship among the individual, space and society [23]. Design trends that follow from this anthropocentric design vision (see Universal Design, Ubiquitous Design, Sustainable Design, Environment-friendly Design), in spite of the consideration of a series of neglected factors – care for “non-standard human beings”, the need for an urban environment able to respond to the needs of users and their different abilities, the importance of a city’s life cycle, and the conservation of the natural environment – maintain a sector-specific relationship to design. From standard-oriented design, we move toward Universal Design, Inclusive Design and Design for All, with the concept of designing “for all” with the aim of enhancing the possibility to live independently [9]. Among these methodologies, Universal Design – as it is defined by the Center for Universal Design in the Design School of the University of North Carolina – is “the design of products and environments to be usable by all people, to the greatest extent possible, without adaptation or specialized design". This definition clearly demonstrates how in Universal Design user-centered design no longer refers to "special" or "dedicated" solutions, but to products, places, and services that have been conceived for use on the broadest spectrum possible without requiring modification. From design centered on the single user, we move to design for people in general, and solutions that are compatible to the needs of everyone, and therefore not optimized to the specificities of individual users. Despite the awareness of the need for design to be able to satisfy the needs of the widest range of users, the user-space relationship is aimed at "usability" through universal solutions, "indeterminate" and "passively adaptable" spaces [24, 25]. Flexible Design [26, 27] is an additional approach that provides solutions that are spatially and technologically flexible. It facilitates the changeability of a space, guaranteeing the optimization of the designed system not in a single period, but over numerous periods of functioning, allowing the system to adapt to the changing needs and capabilities of users [28] (Fig. 3).

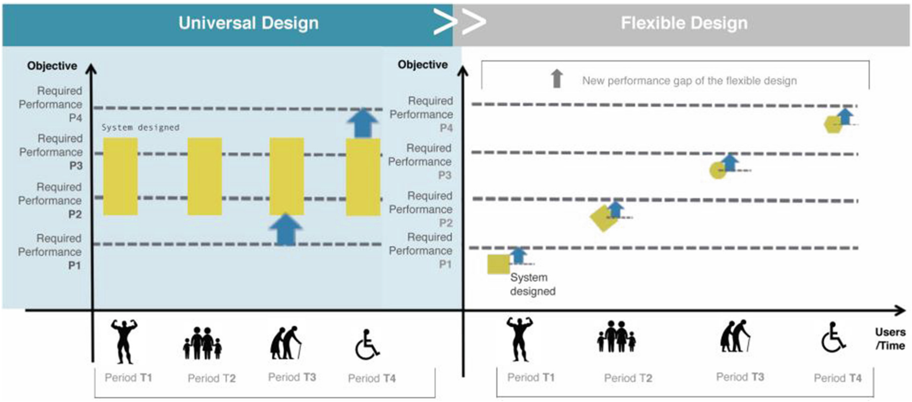

Fig. 3. The second generation of user-centered design, form Universal Design to Flexible Design.

4 Architecture as a Prosthetic Space for Health

In terms of the issue of user-centered design, we witness an evolution in the idea of considering the design of every single architectural component as an issue of adaptation between the organism and its environment. A designed environment is thus considered a prosthetic phenomenon. "It is physiologically prosthetic inasmuch as it favors certain behavioral objectives while maintaining certain requested (behaviorally correlated) and behaviorally prosthetic due to the fact that it intentionally configures specific behavioral topographies" [28]. This approach to user-centered design involves a broad vision of the human-designed system-environmental relationship where the quality of the designed systems is conveyed through the correct correspondence among the physical, psychological, metabolic and social necessities of the users. It is a system of spaces where any given space expresses the behaviors and the object system that identify and equip that space. The aims of this design process are thus focused on designing physical and cognitive interfaces, which are places where a continuous process of functional interaction occurs among the individual, the systems, and the environment.

In this broader view of the human-interface-environment paradigm, the configuration of the interface as a prosthetic system intent on satisfying the needs of an individual's well-being can be identified on three levels characterizing the design process:

- *The object level*, the human-object system relationship involves considerations of the quality of objects constructed in relation to human needs. Within this level we find the equipment system. In order for this system to assume an interface role and thus become prosthetic, it must be capable of enabling/disabling the functional capacities of a person in relation to his/her remaining abilities. This is done through an observation of gestures and is not leveraged on a single standard of performance but rather on the capacity to guarantee performance that is helpful and useful toward the user's remaining functionality [2, 9, 29].
- *The closed living space level*, the human-private space relationship involves considerations of spatial organization and on the technological apparatus that impacts the usability of that apparatus, regardless of the body's shape, posture or capacity to move. This level concerns the choice of spatial and technological solutions able to guarantee the recognizability of space through its ease of changeability over time in relation to the variability of functional and psychological needs [2].
- The open space level, the human-public space relationship involves considerations of the usage conditions of open spaces on the part of inhabitants and the ability of these spaces to be configured as systems to maintain individual health, understood here as mental and socio-physical well-being. A designed environment becomes the means by which one can assess the health and safety conditions a city is able to offer its inhabitants, and where changes can be made to improve its livability [30].

5 Conclusions

The design of contemporaneity in the various scales it can be imagined "is configured as a "dynamic space, an open work, an ongoing process". As Vittoria states, its quality does not lie in the changing of its aesthetic features that have inspired the formal experiences of masters, but in the change of design elements. These elements have moved away from submission to figurative schemes deriving from humanistic culture toward an adherence to relational systems (space-time, matter-energy, nature-form) deriving from scientific culture [31]. Therefore, a design's degree of quality on the various scales to which it refers stems from its capacity to interrelate with the human scale, meaning the ability of physical elements to interact with the factors that characterize design centered on user well-being. A design must therefore be:

- *Inclusive.* This means the ability of a space or an object to be appropriately sized and proportioned to users and their diversities, in order to comfortably and safely "accommodate" people with different specificities and dissimilar degrees of liberty.
- *Active.* This involves the manners of using a space or an object that has an impact on its "active" use. It can be influenced not only by physical-formal features, but is also attentive to the immaterial determinations of the design [10].
- *Adaptive.* This regards the ability of a design to set itself as a place of possibility [32] to contain functional and organizational criteria that are adaptable to the specificities of various users.

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The Influence of Adding Vibrations on the Impression of Messaging on Smartphones

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Abstract. Over the last few years, the number of devices with touch-panel displays, such as smartphones, has increased. This research focuses on the possibility of adding tactile sensation to messaging on smartphones in order to broaden the communication. Our hypothesis is that operational certainty is insufficient when using touch panels and that tactile feedback would be effective in adding to the communication. Consequently, this study researches the effects of tactile feedback and whether it is possible to measure small nuances. Although impressions differed significantly among young smartphone users compared with senior citizens who had only recently begun to use these devices, the hypothesis was partly proved: adding vibration to messaging does increase the sense of pleasure in the process.

Keywords: Haptics · Computer-mediated communication · Touch panel

1 Background and Study Aims

Smartphones have spread rapidly, and methods of communication have also changed. In particular, computer-mediated communication (CMC) has diversified due to computers.

To compensate for the lack of non-linguistic information in CMC text, an amity condition (such as a pictograph or a smiley) can be utilized. Thus, CMC can influence the impression that a message gives. Interest in the field of haptics is also increasing, and it has been shown that a specific vibration pattern can give people a particular impression. Thus, I had to expand the possibility of there being more appropriate communication methods for my object, and I investigated this topic by adding a vibration pattern to CMC text.

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2 The Flow of This Research

Pre-investigation

1. Questionnaire investigation

   Investigation about exchange of the message by the smart phone

2. Pre evaluation experiment

   Investigation of the impression change by adding vibration

Main experiments

   Evaluation experiment by the experimental device

1. Investigation of the impression by adding vibration to the message from friends
2. Investigation of the impression by adding vibration to the message from mail-order houses
3. Vibration is added to the message to friends, especially, inspection of the impression changes more or expectation's to an answer rising

Conclusion
Discussion

3 Pre-investigation

3.1 The Investigation's Outline

To look for the consciousness when sending a message by smartphone in pre-survey 1, we investigated an internet questionnaire. A total of 32 people answered the questionnaire. The average age of the male respondents was 23.1, and the average age of the female respondents was 27.

3.2 Survey Results

We answered the attribute. More than 90% of the respondents (30 out of 32) considered the feeling when a partner receives. We devised the contents of a message and the atmosphere at the time of the message's transmission.

The use of an amity condition could be considered the device's content. Thus, people found that they communicated better when they added some to the text of a message.

There was a lot more "delight" (100%) and "apologizing" (about 69%) for the feeling to emphasize the message, and "got angry." Adding a feeling made conversing easier (about 91%).

This "would make me not so angry with my partner," said.

4 The Main Experiments I and II

4.1 The Investigation's Outline

To examine the influence that adding vibrations (and specific vibration patterns) to a text message has on the receiver's impression of that message, we created a message application on the device. We estimated our subjects' impressions for several messages in different conditions (Table 1). The respondents' average age was 22.2 years.

4.2 Evaluation Method

Similar to Kimura and Yamamoto's (2017) study, positive feelings were measured according to "desirability," "ease of enjoyment," and "joy"; negative feelings were assessed according to "unpleasant feelings," "anger," and "grief." We also used seven stages of evaluation (0 = it was not felt at all; −6 = it was felt very much) (Fig. 1).

Table 1. The conditions of the experiment.

Vibration a	Without a vibration
Vibration b	The vibration that is generally used is added
Vibration c	The vibration that gives a positive impression is added

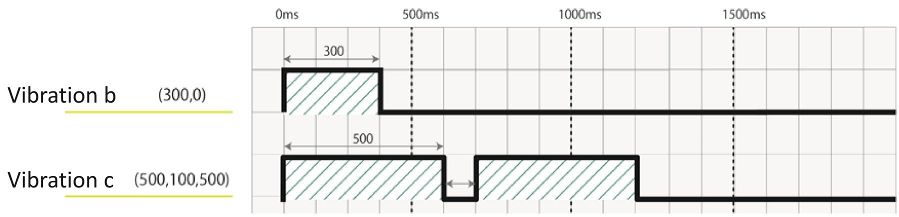

Fig. 1. The vibration pattern used by the experiment.

4.3 Results

We found that a vibration's influence on a message's impression can be different depending on the message's contents.

Figure 2 shows the mean of people's impressions of messages; the impressions were recorded for every condition when people received "Happy birthday!"(A) from a friend.

This figure indicates that the positive vibration produced a more positive reception than the general vibration.

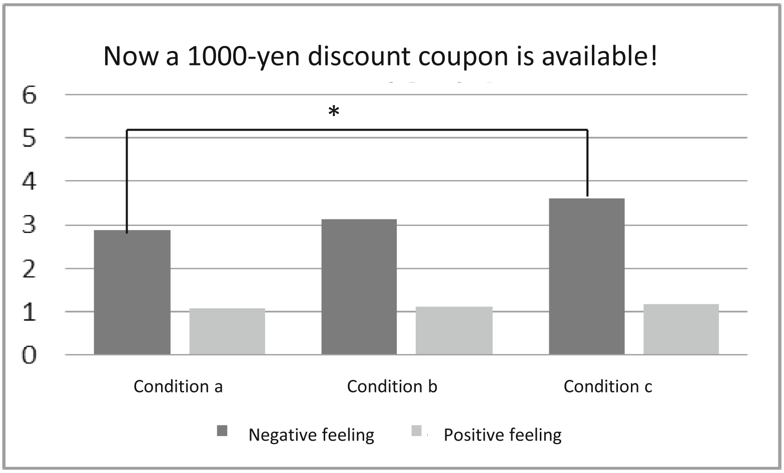

Fig. 2. The impression of A for every condition.

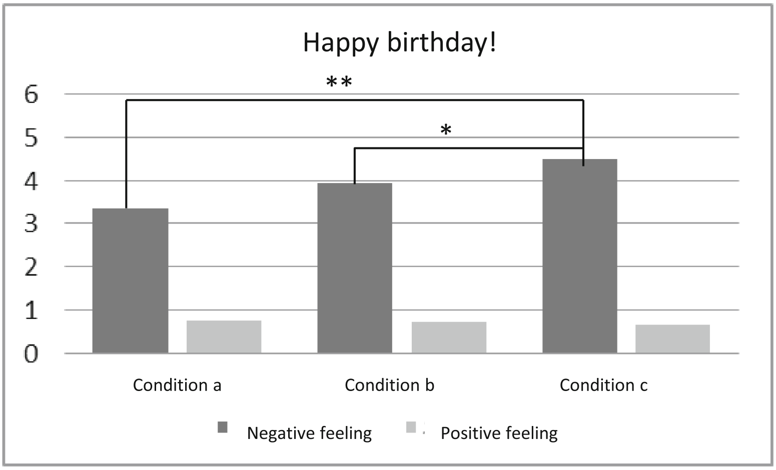

Fig. 3. The impression of KA for every condition.

For the message "Now a 1000-yen discount coupon is available!"(KA), a similar result was indicated. Figure 3 shows people's average impression of KA.

The apologies, which could be considered an emphasized feeling, were also paired with vibrations that give; this was done in the cases of messages U and KI. We found that positive feelings tended to be increased when the messages were combined with positive vibrations.

The message “Sorry. Can’t go today.” (U) was from a friend, and “I’m sorry. It’s sold out now.” (KI) was from an enterprise of EC where it is being used.

For A and KA (A from a friend; KA from the EC site), a vibration that gives a positive impression was added to show that there is the possibility that we have a similar influence (regardless of the sender’s category).

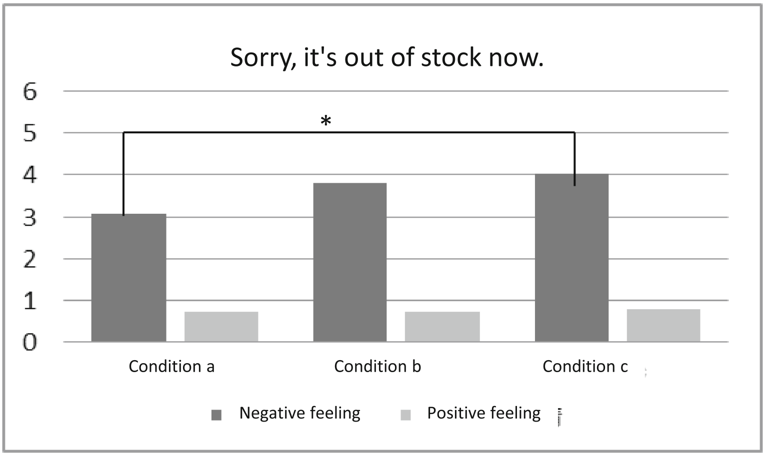

Fig. 4. The impression of U for every condition.

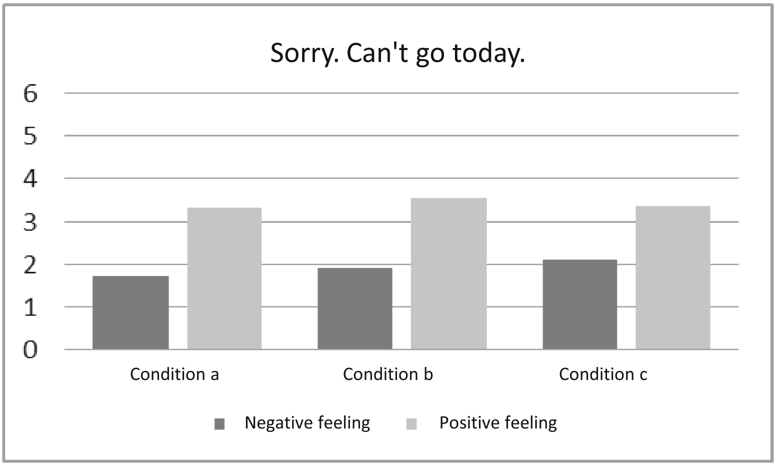

Fig. 5. The impression of KI for every condition.

Figure 4 is the one by which U and Fig. 5 indicated the price of the average positive feeling of KI and the negative feeling.

The feeling would come easiest when sending the message "Get angry."

Do not seem angry about this more than necessary; it was said that they would like to do.

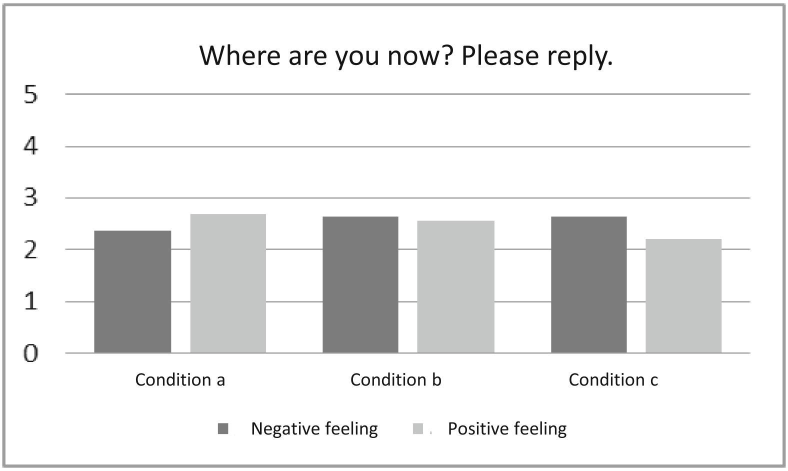

Fig. 6. The impression of E for every condition.

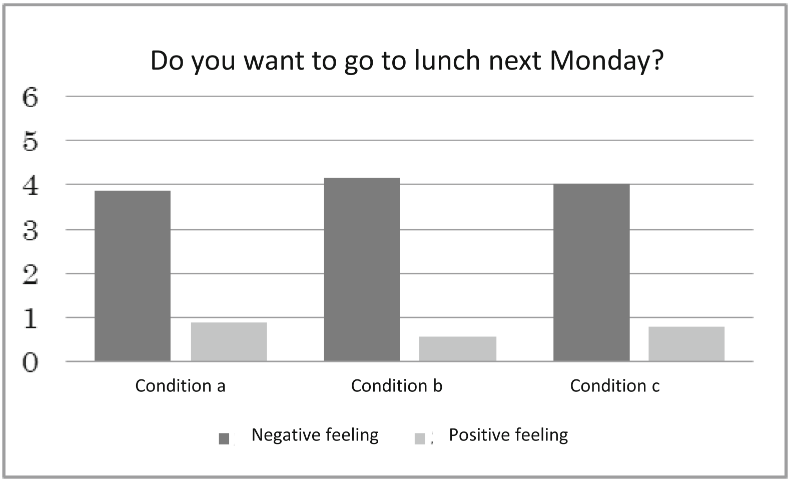

Fig. 7. The impression of I for every condition.

We investigated whether adding vibrations influenced receivers' impression of a message and whether the recipient is the cause (it is self-evident that one is bad). "Where are you now? Please reply."(E) implies that contact is behind schedule and that the sender is angry.

That time was to add vibrations to a positive impression as a result, and it was indicated that there is a possibility that the negative feeling can be reduced.

The result is shown in Fig. 6; almost no influence from vibrations was seen.

"Do you want to go to lunch next Monday?" (I) is a question, and the sender is asking for a reply.

Lots of ones were scheduled decisions according to exchanges with my friend in LINE from a preliminary study; this phrase was used to ask for a reply and schedule a meal.

The average positive feelings and negative feelings for every condition are indicated in Fig. 7.

Every numerical score for a positive feeling in the conditions is indicated in Fig. 8.

Equal dispersion was not seen; however, by the addition of vibrations, Fig. 9 indicated that the vibrations had no influence on the people's impression.

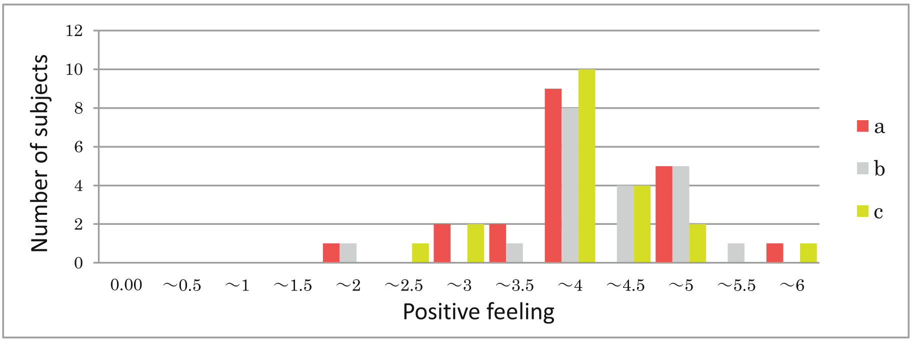

Fig. 8. The classification of the numerical value of positive feelings (I).

It is a message of invitation and a question that provokes the response "I would like to reply" or "I would like to consent." However, the influence of the vibration was not observed.

4.4 Conclusion

See Table 2.

Table 2. Summary of experiments I and II

	Message	Sending partner	Contents	Positive feeling a*b a*c b*c	Negative feeling
A	Happy birthday!	Friend	Joy	** *	
I	Do you want to go to lunch next Monday?	友人 Friend	勧誘 Invitation		
U	Sorry. Can't go today.	Friend	Apology	It increased in a < b < c.	
E	Where are you now? Please reply.	Friend	Anger	Without vibration < with vibration.	It was biggest at b.
KA	Now a 1000-yen discount coupon is available!	Enterprise Business	Joy	*	It decreased in a > b > c.
KI	Sorry, it's out of stock now.	Enterprise Business	Apology	*	
KU	Thank you very much. We have made a reservation.	Enterprise Business	Understanding	It was biggest at b.	

5 Main Experiment III

5.1 The Investigation's Outline

This study investigated adding a vibration to a message that had been sent to a friend. The following experiment was performed to examine the possibility of vibrations influencing how a message is received. The condition is indicated in Table 3.

Table 3. The condition of experiment III

Condition e	The vibration pattern cannot be added.
Condition f	The vibration pattern is chosen like a pictograph, and it is added to a message.

The vibration pattern that was chosen was vibration b. Vibration c was used in experiment I, and vibration d was used when a negative impression was assumed.

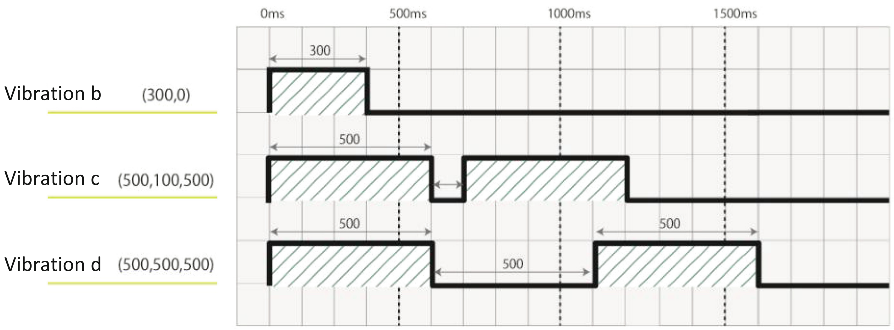

Fig. 9. The vibration pattern used by experiment III.

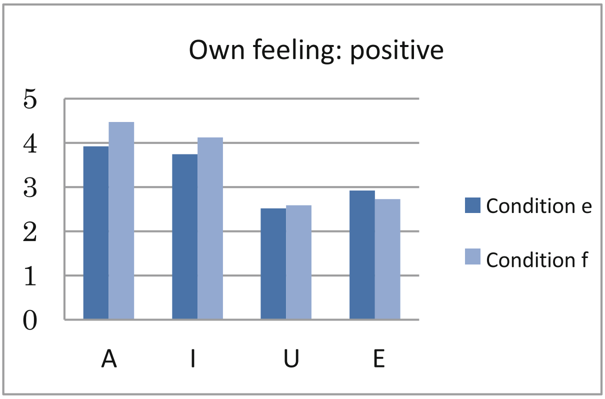

Fig. 10. The numerical value of the positive feeling.

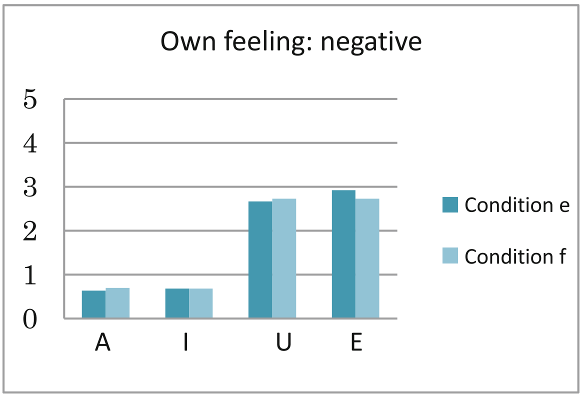

Fig. 11. The numerical value of the negative feeling.

When making and sending a positive message, we found that the receiver's positive feeling tended to be increased when considering the partner, choosing the vibration, and adding.

The results are indicated in Figs. 10 and 11.

6 Conclusion

The results showed that adding a positive vibration to a text message increased the positive impression and lessened the negative impression.

However, at the same time, the results showed that there is a situation where the vibration did not have an effect.

7 Discussion

One of the problems of this study is that people's responses to text messages vary according to each individual. When it was done more and it was a complicated situation, I found that it does not act on it.

We would like to carry out an experiment where a vibration is added to picture-like information from this thing. We would like to carry out an investigation according to a situation with a general interpretation of a broad sense.

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Inclusive Design of Open Spaces for Visually Impaired Persons: A Comparative Study of Beijing and Hong Kong

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Abstract. Over the past few years, researchers, designers and policymakers have made tremendous efforts to move towards a barrier-free society for all by enhancing the accessibility of public space. Barrier-free legislation and design guidelines for built environments have been developed in many cities. However, compared with design for individuals with mobility impairments, design for visually impaired persons (VIPs) is seldom discussed, especially with regards to open and green spaces. Based on a comparative study of Hong Kong and Beijing, this study finds that the implementation and management of public design and policy must work together to ensure effective universal design principles for open spaces. This study discusses how design can be improved to meet the needs of VIPs. Finally, the study provides some directions for researchers, planners and policymakers seeking to enhance the contribution of built environments to healthy living.

Keywords: Inclusive design · Public design · Visually impaired

1 Introduction

In densely populated cities, open spaces and public facilities are important aspects of our daily activities. 'Openness' is the key characteristic of open spaces [6], which have commonly been designated as public spaces. Three aspects should be considered in the design of a public space: (a) responsiveness – whether it meets the users' needs; (b) democratic – whether it is accessible to all city users and provides freedom of action; and (c) meaningful – whether it facilitates strong connections between the place and individuals' personal lives [3]. Inclusive design has grown out of the concept of barrier-free design, which aims to provide barrier-free environments for the widest spectrum of people, regardless of age and ability [7]. In the past few decades, policies, laws and regulations supporting inclusive design have been promulgated and implemented [2, 5, 8, 11, 12]. However, the needs of VIPs are seldom discussed in the design of public spaces in many urban cities. Designers and policymakers should pay close attention to users' perceptions and behaviour, especially in different physical, social and cultural settings [10].

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Using a case study approach, this study reviews the implementation of inclusive design policies in two Asian cities – Beijing and Hong Kong. Policies and regulations pertaining to barrier-free public spaces have been promulgated for nearly three decades, and yet the implementation has been quite different in the two cities. From the perspective of VIPs, there are various problems in terms of accessibility, safety and convenience in both cities. To enhance the quality of open spaces and improve open space experiences for VIPs, it is necessary to examine the views of users in both cities on the implementation and management of inclusive design policies, and to identify the factors that influence the effectiveness of inclusive design. This study has implications for inclusive design policy, implementation and management. A 'FAIR' principle is proposed: *flexibility, accessibility, in place* and *reliability*. This study provides some guidance for researchers, planners and policymakers who wish to enhance the quality of built environments.

2 Methods

2.1 Case Studies in Beijing and Hong Kong

In this study, two densely populated cities with similar cultural contexts, Beijing and Hong Kong, were compared. Both have issued policies and regulations related to barrier-free design and inclusive design over the last three decades. There are numerous open spaces of various sizes in both cities, such as small-scale sitting areas, gardens, promenades, neighbourhood parks and large-scale district parks. Due to time limitations, it was difficult and impractical to study all of these spaces. A previous study showed that when on their own, VIPs tended to visit neighbourhood parks near their homes rather than large-scale district parks. Therefore, this study investigated 30 neighbourhood parks in the two cities.

In Beijing, 15 parks located in eight districts were selected. Nine were located in three old districts: Xicheng, Dong cheng and Chaoyang. These three districts had high densities (number of persons per km^2) – 24,372/km^2, 21,881/km^2 and 7,530/km^2, respectively. Some of the selected parks had been located in the same places in the old communities for decades, whereas others had been built between newly built buildings in the last few years.

In Hong Kong, 15 parks were chosen from three old districts: Sham Shui Po, Kwun Tong and Kowloon City. These three districts had both public housing estates and private houses. The percentage of people aged 65 or above in Sham Shui Po was far higher than the average in Hong Kong. The population densities of these three districts were 43,381 for Sham Shui Po, 57,530 for Kwun Tong and 41,802 for Kowloon City, making them the fourth, first and fifth densest districts, respectively [4].

2.2 Procedures

This comparative study was conducted in Beijing and Hong Kong beginning in January 2017. The qualitative approach included documentation, interviews and observations. With support from organisations for the blind in both cities, semi-structured interviews were conducted with VIPs ($N = 32$) of different ages. The interviews included questions such as 'How do you feel about the settings in the neighbourhood parks?', 'Have you encountered any difficulties in accessing the parks?', 'Are you satisfied with the inclusive design inside the parks?' and 'What factors influence the effectiveness of inclusive design?' The interviews were audio recorded and transcribed. For the observations, the 30 neighbourhood parks were visited on both weekdays and weekends. Photographs and notes were taken during the observations.

3 Results

3.1 Policies Related to Inclusive Open Space

Support for a barrier-free environment has grown in both cities since 1990. In mainland China, laws, regulations and rules have been promulgated. The *Law on the Protection of Persons with Disabilities* (1990) calls for the 'gradual realisation' of barrier-free design in urban roads and buildings for the convenience of disabled persons. The *Regulations of Beijing Municipality on the Construction and Management of Non-barrier Facilities* (2004) describe the design standards and relevant regulations for building non-barrier facilities in accordance with the municipality's goals. The *Code for Accessibility Design* (2012) describes the standards needed for different kinds of facilities, such as tactile paths, accessible entrances and wheelchair ramps.

In Hong Kong, the *Disability Discrimination Ordinance* (1995) prohibits discrimination against persons with a disability by failing to provide means of access to any premises that the public or a section of the public is entitled or allowed to enter or use, or by refusing to provide appropriate facilities. *Design Manual: Barrier Free Access* (2008) sets out the design requirements for providing proper access to and appropriate facilities in a building for persons with a disability.

The regulations and standards pertaining to VIPs are relatively few in both cities, especially in Beijing. Compared with the policies in Hong Kong, design guidelines and standards pertaining to VIPs are general and vague. Most of the guidelines are recommended rather than mandatory. For instance, the terms 'should', 'could', 'not suitable' and 'if applicable' are frequently used in the design guidelines. In Hong Kong, to ensure effective enforcement, some obligatory design requirements have been legislated. Any violation can lead to punishment by local governments. Special obligatory design requirements have been implemented to allow persons with visual/hearing impairments to make various uses of the buildings. However, most of the requirements are applicable to buildings, elevators, public information or service counters and accessible toilets. There are no requirements pertaining to the specific category of open spaces and green areas. The scattered obligatory and recommended requirements make it difficult for developers and builders to implement these design features during the construction of parks.

3.2 Implementation and Management Issues in Inclusive Design

In Beijing, most of the respondents mentioned that it was difficult for them to go to the neighbourhood parks by themselves without help from others. Compared with people with normal vision, VIPs had to spend a lot of energy focusing on every step and their surroundings. In the interviews, the VIPs identified many reasons for their decreased interest in going to neighbourhood parks. These included not only physiological factors, but also the physical and cultural contexts. Due to the lack of non-governmental organisations for VIPs, most were not able to obtain good training and were afraid to go outside alone. Moreover, 'walking' was not a good experience for VIPs in Beijing due to poor physical conditions such as broken tiles on the floors and bikes on the tactile paths (Fig. 1). They would be in danger due to difficulties in identifying the potential risks. Furthermore, most of the VIPs lacked confidence due to their low economic and social status. They felt alienated from the community and were not willing to express their opinions, which made it difficult for researchers to understand their expectations. An old visually impaired woman who lived in the Xi'cheng District spent 30 min walking back and forth in a single lane downstairs, rather than walking to the neighbourhood park nearby. In practice, carparks located around the neighbourhood park, together with many parking poles on the ground, made it difficult for VIPs to access the public areas (Fig. 2).

Fig. 1. Tactile path leading to the neighbourhood park in Chaoyang District, Beijing (Photo by the authors)

In Hong Kong, the implementation and management of inclusive design policies in neighbourhood parks were better than in Beijing. Moreover, unlike Beijing, most of the VIPs in Hong Kong could obtain sufficient training to be able to go outside alone. They

Fig. 2. Neighbourhood park located in Xicheng District, Beijing (Photo by the authors)

were taught how to walk in the streets, how to use the tactile paths and elevators and even how to use the escalators as part of their daily activities. With these skills, they were more confident than the respondents in Beijing in terms of going out for leisure activities. In the interviews, some of the VIPs, especially the elderly, said they enjoyed walking in the neighbourhood parks. Tactile paths were provided at the entrance of the parks, and warning strips strictly defined the edges (Fig. 3). The VIPs who frequently visited the parks seldom used the tactile paths as they had a 'map' in their minds. However, the VIPs who were new to the parks emphasised their need to trust and rely on the tactile path, even though they were sometimes misleading. In practice, most of the respondents mentioned that the tactile paths were not designed appropriately and did not always meet their requirements.

4 Discussion

4.1 Inclusive Design Factors

This examination of the policies about and implementation of inclusive design in both cities found that different factors influenced the effectiveness of inclusive design. The field observations and interviews identified several factors. The PPCIES framework comprises six key factors related to the inclusiveness of open space: physiological, psychological, cultural, ideological, environmental and social (Fig. 4). These factors are not independent, but are linked to each other. The physiological factors are the

Fig. 3. Neighbourhood park located in Kowloon City District, Hong Kong (Photo by the authors)

physical conditions and features of different users, regardless of their age, ability or situation. Psychological factors are mental and psychological conditions such as users' preferences, needs and wants. Cultural factors include the values, beliefs, norms, customs, religions, behaviour, languages, user cognitions and user perceptions [9] of individuals and the community, and should be considered seriously, as most of the design issues are affected by such factors. Users' attitudes towards open spaces can be changed in some cases. Ideological factors, which include epistemology, semantic analysis and philosophical tendencies, are the origin and essence of outward appearance; that is, how people think about their surroundings and actions reflects their willingness to change. For instance, in Beijing, many VIPs feel excluded from the community and have little confidence due to their physical and economic conditions. As a result, most of them are unwilling to voice their opinions and to demand the provision of access to facilities, even when public places are inaccessible to them. Environmental factors can include features of the natural and built environments [1]. The natural environment refers to physical features such as climate, temperature and terrain. The built environment includes neighbourhoods, communities, infrastructure and other aspects of artificial environments. Social factors include various complex areas such as politics, economics, education, and social and family structures, which are closely connected to cultural factors.

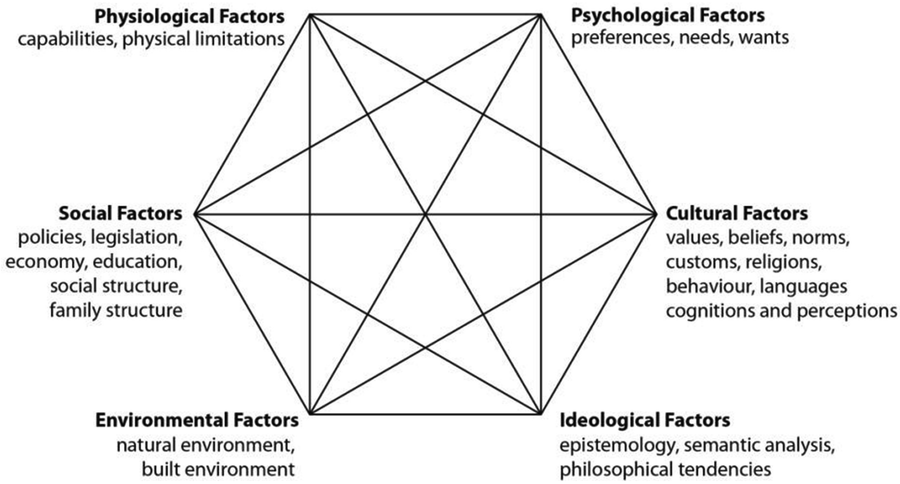

Fig. 4. PPCIES framework (by the authors)

4.2 Implications for Policy, Implementation and Management

This study's findings indicate that there are various barriers preventing VIPs from visiting open spaces in both Beijing and Hong Kong. There are no universal standards in policy, implementation or management due to different local contexts. The factors mentioned above should be discussed on a case-by-case basis. However, some guiding principles are necessary to enhance the effectiveness of the policies, implementation and management of inclusive open spaces. This study proposes a 'FAIR' framework for this purpose.

F (*Flexibility*). The design should accommodate the widest spectrum of individual preferences and abilities. Design guidelines and standards must provide appropriate and flexible choices for users' access and use. Moreover, there should be clear and detailed instructions for developers and builders, making it possible to implement policies in actual settings. In practice, there are many barriers to implementation, such as features of a particular physical environment. Clear and flexible guidance with examples suitable for various situation is necessary.

A (*Accessibility*). An accessible open space aims to provide a barrier-free environment for various user groups – not only individuals with mobility issues, but also those with sensory disabilities such as the visually impaired. The concept of accessibility runs through the whole process, from planning to implementation and management. Planning should address most of the requirements that directly influence VIPs' access to open space and use of its facilities, and this decision-making process should be mandatory rather than based on vague and recommended requirements. The level of accessibility should be evaluated by the users rather than by experts, designers and policymakers. Effective communication with users is of great importance during the process of implementation and management.

I (*In place*). Inclusive public facilities should be provided in place. Appropriate locations and functions should be selected so that the facilities satisfy the expectations of real users rather than policymakers and designers. Inclusive public facilities should focus on convenience for users, rather than on being decoration. Any broken facilities and other actual barriers should be identified and repaired immediately. Collaborations with users frequently enhances the effectiveness of public facilities.

R (*Reliability*). Ensuring the reliability of the implementation of inclusive design policy is key. First, policies, laws and rules must be promulgated in detail. Next, implementation and maintenance are of great importance to the success of the whole process. Furthermore, as this study has shown, obtaining opinions from users during the early stages of the design process allows different stakeholders to develop ideas together. Public participation in improving the design of open space builds users' trust, which is pivotal to enhancing the reliability of public design.

5 Conclusions

This study contributes to the literature on the inclusive design of open space for VIPs. Comparing two Asian cities with similar cultural contexts – Beijing and Hong Kong – shows that VIPs face various barriers and challenges when visiting open spaces in both cities. This study identifies six inclusive design factors that influence the effectiveness of inclusive design and proposes a 'FAIR' principle to enhance the quality of inclusive design.

To identify the challenges and barriers faced by VIPs who wish to engage in recreation in open spaces and to provide effective implementation of policies promoting the inclusiveness of open spaces, it is necessary to conduct systematic, in-depth research into the particular features and conditions of each society.

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Lighting in the Workplace: Recommended Illuminance (lux) at Workplace Environs

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Abstract. Light is just for seeing. Well, this is an old concept. Nowadays, we realise that light is needed for many other things such as synchronizing our non-visual system. Non-visual systems include the circadian rhythm, which, in turn, regulates our biological and physiological systems, as well as influences our emotional state and, therefore, plays a crucial role in our wellbeing. So, why do we keep on projecting workplaces with only 200/500 lx? This paper's objective is to study the "do's and don'ts" of a lighting design in a workplace design. To achieve such goals the research was conducted throughout literature review. We conclude that it is more rewarding for the companies that increase and decrease the light levels all over the day and should promote healthier human beings, which in turn will become more motivated, happier and will contribute for the good results of the company profits.

Keywords: Daylight · Artificial light · lux · Workplace · Circadian rhythms Non-visual system · Visual system

1 Introduction

Light, is not just for human visual needs; it is also for those non-visual. Natural and artificial light influence human health, wellbeing and productivity throughout the visual and non-visual systems. The duration, intensity and spectrum of light that reaches the eye are determinant factors, that depend on the intensity of light, the duration of exposure, time regime, time of day, spectral composition and the spatial distribution of light [1]. The time of exposure to light and its characteristics, such as illuminance (lux) are crucial for the production of melatonin or serotonin [2, 3]. Light is an important prompt for the human brain and to entrain circadian rhythms; sleeping/waking cycles, activity/inactivity cycles. The circadian system is very sensitive to light levels, especially in the first 6–7 h of the biological night. Thus, more than ever, it is important to discuss the concept of illuminance (lux), how much lux is needed to achieve a better balance between human visual and non-visual requirements. Nowadays, there are data, although inconsistent, about the desired quantity of lux at workplace environment. Therefore, it is vital to understand the impact of the required amount of lux at workplaces. For instance, in order to strengthen melatonin (darkness

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hormone) production we need less than 100 lx; and to avoid seasonal affective disorder (SAD) we need more than 1.000 lx. As for serotonin (mood hormone) production, and cortisol (stress hormone) higher illuminance levels are crucial too. Light can also incite a phase advance, or delay (circadian rhythm), which could endanger our balance leading us to other biological disorders [4].

This article comprehends three phases: the first discusses the distinction between natural and artificial light. The second approaches the visual and non-visual systems, namely the SAD, chronotypes, hormone secretions (according to illuminance levels), factors, such as age, individual preferences, time of light exposures, different sensitivities (areas of the retina), stress levels and daily habits. All contribute significantly on human quality of life. The appliance of these concepts was crucial on workplace environment design, the third phase, and this is our scenario study to promote the discussion of light direction, such as vertical and horizontal plans, task lights performance and lighting systems since they contribute significantly to employee's productivity.

1.1 Daylight Versus Artificial Light

Daylight is dynamic since the morning light differs from the one at lunchtime or in the evening. The light dynamic character depends on geographical latitude and altitude, as well as seasons. Everyone understands that the summer light is very different from that in the winter. This dynamism influences our mood positively [3, 5]. Daylight has a positive influence on human mood, given its importance in indoor environments while requiring the same dynamism from indoor lighting throughout the day. These light changes have a great impact on human health and wellbeing, mainly on non-visual system (circadian system). Daylight and electric light differs and the major difference is the dynamics in the intensity level (Figs. 1 and 2), colour temperature and spectrum. In this article, it is our pursuit to discuss the illuminance levels that should be used in the workplaces.

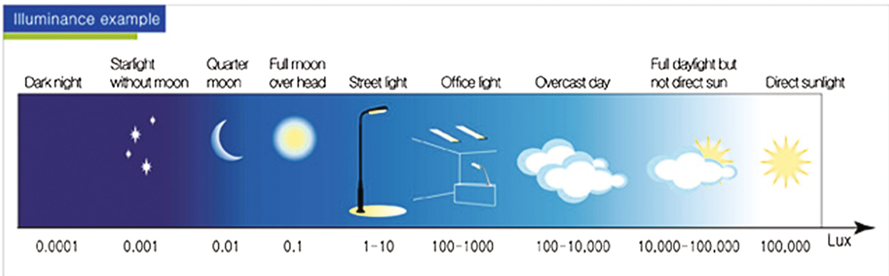

Fig. 1. Illuminance levels [6].

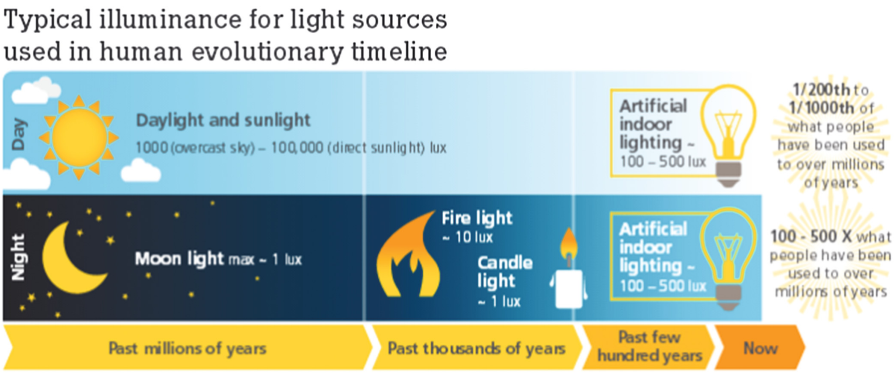

Fig. 2. Typical illuminance for light sources [7].

As far as illuminance is concerned, the difference between daylight and artificial light is significant, once daylight can reach 100.000 lx with direct sunlight and 10.000 lx in a cloudy day [8, 9]. The available data show that to reach biological effectiveness, light levels must be higher than 1.000 lx (Fig. 3) [10].

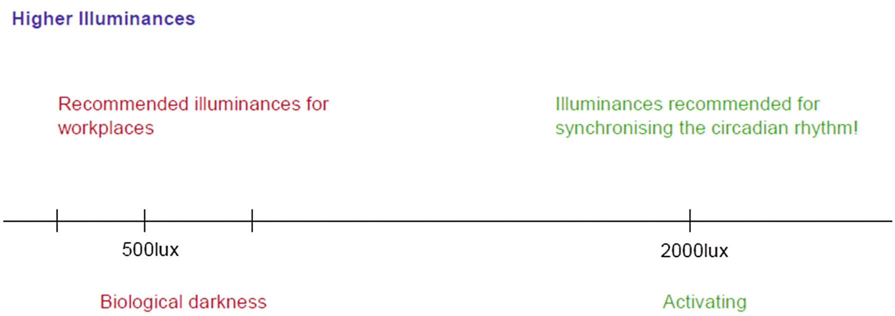

Fig. 3. Illuminance recommended for the optimization of the workplace environment and the synchronization of the circadian rhythm [11].

1.2 Visual and Non-visual Systems

Furthermore, we cannot ignore that light has five parameters of light exposure: intensity, spectrum, duration/pattern, history, and timing which influence our visual and non-visual systems [3, 5]. This is a complex issue because, every so often, both systems depend on and interact with each other.

Humans have an extraordinary control of the light-dark cycle that occur accordingly to the daily variations of light. These variations contribute to body temperature, resting/activity, melatonin production and other neuroendocrine secretions and the sleeping-waking systems, which are important regulators of neuroendocrine, metabolic, renal, cardiovascular and neurobehavioral [12]. As a result, neurobiological and environmental factors progress to control the phase of entrainment. For humans who live far away from the Equator, for example, it is more difficult to control the light/dark cycle, allowing and encouraging the SAD (Seasonal Affective Disorder), which, in daily routines, takes the form of fatigue, hypersomnia, carbohydrate craving, and weight gain [13]. This is why phase entrainment occurs, when there is no daylight, or where it is scarce. Phase entrainment is what make us to conform with our modern way of living. In addition, since we all are different, sometimes it is difficult to have sleeping and waking habits that allow us to achieve a positive state of health and wellbeing. Human beings need light in the morning and darkness in the evening towards the absence of light if they want to balance circadian cycles. This is important in view of the fact that SAD, it is relieved with high levels of illuminance (recurring to artificial light when the daylight does not exist or it is insufficient).

There are many factors that influence human visual, and especially human non-visual systems direct, and indirectly allowing their balance. One of these factors is human heterogeneity, by having different chronotypes, human being is influenced by light in different ways. In other words, human sleeping pattern interferes with human circadian balance. So, we must be aware that sleeping timing differs among individuals, dividing them into two groups: the "owls" and the "larks". If we naturally wake up early in the morning, we are "larks" (who get up early), while if we go to sleep very late we are "owls" (go to sleep late). The living patterns of the industrialized society contribute to the disruption between human circadian rhythms and the daily schedule. This reality is greater by the amount of time that we spend indoors under artificial light. When the "owls" and "larks" have to follow normal schedules, they can have reactions such as insomnia, sleepiness, psychiatric disorders, metabolic syndrome and other ailments [14]. For example, people with a late sleep phase (late chronotypes) frequently suffer from social jetlag [3] since their biological clock is delayed to the accomplishment of social life obligations. Morning light exposure could provoke a phase advance and may be a solution for the circadian realignment whenever needed [15, 16]. Once again, phase entrainment is an important concept, and the use of higher illuminance levels in the morning can be an effective help, especially for an owl personality.

The importance of the illuminance levels contributes for an approach of critical thinking to define its quantity and the place where to apply the different quantities established. So, when we think about human biological (non-visual) stimulation we must know that different illuminances have dissimilar impacts. Available data confirm that lighting levels for human biological stimulation should be between 500 and 1.000 lx (at least) [2, 17]. This is not irrelevant because, during workdays, since we use and reduce greatly our mental resources, it is easy to increase the feeling of sleepiness, lack of energy, psychological stress and in consequence a decrease in performance. Bright light (high illuminance levels) can influence alertness in a positive way, increasing human performance and may counteract fatigue by helping to recover decreased mental resources [18]. Intense light improves cognitive performance, because there are fewer feelings of sleepiness with 1.000 lx when compared with 200 lx [18]. Since intermittent pulses have a greater resetting efficacy, it is a way to delay the phase of the circadian rhythm. Light in the evening also causes a phase delay, which convinces the body that it is still day [16].

Questions of gender, chronotypes and age can also be affected by light differently: for instance, the SAD, is more common among women, and increases with age until the sixth decade and after that it declines greatly. The illuminance can help with light for the eyes of 2.500 lx to 10.000 lx. However, this is not a lighting level that we experience indoors, especially in the workplace [2, 18]. Human nature suggests that we need to pay attention to our chronological age and we also must consider visual pathologies. Besides, there are also functions and tasks requirements [19]. In addition, due to ageing the amount of light that reaches the retina demands more light, the same is to say we need to have higher illuminance levels. From the age of 35, there is a decrease in the pupil size and the lens becomes thicker promoting light scattering in the eye and increasing human sensitivity to glaring, thus weakening the brightness adjustment. The yellowing of the crystalline makes the distinction between similar colours, such as dark blue and black more difficult [20, 21]. Moreover, the disturbances in mood can be due to sleeping problems, because of poor exposure to daylight [8, 22, 23]. Once again, it is crucial to consider lighting levels in indoors environments, and the key can be the use of a dynamic lighting system, which could mimic daylight, and stimulate the human body [22, 24]. Besides, the requirements of the elderly demand three times lighter, identifying 1.500 lx as the minimum of horizontal lighting level [2, 17]. Regarding the vertical illuminances, people who worked under lower vertical illuminance levels reported more fatigue and worse sleeping quality than people working under high levels of vertical illuminance; same responses were shown when taking gender, age, eye correction, seasonal sensitivity and chronotype adjustments into consideration.

Besides human visual and non-visual requirements there are individual's preferences. For example, people prefer high additional electric lighting in office environs, an average 800 lx with daylight [25]. Bright light, normally, has an impact on arousal level and is often used to treat the SAD, or to reset internal biological clocks supporting sleep pressure, alertness, performance on mental tasks and to endure attention [26, 27]. Morning light exposure might be effective in reducing the sleep inertia while evening exposure to light could increase alertness. The same is to say that the impact differs depending on the PRC (Phase Response Curve), where around 3 a.m. delay shifts arise and the peak advance occurs around 9 a.m. So the impact on alerting differs with the time of the day (hour). The history and duration of light exposure also have a great impact on the circadian system [28]. Light at midday has a very limited influence on phase-shifting [1]. Again, phase-entrainment is especially crucial for us to keep balance.

Factors, such as sleep-wake cycle, sleepiness, fatigue, mood and performance are ruled by cortisol and melatonin. Cortisol is produced by the adrenal cortex and its levels increase during the morning and prepares us for the day ahead, whereas melatonin level drops reducing sleepiness [25]. High levels of morning cortisol are associated with sociability, whereas, moderate or low levels promote concentration and improves alertness [29]. Light influences different hormones in the brain where the pineal gland plays a vital role in controlling the melatonin [29]. Adenosine is a neurotransmitter that increases sleepiness, and its synthesis and/or its transport may be suppressed by bright light exposure and is currently receiving attention as a factor in sleep/wake regulation. Brighter light exposition (higher illuminance levels) is more effective in terms of melanopsin driven non-visual responses [5].

The duration of exposure is also an important factor. Short-term exposure to natural bright light improves afternoon levels of the physiologic arousal [27]. Therefore, a higher illuminance level has a positive effect on alertness, concentration, mood, leading to a lower error rate [30]. The subjective fatigue decreases and the subjective alertness increases with illuminance levels of 100 lx at the cornea and greatest effects can be achieved with 300 lx [1, 13]. Changing the lighting from 300 to 500 lx may increase the productivity by 8% [3]. A higher level of melatonin suppression was found with all the lamps featured by a higher illuminance level (600 lx) [1, 2, 31]. Daytime exposure to bright light decreases sleepiness and improves psychomotor vigilance performance [28].

As already mentioned above, the areas of the retina of the human eye have different sensitivities to light. Light from above (inferior retina) is more effective for the suppression of melatonin [1]. Higher levels of illuminance are usually required to suppress melatonin with inferior retinal illumination when compared to full retinal exposure. Unexpectedly, the exposure of the superior retina does not suppress melatonin [32].

Luminance levels are vital for human stress levels, since indoors environments show an amount of daylight considerably lower in the summer than in the winter. Bright light (artificial) in the winter compensates this difference [15, 25]. Not only does bright light increase stress levels, but it also increases blood pressure while decreasing immune activity. Under high stress levels, cortisol, epinephrine, norepinephrine, and estrogens increase, and the result is the increase in breast cancer up to 50% and the development of chronic stress [33]. So, the downside of using high illuminance levels for those who do not need (larks, for instance) is to increase stress levels that could lead to unhealthy way of life (Fig. 4).

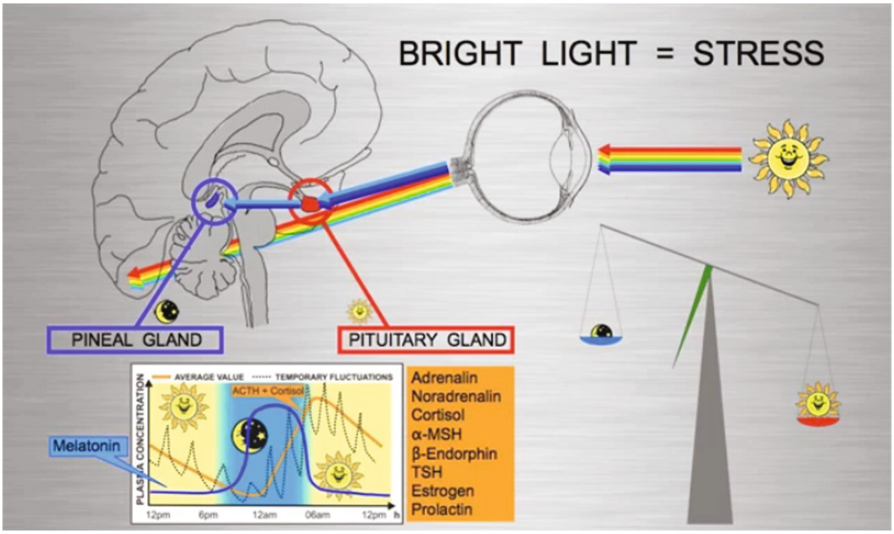

Fig. 4. Pituitary and pineal glands [33].

Nonetheless, there are other factors that influence human sense of wellbeing. For example, one should have in mind that many daily habits contribute to individual alert level: the type and intensity of the activities performed earlier, food and beverage consumption, sleep quality, social context, and health. There is the possibility that chronic fatigue leads individuals to receive less light and maybe because of going outdoors less often, or staying in bed longer accounts for the fact that those individuals that by choice or by obligation receive less light might feel more chronically fatigued [32, 34]. Hence, the exposure to more intense light improve the mental states of individuals. People are more sensitive to variations in illuminance level during autumn and winter. During the autumn and winter months individuals are more exposed to lower illuminance levels and less to bright light. Healthy active persons can benefit from higher illuminance levels during the autumn and winter months once compared with people who suffer from the SAD [34].

In spite of all the factors stated above, a particular concern when planning lighting design in workplace environments is highly recommended.

1.3 Workplace

Requirements related to lighting spectrum, colour temperature, and lighting levels of around 1.000 lx are recommended for biological entrainment, at least a few hours a day and especially in the morning. Additionally, the light direction should be considered, as vertical (directly on the eye) rather than horizontal (on the table or desk). In most of the existing offices, lighting design is supported by aesthetical and trendy parameters overlooking human non-visual lighting needs. Only 20% of the offices have illuminances over 1.000 lx at the eye. Illuminance levels are correlated with the quality of sleep (positively) and fatigue (negatively) of the employees [26]. A daylight curve with higher exposure in the early afternoon and lower levels in the early morning and evening. Exposure to bright light (>1.000 lx at the eye) is rare, thus most users are exposed to illuminance levels below 500 lx at eye level during the day.

The illuminance levels are usually taken into account in the working plan (horizontal surface) underestimating the vertical plan (at the eye level) [10, 35]. Workplaces are enlightened by natural and artificial light and users become more tired when exposed to lower levels of vertical illuminance [10]. The workplace lighting design is based in general and task light switching from the illumination over a large area to areas such as desk (Fig. 5). A task light can be oriented to a place, allowing the user to manage its direction and area of incidence according to his needs [10, 22, 35]. An arrangement of systems of general and local lighting is the best solution to increase the wellbeing of users through visual and non-visual comfort [21, 35]. Parameters, such as illuminance and colour temperature are quantitative indexes used to calculate and assess office lighting design. The constancy of illuminance level affects human visual perception and mood [35]. Traditional methods of work encouraged mainly the visibility on desk's surface; the intensive use of computers shifted the main goal towards the screens of digital equipment. Luckily, the IESNA Lighting Design Guide no longer considers the horizontal illuminance as the main goal when conceiving workplaces lighting design. The change in the working methods from paper to computer encourage to reduce horizontal illuminance levels [35, 36].

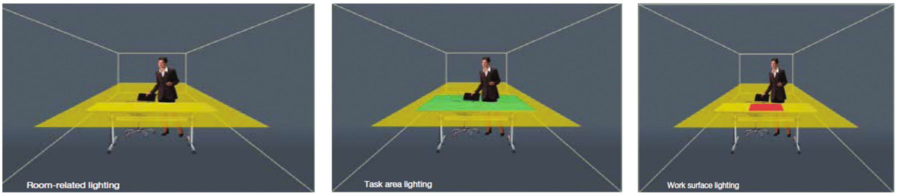

Fig. 5. Room-related lighting. Task area lighting. Work surface lighting [9].

To achieve a healthy lighting design layout both vertical and horizontal illuminance should be used as lighting design parameters [37]. Standard solutions show that the levels of illuminance are higher when windows are close to the working area and the illuminance level decreases significantly when windows are far [37].

1.4 International and European Recommendations (Iluminance Levels)

Indoor artificial light levels without daylight contributions are between 100 and 500 lx only and are frequently determined by the standards or recommendations [25] The recommendation in the UK for the working plane illuminances is 300 lx, mainly for computer-based work and 500 lx is the upper limit for paper-based work. Recommendations for North American working place illuminances are between 300 to 500 lx. In Australia and New Zealand, 320 lx are recommended for routine office tasks. Recommended illuminances for workplaces are 500 lx, the so-called biological darkness. Nevertheless, 2.000 lx are the illuminances recommended for synchronizing the circadian rhythms [37]. Fortunately, in many cases daylight goes through the windows at least for a few hours per day, increasing the whole lighting levels considerably [25] (Table 1).

Table 1. Uniformities and relationship of illuminances of immediate surrounding areas to task areas [38].

Task illuminance (lx)	Illuminance of immediate surrounding areas (lx)
>=750	500
500	300
300	200
<=200	E task

2 Conclusions

To sum up, lighting design influences human wellbeing significantly, namely people's health and performance, because higher illuminance can improve human cognitive performance and reduce sleepiness. Office employees prefer a higher illuminance than the recommended by current standards for offices environments, which are based on visual needs. It is imperative to develop research in this field to avoid design decisions that are that do not take a full account of the requirements of users. The exposure to the daytime light reduces sleepiness and improves performance; however, there has been no consensus, yet, about the optimal daily natural light amount [5]. Human heterogeneity has different chronotypes, different needs due to age, emotional states (SAD) and pathologies that could be avoided or helped by higher illuminances in the morning and by lower illuminances at the evening. There are too many parameters, both visual and non-visual, that are influenced by illuminance levels positive and negatively, making it difficult to achieve a general solution.

We need to conceive new indoor spaces, particularly the workplaces, where daylight assumes its importance and impact. Professionals highly-skilled at lighting design, despite their academic background need a more holistic and informed approach. Multidisciplinary teams with a user-centred design methodology are desired and needed. [9, 39]

2.1 Discussion

Standards are more concerned with visual needs than with those non-visual. We should have a greater range of illuminances available in lighting sources. A dynamic artificial light is an important help, or at least an artificial lighting more similar to the daylight is desirable. Moreover, a task light (individual) could be the answer to human heterogeneity and requirements due to different ageing, chronotypes, preferences, geographical location (altitude and latitude) and seasons (summer and winter). Dissimilar functions and tasks to perform in indoors office environments require qualified lighting conditions (towards natural and artificial light).

There are many studies on lighting design which can help academia and professionals to reach better solutions, given the fact that some of them establish particular conclusions/answers/solutions.

Architects and designers (despite their area of expertise) should keep up with research studies about lighting (natural and artificial). Light is not just about visual needs, or aesthetical solutions we cannot overlook the human non-visual system.

Lighting systems should help us to improve our health and wellbeing in our professional and personal life, and the artificial light need to be more similar to daylight. Further research is needed to better understand which values, spectrum, luminances and colour temperature improve our non-visual and visual systems.

It is necessary to take the age of individuals, their visual pathologies, distance from windows (where more natural light is provided, when available). When angles (direction of light) are planned our visual and non-visual needs should be taken into consideration. Lighting systems must be considered as a whole, ranging from the position of lamps/luminaires and the nature of the lamp - if it is a CFL (compact fluorescent lamps) or a LED (light emitting diode) should all be part of a workplace project.

Illuminance, the theme discussed in this paper, is a light feature that is, repeatedly, ignored. Human being needs different illuminances levels during the day. Professionals from the construction cluster must realise that lighting characteristics have a significant impact on the health, wellbeing and productivity of individuals.

It is not desirable or possible to continue to conceive lighting design of workplace environments based on aesthetical, trendy or commercial patterns. Lighting design needs to consider its real impact on the individual.

There is a question that needs an informed answer:

> "When you conceive an indoor space, namely a workplace, do you think about the human non-visual needs?"

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The Inclusion of Children with Total Visual Impairment in Learning Activities of Daily Living, Especially the Act of Eating Independently

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Abstract. This article is focused on the teaching and learning process of eating activity in children with total blindness between 2 and 5 years old, in Medellin – Colombia; and the way in which the guardians impede their development, autonomy and independence, due to ignorance, fears or frustrations [1]. A person from the time he gets up until he goes to bed, demonstrates a motor, cognitive and psychological learning that is traced from early childhood. A child with total blindness will have a lower performance in different areas of life, for all the restrictions that he has with the perception of visual information. Unless the family incorporates teaching and learning strategies in his life [2]. From this approach, it was proposed as a general objective to design a didactic product framed to the eating activity of children with total visual disability, through the integration of techniques and teaching methods, to improve the learning process and autonomy of the child, and strengthen the relationship with his guardian/family. The artifact contains the food and keeps the elements in place, also allows the child to understand how to interact with the object during and after the activity, linking other senses such as listening and touch.

Keywords: Children with visual impairment · Total blindness
Overprotection · Independence · Eating activity · Teaching
Activities of daily life · Design

1 Introduction

The most difficult activities of daily life for a child with total visual limitations are: eating, dressing, using the bathroom and bathing. These require a long-term level of independence, so that they can adapt to different social and collective contexts [1]. The degree of dependence is a reflection of the parent's fears and insecurities [3], which it affects in one way or another the adequate performance of the daily activities of a child with this functional diversity.

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Taking into account the previous premise, and analyzing the results of the fieldwork in “La Fundación Multis”, “Aula Cinco Sentidos” and “La Rueda Arte Sordo”, these children have some difficulties to adopt the routines due to: (i) overprotection of the father or legal guardian, (ii) the difficulty in accepting the disability, (iii) the ignorance of the teaching processes, and (iv) the discontinuity of the teaching-learning process in the different contexts of the child’s daily life (home, daycare, etc.). This suggests to the parent or guardian as a central nucleus of the teaching and learning process, who has the responsibility to provide The child’s stimulation around his world [4].

A child with visual impairment has difficulty in learning these activities, because they have never had the opportunity to perceive what exists around them; considering also that, in the first stage of life, people learn by an imitation process, keeping images in the mind relevant to language, the analysis of the effects of the environment that surrounds and knowledge of social mechanisms [5–7].

This research project focuses on analyzing said user, establishing as a starting point a Medium-low and low social stratum. As a result, the resource type available of the family group to support the disability of his son is considered, and the limitations he has of accessing foundations or entities that support a specialized education. In addition to this, the observation is specifically limited in the activity of eating. This was the context in which there were major difficulties during the tests in relation to: (i) the learning time, (ii) the morphemes of the utensils grip, (iii) Manipulation of elements (plants, cutlery, etc.), (iv) the distribution of food, (v) the motivation to perform the activity autonomously, and, (vi) frequent spills; generating frustrations in social contexts and dependent behavior in the child, which even affects their adult life [1, 8–10]. Starting from this, it is proposed as a central topic of research a product design that allows to improve the learning process and autonomy of children with total visual impairment from 2 to 5 years of age, during the eating activity, and the exploration of other senses (listening and touching); in order to strengthen the relationship with their guardian.

2 Methodology

The research is of qualitative type, since it seeks to analyze the inconveniences around the activity of eating, describing and interpreting the observed findings through ethnographic interviews, sessions with users and a participative methodology that allows to understand the flaws analyzed in the realization of said activity. Also, it was constituted by 2 studies; The first study, of descriptive type, focused on explaining the facts analyzed, This case was related to the eating activity of the blind children, in the three institutions where the field work was carried out: “Multis”, “Aula Cinco Sentidos” and “La rueda, arte sordo”. The second study, of explanatory type, focused on explaining the phenomena analyzed and the visual disability importance in early childhood.

The methodology was divided into three phases: (i) bibliographic compilation, (ii) analysis, and (iii) design. in which participant and non-participant non-structured interviews were conducted with 35 users, 28 children, 4 young people and 1 adult with visual disability, with questions and life stories the behaviors and thoughts of parents, tutors, and children were analyzed in a daily context. Next, each phase of the investigation is explained (Fig. 1).

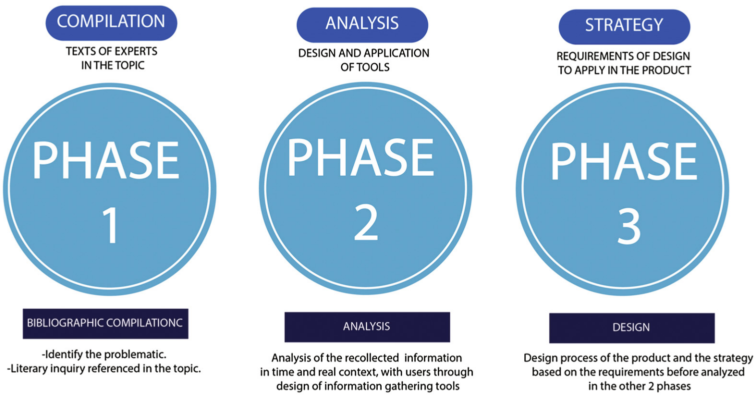

Fig. 1. Phases of the methodology (Students final project UPB-2017)

2.1 Phase 1. Bibliographic Collection

In this, the problem and the pertinence to approach it in the line of Ergonomics was defined. This phase was built based on studies, guides and methodologies of experts in the field; large national institutions such as the (INCI) and international institutions such as (ONCE) (Table 1).

Table 1. Collection of bibliographic information.

Name	Who is it for?	Author	What is it about?	Age of publication
Guide for blind child parents from 0 month to 3 years	Parents	Saint Miguel Santiago - Chile	Accompaniment of parents in the development of activities and abilities	2008
Pedagogical guidelines for the attention and promotion of the inclusion	Family	INCI	Visual disability, teaching and learning tools, importance family in the process	2008
Guide: helping my son grow. Practice guide to provide tools that help blind child	Parents	INCI	Acquisition of basic skills and basic tools to help stimulate other senses	2007
Teaching material for blind children	Teachers	INCI	Motor and cognitive development	2006
Games, toys and visual disability	Family	INCI	The game in the learning process	2006

Students final project UPB-2017

Booklets, methodologies and studies in relation to visual disability in children, both in school and domestic contexts, guides for parents in the process of acceptance and teaching of their blind children.

2.2 Phase 2. Field Work

This phase, the information collected initially in the literary search was validated, and the activity was further analyzed through contact with real users, through the design of information gathering tools.

Within these activities, music and theater classes, meetings to Eat snacks, concerts, games and outings to walk in the city were made (Fig. 2).

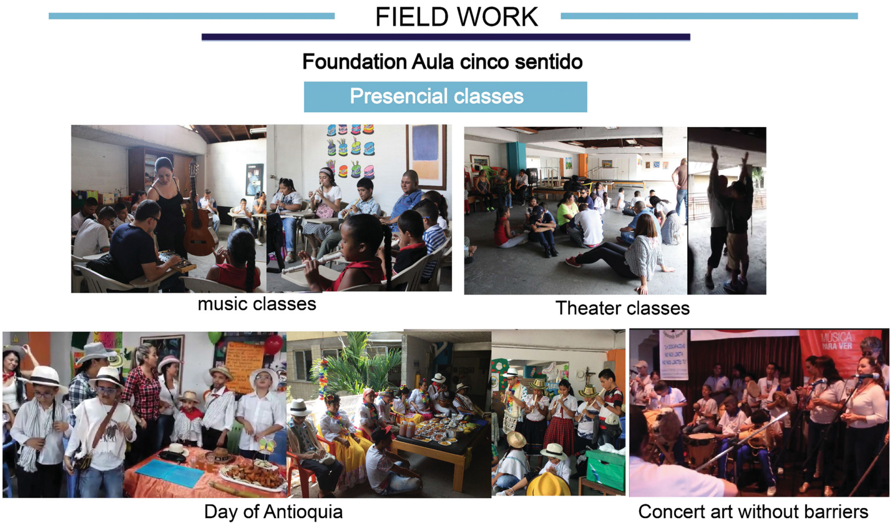

Fig. 2. Photographs taken at the foundations Classroom "Cinco Sentidos" and "Multis" that account for the fieldwork. (Students final project UPB-2017)

2.3 Phase 3. Design Process

In this phase, we sought to integrate the requirements collected in the two previous stages to be integrated into the project solution; in this case in the product to facilitate learning and motivation to eat of blind children (Fig. 3).

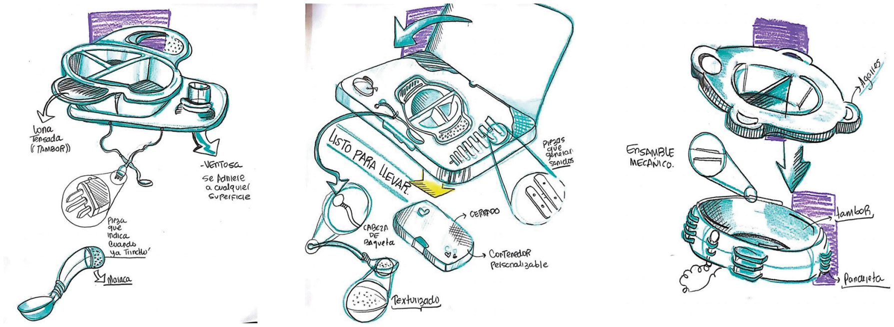

Fig. 3. Initial formal exploration. (Students final project UPB-2017)

3 Results

Through the information collection tools, user characteristics were identified among these fears and frustrations caused by their visual disability, in which there is evidence of lack of autonomy to perform certain activities. Fear of facing certain things without help and great overprotection from parents.

Of the personal profiles made, 100% showed difficulty eating alone, two of three students at 3 years still did not know how to control their sphincters, and can not be separated from their mothers to perform collective activities in the classroom, especially when it's time to eat. In addition, skills were identified in relation to music, singing and interaction with musical instruments, the development of the sense of listening and the motivation generated from it to perform playful-didactic activities.

Then, the results of the investigation were divided into two parts: A Product and a manual (strategy) (Fig. 4).

Fig. 4. Product and a manual (strategy) (Students final project UPB-2017)

3.1 The Product

Based on these results then, a product was proposed, which seeks to facilitate the activity of eating for blind children through the company of a guide, which is evident in the morphology of the container.

This guide besides containing food and keeping the elements in place, it allows the child to improve their orientation and distribution at the table, allows you to have fun through music (Fig. 5).

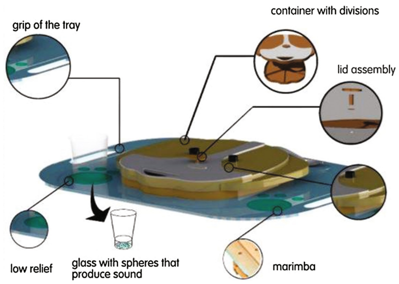

Fig. 5. Product with magnifying glasses where morphology and contact interfaces are evident in detail (Students final project UPB-2017)

The lid of the container, Which is the face of the dog as well, is a drum which the child can touch once finished eating, Only by closing the container. It is also part of a strategy for the child to eat everything that is served, and once finished he can play with it.

The spoon, in this case, takes the role of a drumstick, it is responsible for producing all the sounds on the lid as in other elements of the system (marimba), the child learns to recognize how the materials sound by means of the beat generated delete with she (Fig. 6).

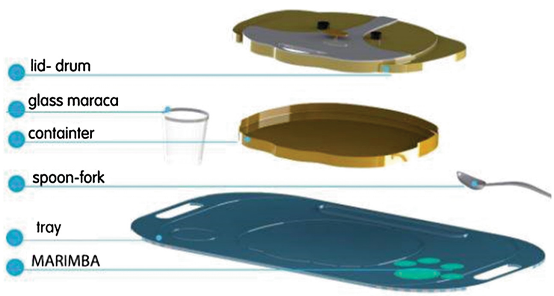

Fig. 6. Explosion where the place occupied by each element within the system is evident

And the glass, takes the role of maraca; in it is lower part of this, some spheres are integrated that, when the glass is shaken, produce sounds and the child will be able to experiment with it only by using it in an ordinary way (Fig. 7).

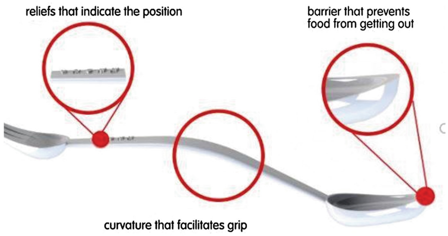

Fig. 7. Handling elements (Students final project UPB-2017)

3.2 The User Manual for the Product

This user manual is addressed to the father or guardian of the blind child; This seeks to integrate Sonoro, as a system of objects to teach his son to eat through a strategy in which the father can approach his son in the activity of eating, understanding his capacity and autonomy.

The booklet or manual is divided into:

(i) Introduction: this part explains the product and the purpose of this in the learning process of the blind child.
(ii) History: Seeks to create a connection between the child and the guardian by the proximity to the character, seeks to motivate the child to perform the activity, understanding sound as his friend and guide, (at this point, the caretaker must approach the child and strengthen that link).
(iii) Manual of use: In this point it's graphically described step by step how to teach the child to use the object system, the mother will help him to recognize the morphology of the elements, he will place it in the tray and will explain clearly the distribution of it, It will make it easier for them to understand the grip of the utensils and explain their alternative musical function.
(iv) How to teach to eat: This point is constituted based on references of expert authors in the subject, which have already validated methodologies and that work on the eating activity.

3.3 The Strategy

The object system "Sound" works under three stages: (i) Contextualization, (ii) Introduction and, (iii) activity development. In stage (i), the strategy is who plays the most important role, because in this phase of the activity to eat, the mother or guardian, should present to her child the object system, this accompanied by a reading of a story that explains who is sonorous, because it is their guide to learn to eat, with this the child can understand the importance of this activity.

The story is fully graphed, and pretends to be understood by anyone with a low level of schooling; also it integrates reliefs so that the child can accompany the reading of the same while recognizing in him, the forms of the object with which he will begin to interact.

4 Conclusions

Based on the methodologies obtained by the literary search of authors specialized in visual disability, support guides were found, of which two are focused on children with visual impairment, two in parents, three in families and one in educators. It was possible to identify shortcomings in the ways of proposing these guidelines according to their methodological nature they become difficult tools to understand and apply in daily life.

- Of the existing products investigated, we found: objects aimed at the learning process of daily life activities, of which three are focused on universal didactic material, two on didactic material specialized in disability, and five on eating instruments. In relation to this, it was possible to identify different flaws and gaps in these tools, which yielded design opportunities to improve the eating activity benefiting the blind child and his family in the process.
- From the information collection tools were selected: person profile, focus group, stand up if you, in the shoes of the blind child, interviews, participant and non-participant observation which were applied to 35 users, of which there were 28 Children, 4 young people and one adult.
- As a result of these tools, were identified: poor eating habits and hygiene, inappropriate interactions with eating utensils, difficulty understanding the distribution of food, lack of motor skills to hold utensils and lack of motivation to eat independently determining requirements for the design of a product that improves these shortcomings.
- Regarding the findings obtained in the fieldwork, there was evidence of a flaw in the learning process by blind children due to the overprotection of the parents, which prevents the correct development of certain activities such as eating.
- A strategy was proposed that integrates: the blind children and their Legal guardians strengthening the relationship between them, the art of music, the guide as their best friend and the motivation to learn to perform the activity of eating independently.
- Based on the shortcomings and gaps identified in the entire investigation process regarding the act of eating by blind children, a product was developed accompanied by a user manual that integrates ergonomic features in the instruments, striking morphologies for the child and a playful demeanor enriching the learning process, making the activity of eating more enjoyable and fun.

5 Recommendation

It is recommended to have more users in the age range analyzed, to generate validation tests with product. It is also important to have more resources to generate rapid prototypes that can be used for validation prior to the final development of the product where problems can be solved in the morphology or in the function of a developed element. There must also be a longer time to analyze the before and after use of the product during the performance of the activity, taking time and observing the acceptance by the child and their guardian. It is recommended to test the product for a long time, where a family makes use of both the manual and the object system and evaluates the acceptance of them, and the child's motivation to learn to eat only with the help of the set.

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Design for Inclusive Transportation, Information and Communication Technologies

Inclusive Responsiveness – Why Responsive Web Design Is Not Enough and What We Can Do About This

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Abstract. Responsive web design has pioneered the way in which modern web applications adapt to the screen. However, catering for the interaction device is not enough when aiming for the best user experience that is tailored to a specific context of use. In this paper, we describe existing and envisioned design techniques that allow a web author to adapt to the full range of parameters provided by a specific context of use. We hereby examine the four components of context of use as drivers for adaptations: the user, their task, their equipment, and their environment. In conclusion, we fathom how far we are, and what obstacles have yet to be overcome on our way to "inclusive responsiveness" on the web.

Keywords: Responsive web design · Context of use · Adaptivity · Adaptability · Accessibility · Inclusive design · Universal design · Personal profile · Personal needs and preferences · GPII · Media queries · Context queries · Matchmaker

1 Introduction

In an ideal world, a web application adapts aspects of its user interface and digital content to: (1) the user with their needs and preferences, (2) to the task the user is trying to accomplish, (3) to the input and output devices the user is using, and (4) to the situation in which the user uses the application. These four components which are driving adaptation reflect the composition of *context of use*, as defined by ISO 9241-11:1998: "Users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used" [1]. Figure 1 illustrates the four components of context of use ("pie" in the center) as *drivers* of adaptation during an interaction.

In many cases, the user needs to explicitly trigger an adaptation by making some kind of a deliberate choice, including switching to a special configuration mode. In this case, we talk about an *adaptable* system. Examples include changing the font size, the contrast theme, and setting the mouse speed.

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In some cases, though, an interactive system may adapt automatically to some drivers. In this case, we talk about *adaptive* systems. Such a system "responds" to specific parameters in the context of use. Examples include changing from a one-column layout to a three-column layout on a narrow screen, or reducing the brightness of the screen in a dark environment.

In general, it is desirable to have adaptive systems so that the user is not bothered with having to choose their preferred interaction aspects. In fact, for some users, it might be necessary so that they can interact with the system at all, e.g. a blind user can only interact with a system that has voice output. However, a system that automatically changes all kinds of interaction aspects may quickly create a severe usability problem by overwhelming the user with sudden changes in the user interface and content that may or may not be perfect in the user's eyes. Therefore, adaptive systems typically ask the user before they change an interaction aspect, or let the user configure the circumstances and boundaries under which an automatic change is supposed to happen. In any case, the user should have the ability to undo the change at any time.

There are many *aspects* that an interactive system (of which a web application is part of) can adapt to accommodate specific parameters of the context of use. A 3-layer model has been proposed to group these aspects into the following layers: Presentation & input events, structure & grammar, and content & semantics [2]. For exemplary aspects that can be adapted based on the context of use, see Fig. 1.

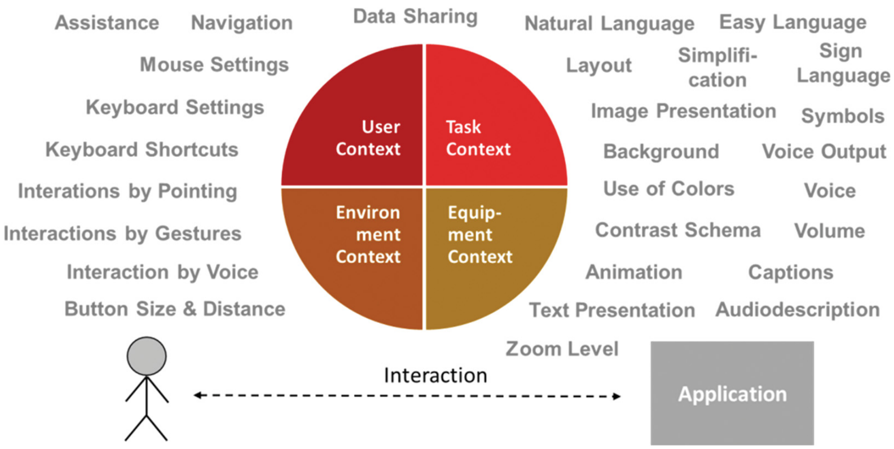

Fig. 1. Model of a user interaction with four parts of context of use, based on ISO 9241-11:1998 [1]. Aspects of interaction (shown as a tag cloud) can be adapted to accommodate a specific context of use. Note that the aspects related to input are on the left side, and those related to output on the right.

Some of the interaction aspects are usually controlled by a web application itself, e.g. the natural language, or the size of the buttons. Other aspects are typically controlled by the hardware and software platform on which the web browser runs, e.g. the brightness of the screen, or speech recognition provided as an additional input modality for text boxes. For an adaptive or adaptable system, the "controllers" of adaptation need to work closely together, and the user should not need to distinguish between application-controlled and platform-controlled aspects of interaction.

In this paper, we examine the ability of web applications (and the platforms that they run on) to adapt to the various components of the context of use. In Sect. 2, we look at how web applications adapt to the equipment context by the *responsive web design* approach. We see this approach as a model for further adaptations that address other parts of the context of use. In Sect. 3, we talk about *personalization* as an approach to adapt to the user context. In Sect. 4, we present *context queries* as an adaptation approach that is driven by the environment context. In Sect. 5, we will see that any decent web application adapts to the task context. In our conclusion (Sect. 6), we introduce the vision of *inclusive responsiveness* that caters for all four components of the context of use in a way that lets the web author specify the boundaries and the user control the specific adaptations.

2 Responsive Web Design: Adapting to the Equipment Context

Responsive web design is a popular web design technique that automatically adapts the layout of a webpage to the screen size on which it is rendered [3]. Using this technique, web authors employ fluid grids, flexible images and CSS Media Queries to define variations of layouts for different screen formats. The web browser is responsible to instantly switch to a different layout at runtime when a "break point" is reached, e.g. when the user enlarges the font size or flips orientation from portrait to landscape mode.

Responsive web design is based on three technical features of HTML and CSS: (1) *fluid grids*, in contrast to fixed-width layouts, (2) *flexible images* that are dynamically sized by relative units, e.g. percent, `em` (see Example 1), and (3) *CSS media queries* (see Example 2).

Example 1: CSS rule using the property "max-width", thus constraining the width of an image to the width of the page it is being rendered on ("flexible image").

```
img { max-width: 100% }
```

Example 2: CSS media query used in a <link> element to apply to screens with a maximum width of 980 pixels only.

```
<link rel="stylesheet"
  media="screen and (max-width: 980px)"
  href="style_medium.css"
  id="style_medium">
```

The drivers for adaptations in responsive web design are parameters that are available through CSS as *media features* which are part of media queries [4, 5]. Most media features belong to the equipment context (e.g. screen size, color mode). As an exception, the media feature "orientation" is part of the environment context.

Responsive web design was introduced by Marcotte in 2010, a time when smartphones became abundant and the designers were looking for design solutions that would not require web authors to write separate web page versions for all possible layout variations. Marcotte pointed out that web authors should embrace the fact that the layout of a web page can be flexible and adaptive to the media, as opposed to the print media where everything is set in stone [6]. Since then, responsive web design has proven to be a powerful tool to cater for a large variety of screens, including desktop, smartwatch, smartphone, tablet, phablet, smart tv, and car dashboard.

With browsers that implement the most recent CSS media queries level 4 [5], web authors can nowadays adapt the following interaction aspects:

- *Layout & background*. This has always been the most prominent aspect of responsive web design.
- *Image presentation*. Choice of image type being rendered, depending on resolution and color mode of the screen.
- *Navigation*. Switch between different navigation mechanisms, e.g. a full-blown menu navigation vs. an iconized menu button (sometimes called "hamburger menu").
- *Button size, spacing and alternate pointing interactions*. Enlarge buttons and other input elements, increase the spacing between them when the pointing device is inaccurate; provide alternatives for pointing when there is no pointing device available; provide alternatives for activation of hovering effects when hovering is not possible. These adaptations are based on the new media features "pointer" and "hover" [5].
- *Substitute animations*. For screens that cannot refresh quickly, animations can be replaced by other means. This adaptation is based on the new media feature "update" [5].

Nowadays, *responsiveness* is understood as a quality mark for websites that are "universally" usable on all devices from large desktop screens to small handheld devices. Web authors employ code frameworks that make it easy to build their web pages upon this technique, e.g. Bootstrap[1].

3 Personalization: Adapting to the User Context

Personalization (also known as *individualization*) happens when an application adapts its content and/or user interface to better match the needs and preferences of the individual user. Personalization corresponds to the seventh dialogue principle, the *suitability for individualization* [7]. When done in a perfect manner, personalization

[1] https://getbootstrap.com/.

provides full *accessibility* by accommodating the specific interaction needs of a user with disabilities.

Most of today's web application implement the most basic mechanism for personalization: they cater for the user's preferred natural language(s), thanks to the HTTP request header field "Accept-Language" that has been part of the web technologies since its early days [8]. Beyond that, some web applications allow for other personalization features, mostly by letting the user modify simple presentation parameters such as font size, color and type.

However, when looking at the full range of users with and without disabilities, there are more interaction aspects that should be subject to change for particular users.

- *Line height*. Some users may need to have an extra space between text lines.
- *Speech output*. Some users (e.g. users who are blind, who are dyslexic, who are analphabets, who are reading a foreign language) may want to have text be spoken to them rather than having to read it. For speech output, the will want to control parameters such as volume, speed and pitch. Also, some users may want to have the text highlighted as it is read aloud. Highlighting granularity can be set to word, sentence, or paragraph level.
- *Size and distance of input elements*. Some users (in particular those with manual motor impairments) may prefer to have input elements and buttons increased in size and be farther apart from each other. This will make it easier for them to hit them with a pointing device.
- *Navigation*. Some users with cognitive disabilities may need a simplified navigation tree, with less items. Users with motor disabilities may prefer a "button matrix" rather than a navigation menu. The matrix of buttons can be quicker operated switch access interface[2]. See Fig. 2 for an example.
- *Layout*. Some users may not want to switch orientation from portrait to landscape (or vice versa) even when the mobile device is tilted.
- *Simplification*. Some users may need a simplified version of the content, or specific words and symbols to be explained in simple language. See Fig. 3 for an example.
- *Sign language*. User who are deaf may prefer to receive information in sign language, and to provide input by signing in a specific sign language. See Fig. 4 for an example.
- *Symbols*. Some users may need text to be translated to symbols, or specific words to be translated to symbols for a better understanding. See Fig. 5 for an example.

[2] Some users with motor impairments use either one or two buttons to operate a user interface in a linear manner. This is called "switch access". When using one button, a cursor is moved from item to item automatically in a timed fashion. The user then hits the button when the cursor is at the desired item. When using two buttons, one button is used to advance the cursor, and the second to select the item.

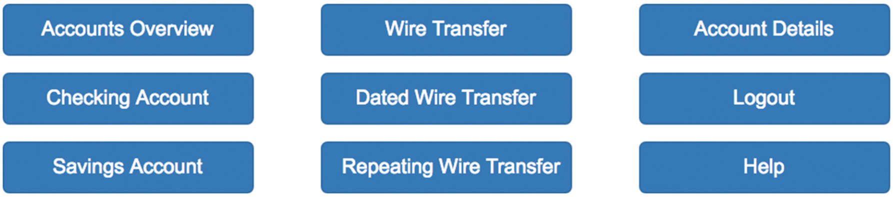

Fig. 2. In the prototypical HDM banking solutions app, a special personalization option changes the user interface into one that is optimized for switch-based input. In this mode, the navigation menu is transformed into a matrix of buttons.

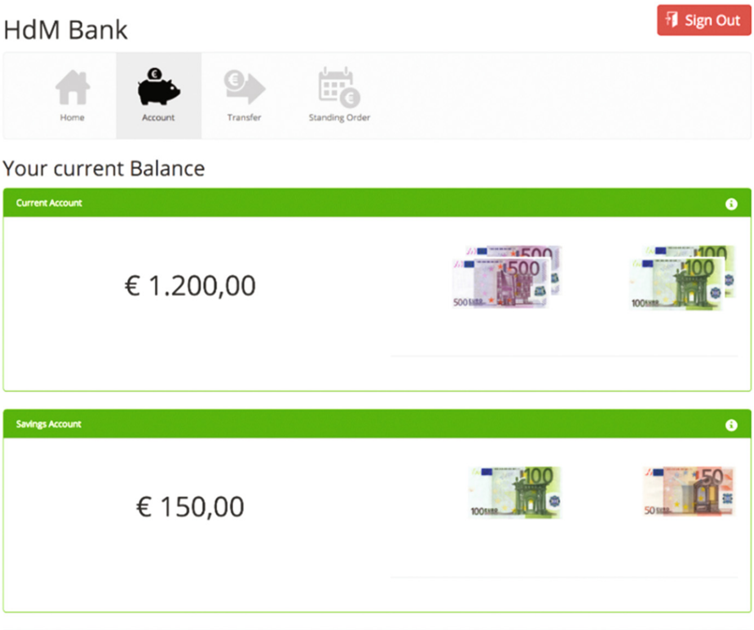

Fig. 3. A special personalization option changes the user interface into one that is simplified and has only the most important functions. For example, in addition to providing the account balance as a number, it is shown in bills and coins, for easier understanding.

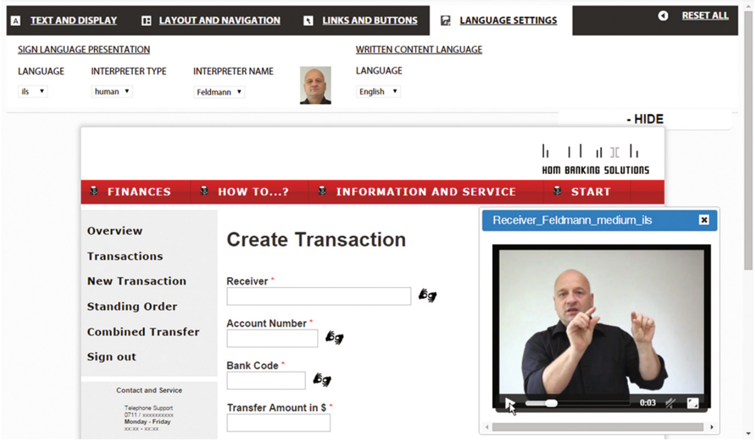

Fig. 4. In the prototypical HDM banking solutions app, the user can choose a sign language ("ils" means international sign language), a preferred interpreter type ("human" or "avatar"), and a preferred interpreter person (here "Feldmann"). When clicking on the "sign language" symbol (🤟), a popup window opens with a sign language video that explains a particular input field.

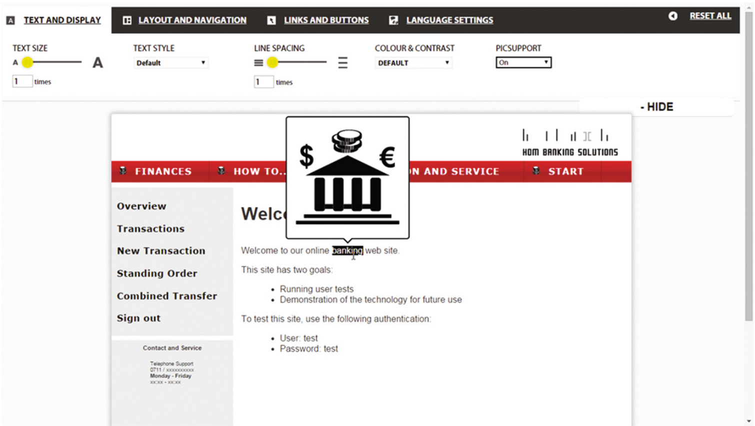

Fig. 5. In the prototypical HDM banking solutions app, the user can enable the "PICSUPPORT" option. Upon hovering over a word with the mouse, a symbolic presentation of the word is shown in a popup.

Note that for some of these aspects, a change could also be driven by the equipment context and/or the environment context. For example, somebody sitting in a shaky bus may want bigger input elements, and somebody driving may want speech output as well.

Although not a pre-requisite, it is useful if the user's settings are persistent, i.e. they are saved from one session to the next. It would be even better though, if they were available across applications and platforms (if the settings can be applied across applications and platforms). Thus, the user would not need to set up their preferred configuration for every single application and device.

The Global Public Inclusive Infrastructure (GPII) [9] addresses this issue by defining a framework for *Personal Needs and Preference Sets*. This includes standardized formats for preference sets (key-value pairs) [10] and for the definition of vocabulary terms to specify granular items within personal preference sets [11 - currently under revision].

ETSI, a European standardization organization for Information and Communication Technologies (ICT), has specified a cross-platform and cross-application framework for user profile management [12, 13].

In general, if an application is very adaptable and allows for many adaptations to be set, this can be overwhelming for the user. Many users either do not know about the settings that would make the user interface easier to use for them, or do not dare to touch them. Therefore, an adaptable application should provide an easy and understandable way for new users to set up an initial user profile. Moreover, it should allow the user to modify adaptation settings on the fly, while they are working with the application.

There are multiple ways that make it easy for users to set up an initial user profile, including:

- *Step-by-step dialog*. A dialog guides the user through all settings that are relevant for them. Examples include the ways that most operating systems help their users to find appropriate settings by choosing a type of disability (e.g. "I am vision-impaired) or a type of requirement (e.g. "I need to get the screen read out loud").
- *Serious games*. Game play can – in some cases – reveal characteristics of a user and their impairments (e.g. [14, 15]). Rather than filling out tedious forms, a user could "joyfully" set up an appropriate interaction profile for themselves by playing a game.
- *Pre-defined user profiles*. Sometimes it is easier for a novice user to start with a pre-set personal profile that fits approximately their abilities and preferences. Then, as they get along with the application, they can fine-tune their profile as needed later. Such pre-set profiles can be derived from user research and personas. Figure 6 shows an example of a set of pre-defined personal profiles with names of fictitious users.

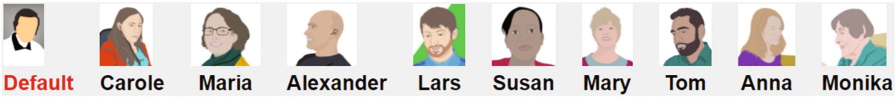

Fig. 6. In the prototypical HDM banking solutions app, the user can pick an initial user profile from a panel showing fictitious users. "Default" is the name for the initial settings when the user chooses no profile.

Sometimes, a preferred setting is only supposed to be active if a specific condition is met. For example, a user may want to have a bigger font, but only in the evening. Or a person may want to have the volume increased if there is ambient noise. We will pick up on this issue in Sect. 6 on inclusive responsiveness.

4 Context Queries: Adapting to the Environment Context

Responding to the *environment context* requires the system to sense the situation in which the user interaction takes place. Typical parameters that drive such an adaptation are date/time, location, connection (e.g. cellular vs. Wifi, flat-rate vs. pay-per-amount), bandwidth, ambient light and noise, movement, and screen positioning (vertical vs. horizontal). Parameters of the environment context are more likely to change during a user interaction session than those of other contexts. Therefore, it is a challenge for web authors to adapt content and user interface to the environment context since they have to embed *dynamic* adaptation mechanism into their application rather than just setting up an accommodation at the beginning of the session.

Today's mobile devices have sensors built-in that provide a constant stream of situational data, including the screen orientation. Mostly these data trigger adaptations on the operating system level, e.g. switching to night mode (with audio signals turned off), adapting screen brightness to the amount of ambient light, and flipping screen orientation (portrait vs. landscape). On the web application level, most of these sensor data are not easily available (except for date/time and screen orientation). Recently, new web APIs have been emerging that allow web authors to query the state of device sensors that provide information on the specific *environment* in which the interaction takes place. A web author could employ them to the benefit the user, as the following examples illustrate.

In his bachelor thesis, Gómez introduces *context queries* as a notion to sense and react to parameters of the environment context in the same way as through media queries [16]. He proposes a syntax that looks exactly like media queries (except using `@context` instead of `@media`), and has implemented prototypical scenarios with a polyfill[3]:

- *Night mode for image rendition.* At night time, an image may be rendered in a "warm temperature mode" by reducing the amount of blue color that can be unhealthy and delay falling asleep at night. Although a night mode is available on some devices on operating system level, employing it on a web application level gives the web author a more fine-grained control over scope and effects of color filtering.
- *Seasonal layouts.* Web applications may appear in different layouts, depending on the season of the year. This requires web authors to react to changes in date/time and location.

[3] A polyfill is a script that lets the web author add extensions to the HTML and CSS code as if they were natively supported by the web browser.

- *Ambient light-sensitive themes.* In environments with very high ambient light (e.g. in the sun light), it can increase ease of reading when choosing a theme that inverses colors (e.g. black on white rather than white on black). Also, in very low ambient light conditions, the user's eyes may be strained when using a theme with a lot of white background.
- *Enlarge input elements when moving.* The web author may increase the size of input elements when they sense that the user is moving, to make up for a potentially shaky environment.
- *Location-based content.* Web content that is specific to a physical location (e.g. a public library) can be presented more prominently when the user is in close proximity.
- *Bandwidth-driven image resolution.* When the connection speed is constrained by a low bandwidth, low-resolution images may be loaded to reduce the waiting time for the user. Example 3 provides a code suggestion for this scenario.
- *Saving energy on low battery status.* When the battery reaches a low level, the web application could be more energy-conservative by switching to a low-light theme. Note that many devices today have an OLED screen on which black pixels do not consume any energy.

Example 3: Proposed CSS context query to choose between multiple images with varying resolution, based on available screen size and bandwidth.

```
<picture>
  <source srcset="mobile_highres.png"
    media="(max-width:480px) and (bandwidth: high)">
  <source srcset="mobile_lowres.png"
    media="(max-width:480px) and ((bandwidth:low) or (bandwidth:reg))">
  <source srcset="tablet.png"
    media="(max-width:768px)">
  <img src="default_desktop.png" alt="(text alternative for image)">
</picture>
```

When reacting to a changing environment context, web applications could get in conflict with adaptations that are triggered by the operating system. For example, if the user has already chosen a white-on-black color scheme on the operating system level, it would not make sense to invert the colors (again) on the web application level. Therefore, it is important that the web application can sense the settings and adaptations on the operating system level through an appropriate API, and thus adjust its reactions to environmental parameters.

5 Adapting to the Task Context

Adapting to the task context is the easiest exercise of the four types of adaptation. Most web applications are made to facilitate a set of tasks of which the user can select from. For example, an online shop allows the user to browse the shop items, read their descriptions, put them into a shopping card, and finally check out. There may be supplemental tasks offered such as contacting the customer support. Whenever the user

– by navigation – selects a specific task or subtask, the web application adapts by changing the content of the web page. This is one of the most basic functionalities of a web application, and it follows right from the first dialogue principle, the *suitability for the task* [7].

A web application may also react to task changes in a subtler way. For example, on the check-out page, when the customer selects the payment type "credit card", input fields for the credit card number and expiration date (which were previously hidden) become visible on the page.

Applications reach their limits when the user tries to achieve a task for which they are not made. For example, if the user tries to solve complex mathematical operations in a text processing application, it could inform the user that it is not suited for this kind of task, and (for good usability reasons) ask them if it should start a spreadsheet application and embed the spreadsheet in the text document. So, although most web applications handle the basics of adapting to the task context, there is still some leeway in making this adaption even better to the benefit of the user.

6 Inclusive Responsiveness: A Vision

With today's web browsers that already support a limited portion of adaptive design techniques on many platforms, we have made some way from a fragmented web that is usable in only a few situations ("contexts of use"), to an "inclusive" web that is usable and enjoyable in many situations with varying users, tasks, devices ("equipment") and environments. In this paper, we have argued for a wider range of techniques, to push the envelope for web applications being able to adapt to all relevant parameters of the context of use.

Inclusive responsiveness pushes the limits of universal design – as it is mostly applied today – by facilitating web content and user interactions that are carefully tailored to an individual user and the pertinent use situation, allowing for dynamic changes as needed. However, this is a complex task, as there are multiple drivers of adaptation that drive multiple (sometimes conflicting) interaction aspects on potentially multiple (sometimes competing) levels (application, software platform, hardware platform). For example, switching to a high-contrast theme may be triggered by exposure to sunlight (ambient light), and by a user with low vision (personal preference). The adaptation may be triggered on the operating system level, or on the application level. To avoid conflicting adaptations on multiple levels, a web application need to be able to sense user interface settings on the operating system level, and must be informed about dynamic adaptations that the operating system performs. To make things more complicated, oftentimes adaptations depend on multiple parameters potentially coming from different components of the context of use. For example, some users may prefer a bigger font size, but only on their desktop computer at night.

Personal profiles are the key for fully inclusive and adaptive applications. They need to work across applications and platforms to reduce the burden for setting them up for every single application. Since there are no "one size fits all" adaptations, personal profiles need to clearly describe the preferred adaptations to all drivers in the context of use in a way that is tailored to the individual user's needs and preferences. *Extensible* *vocabularies* are needed to specify which parameters of the context of use should drive exactly which adaptations. Hereby, all adaptation levels need to be addressed, to avoid competing adaptations. *Personal rules* should describe when (i.e. in which situations) these adaptations should happen, and when not. The big challenge is to make this complex adaptation process understandable by the user so that they can modify their personal profile in a way that satisfies their needs and preferences. One promising approach are *matchmakers* that try to anticipate a user's preferred adaptations based on statistical analysis of a large pool of anonymous user data across applications and platforms [17]. Matchmakers allow the user to make manual corrections to their results, and learn from them. Ideally, this will bring about systems that continually increase the accuracy of predicted adaptations, even with new adaptation drivers and adaptation aspects being added from time to time.

In this paper, we have described our vision for *inclusive responsiveness* as an open set of adaptive design techniques that facilitate inclusive media (such as the web) catering for a large range of contexts of use. The examples we provided are not to be construed as exhaustive, but rather as an inspiration for adaptations that go beyond the state of the art – to the benefit of the individual user. It is important to note that inclusive responsiveness is not restricted to the web; it applies to all types of electronic media that can inherently adapt aspects of their user interaction. For this vision to come true, we need efficient tools and frameworks that allow designers and developers to effectively and efficiently develop applications featuring inclusive responsiveness.

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Evaluating Accessibility and Usability of an Experimental Situational Awareness Room

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Abstract. New advanced emergency management facilities such as a control room which is equipped with advanced ICT technologies should consider universal design principles and ensure the accessibility and usability of some important technical functions available in the room. This paper aims at evaluating the accessibility and usability of an experimental control room. This room has a flexible architecture, i.e., the information displays are interchangeable through drag-drop system on a control-panel. We used a complementary heuristic and user testing approach. A video analysis, open questionnaire and discussion with testers were applied to detect technology usage barriers. The results show that the proprietary control tablet and its setup has some room for improvement. Our approach can examine the sources of difficulties of our testers, especially on linking the information sources, machines and wall or desk displays. Several recommendations are outlined to be a basis for developing guidelines for future usage of this room.

Keywords: Control room · Situational awareness · Universal design Testing · Accessibility · Usability · Heuristic testing · User testing

1 Introduction

There is an increasing awareness about the importance of Universal Design (UD) of Information and Communication Technology (ICT), where the goal is an inclusive digital society with as few barriers and hindrances as possible, for a broad diversity of users, including the elderly and people with disabilities, in a wide range of situations and with a diversity of equipment. While accessibility is primarily focused on disabled users being technically able to use a system; universal design takes a broader perspective, including usability for all as an important factor. Likewise, when designing a room with complex ICT equipment such as a control room, the universal design principles including accessibility and usability are becoming important.

A control room is a physical facility that is built for a specific purpose such as monitoring a process or coordinating, collaboration tasks and actions to distributed task-force, including to provide directions, orders and decisions [1]. There are various terminologies in the literature when it comes to the control room, which may be known

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as “command and control (C2C) center” [1], “operations center” [2], “incident command center” [3] or “situation room” [4]. The usage of these terms varies, depending on their purposes or application areas such as military, politics, space center, meteorological satellite, emergency management, network monitoring, industrial production processes, transportation, and data centers. Typically, a control room consists of multiple displays or even wall-sized area and control panels, where operators can collect, visualize and monitor information received through its facilities, in the form of images, videos or data stream. In this paper, we use two interchangeable terms, i.e. situational awareness or control room to refer to a newly established experimental situational awareness room.

The aim of this paper is to evaluate the accessibility and usability of this experimental situational awareness room, in order to detect accessibility barriers as well as usability issues, and to propose solutions. By taking advantages of todays’ multimedia technologies, this room has been designed as a flexible room for training. In a traditional control room, one operator may control 1–2 PCs. In this experimental control room architecture, with one control panel, an operator can control each available PCs in the room and visualize any information sources on any displays in the room easily through “drag and drop” technique on a single touchscreen control tablet. One operator can control and distribute up to 11 information sources simultaneously. The control room in question contains two wide multi-monitor walls (2×3 and 2×2 monitors) in addition to dual-monitor setups on each work space. Any view from the workspace monitors can be set to display on the wide monitors on the wall; either a single one or extended across 2×2 or 2×3 monitors. Any information can be swapped across the wall monitors. These views typically show visualisations simultaneously like charts or graphs, filtered twitter feeds, maps, presentations or simulations in the form of serious games, sensor readings, or live video (see Fig. 1).

Fig. 1. Sketch of experimental situational awareness room

This study is not only intended to improve the usability and accessibility and remove barriers in the control room in question, but to be able to serve as input for others in the process of establishing control rooms designated for increasing situational awareness. Our usability testing procedures can also be replicated for others who want to test the usability of their facilities. Since a control room is a controlled situation with fixed equipment, two important aspects of universal design, ambient situation and technical equipment, can to some degree be optimised for the intended primary users. One of the newly introduced features in this room is a centralized control panel that allows flexible use of all capacities in the room, including all PCs, monitors and video conference system. However, the diversity of users still may trigger potential barriers, and usability issues can easily occur in systems that are designed with a fixed set of requirements, based on needed functionality rather than a user-centred design process.

Concerning universal design, we hypothesise that typical barriers and usability issues that may occur in this type of control room include:

- Information overload. Too much information means that potentially important information will be lost.
- Too complicated user interfaces of the control panel that controls the video walls, meaning that the full potential of the equipment will not be exploited.
- Lack of keyboard equivalents for e.g. drag-and-drop or multi-touch zoom.
- Visualisations such as maps or graphs may lack an alternative representation of the data.

For performing the evaluation of the control room and indicated barriers above, several methods will be used, including heuristic testing and user testing of selected aspects of the control room, including the typical barriers and issues mentioned above.

The rest of the paper is organized as follows: Sect. 2 is a literature review on the design of the control room and usability testing in the control room setting. Section 3 comprises suggested method for usability test. Section 4 presents the results of the testing, followed by discussion in Sect. 5. The conclusions and future works are presented in Sect. 6.

2 Literature Review

Konskinen [5] points out that traditionally control rooms have been seen as a *place* that has been designed for certain *actors* for the *control* of some *process*. Today, there is however a pressure for change with regard to each of the main components of the above control room definition:

- *Remodelling of control room structures*. The definition of the control room has shifted from a stationary, single room space to also include mobile and spatially distributed control spaces.
- *Changes in the allocation of operative tasks*. The operator is no longer a single person but rather a team of people or, even joint automatic agents that collaborate with human actors.

- *Enlargement of the focus of the process.* The operator is no longer only thinking about present situation, but also emphasizing to consider both the past events and the expected future behaviour of the process.
- *Enlargement of the control room focus*. There is a pressure to enlarge the focus of control from operations.

It has been long known that introducing technologies of complex socio-technical networked systems pose new problems for design that require development of new methods. Design of collaboration support is described in [6], and user-centric design is very relevant here as well [7, 8].

Ecological Interface Design (EID) is an approach that is being promoted for situational awareness operators, that assists monitoring activity for system change and designing interface to decrease the cognitive burden of operators [4, 9].

Concerning computer-supported collaborative work (CSCW) in a control room, it has been argued that a focus on the collaborative social context and an ethnography approach would be beneficial in the design of the systems [10]. For our context, user centric design and CSCW would be most beneficial before the control room is built. However, this perspective is still useful for developing usage guidelines that are adapted to the user's working style.

Methods are being developed for more flexible interfaces in the control room [11], and the mobile control room operator interface [12] is also being investigated. The impact of visual information and display formats is examined in [13, 14]. Resilience through sense-making and control are discussed in [15], and the increasing use of social media for crisis mapping is the topic of [16]. There are significant challenges and obstacles in sharing information and coordinating between different agencies in an emergency, as discussed in [17]. Several of the challenges discussed in these papers are relevant for the use of our control room.

Metrics and methods for evaluating control room operator performance are described in [18, 19]. Control room quality and improvement have been evaluated through analysis of critical operator decisions [20], person-in-the-loop testing [21], and finally.

Boring et al. propose a framework for design process and evaluation metrics for control room modernization in [22]. However, most of these evaluations tend to focus on industrial processes which can be very different from crisis situations. Therefore, based on some common approaches to evaluating usability of environments, devices and technologies, we will adapt and suggest usability testing methods that can be considered as part of the contribution of this paper.

3 Evaluation Methodology

We will perform a two-part evaluation, based on user testing as well as a brief heuristic evaluation. The test methodology and setup will be described further in the following.

3.1 User Testing Setup

User-based testing usually involving direct participation of the testers. Users are invited to do typical tasks with a product, or simply asked to explore it freely, while their behaviours are observed and recorded in order to identify design flaws that cause user errors or difficulties. During these observations, the time required to complete a task, task completion rates, and number and types of errors, are recorded [23]. The procedure as suggested by Bastien [23] is as follows:

- *the definition of the test objectives*: testing the usability of functionalities of equipment in the ESA room.
- *the tester qualification*: users interested in multimedia will be sufficient.
- *the selection of tasks participants to realize*: the users should be able to operate the dynamic features of the room.
- *the creation and description of the task scenarios*: the tasks are listed in the script below.
- *the choice of the measures that will be made*: time to complete task (or failure).
- *as well as the way data will be recorded*: results will be recorded in a spreadsheet. Video will be recorded with the tester's permission, to catch any comments along the way and to verify timing.
- *the preparation of the test materials and of the test environment*: the initial state setup is outlined below.
- *the choice of the tester, and the design of the test protocol per se*: after a brief introduction to the system, the script outlined below will be followed, and finally the questions of the questionnaire will be asked to the user.
- *the design and/or the selection of satisfaction questionnaires*: the questions of the questionnaire are listed below.
- *the data analyses procedures to get results*: we will use the data recorded in the spreadsheet, questionnaire responses as well as video analysis, to discover and highlight the barriers and usability issues discovered during the testing.

Initial State Setup. The initial state is based on the following scenario: mastering the usage of the control panel equipment that will control information distribution on the wall screens and PC input and output control on the table. The testing is divided into two parts: (1) understanding the use and change the PCs controlled by the table, and (2) the usage of functionality to present multiple information on the wall screens.

The PCs on the table is set up as shown in Table 1. Any of the PCs can be used on either the left or right side of the table, but a PC can only be controlled by one operator at a time, and the operator can only control one PC at a time.

Table 1. PCs for desktop operator

Left table		Right table	
Desk monitor 1	Desk monitor 2	Desk monitor 1	Desk monitor 2
PC 1	PC4	PC 1	PC4
PC 2	PC5	PC 2	PC5
PC 3	PC6	PC 3	PC6

Each side of the table has a mouse and keyboard and two monitors. The control tablet allows to control on of the PC which in turn provides from 2 to 4 Sources (outputs) that can be displayed on the different monitors on the table as well as the wall screens. We have illustrated the setup of the wall screens (1–10) as seen in Fig. 2.

Screen 1	Screen 3	Screen 5		Screen 7	Screen 9
Screen 2	Screen 4	Screen 6		Screen 8	Screen 10

Fig. 2. Video wall layout

The following sources have been pre-set to be initially shown on the wall screens:

- Screen 1: Ushahidi Syria Tracker (source6)
- Screen 2: #onemilliontweetmap (source12)
- Screen 3: Earthquake forecasting and prediction (source3)
- Screen 4: Emergency 2.0 Wiki (source5)
- Screen 5: yr.no wind map (source11)
- Screen 6: GDASC (source14)
- Screen 7: Lightningmaps.org (source13)
- Screen 8: NVE Flood Map (source4)
- Screen 9–10: Unassigned

The control tablet is a proprietary product, it is a touch-screen based tablet device with tabs for controlling wall screens, desktop PC control, videoconference (not tested), etc. On the two control panel interfaces that were used in the test, gestures like swipe, press, press-and-hold, and drag-and-drop are used extensively to assign and control resources. No alternatives to these touchscreen gestures are provided, and no alternative input or assistive technologies can be assigned to the control panel.

The testers are three persons with solid ICT and Multimedia background, 1 male and 2 female. We will call them Tester1, Tester2, Tester3 or in short T1, T2 and T3. Testers 1–2 are not at all familiar with the setup, while Tester 3 has briefly observed it in use before, but never used it actively. Tester 3 also had the advantage of being able to observe Testers 1 and 2 in the first round.

The testers will first get a brief explanation of the equipment before the start of the test. Then two of them will take the left and right seats at the desk, while the third is free. There will be a map showing which monitors belong to which PCs on the table available to both active testers, and also a list showing the naming of the screens and the initially setup web-sites visible on each screen.

After going through the script a first time with some guidance if needed, they rotate so each person will perform both the left and right side scripts. In the second round, they are expected to manage without assistance. The partial repetition is intended to see if it is significantly easier to use with some previous experience.

Script. The following script will be used.

(1) Table part introduction
   (a) Left Table: Press local desk, select PC3, examine map of sources, to determine which sources are connected to PC3.
   Right Table: Press local desk, select PC2, examine map of sources, to determine which sources are connected to PC2.
   (b) Check on monitor if the correct sources are displayed on the desk monitors.
   (c) You can scroll sources to the left and right, select them and drag and drop to desk monitors. See what happens if you put source11 and source12 on your monitors. Can you control them? Do you know why/why not?
(2) Wall screen introduction
   (a) Left: Move focus to Screen 1 – which PC controls the source on screen 1?
   Right: Move focus to Screen 4 – which PC controls the source on screen 4?
   (b) Both: Select that PC on your desk, and optionally put the source on one of your desk screens.
   (c) Open a new tab in the browser (you may need to press F11 to exit full screen).
   (d) Open local weather forecast (www.yr.no).
(3) You expect a thunder storm and want to monitor weather-related sites.
   (a) Left: Move source of Screen 7 to Screen 1.
   Right: Move source of screen 8 to screen 9.
   (b) Left: Expand Screen 1 (Weather forecast) to cover 2 $\times$ 2 across screens 1–4 (press and hold).
   Right: Expand Screen 9 to cover 2 $\times$ 2 across screens 7–10 (press and hold).
(4) Left side: You need more information.
   Check if there are any recent (last 30 min) tweets mentioning thunderstorms in Norway (how do you get back twitter to Screen 2?)
   Right side: Earthquake reported on the west coast of Sri Lanka.
   Open/retrieve QuakeWatch (originally on Screen 3) to Screens 7–10 (2 $\times$ 2)
(5) There was an earthquake strong enough to potentially trigger a tsunami.
   (a) Left side: Open https://tsunami.gov in a suitable screen.
   Right side: Check for related tsunami warnings using twitter on Screen 2.

Evaluation Questionnaire. The following questions will be asked to the participants after finishing the test.

- Did you feel information overload at any time during this test?
- Was any of the user interfaces very/too complicated to use/understand?
- Which subtask was most difficult?
- Which subtask was easiest?
- Was it much easier in the second round?
- Any other comments or suggestions?

3.2 Heuristic Evaluation of Selected User Interfaces

The heuristic evaluation will focus primarily on the control tablet, it may be a usability bottleneck since it is a fixed proprietary piece of equipment, while the software running on the different screens can be adapted at will. The potential issues mentioned in Sect. 1 will in particular be noted. Nielsen has defined a set of 10 usability heuristics for user interface design [24] that we adopt as our main heuristics, and in addition, we will search for accessibility issues from the perspective of personas [25], imaginary users representing diverse user groups:

– John (55), blind. Experienced computer user with diverse assistive technologies.
– Linda (25). Experienced computer user, used to (fixed) multiple monitor setups.
– Tom (33), motoric disability affecting dexterity of hands. Uses switch control as assistive technology.
– Rita (42), hard of hearing. Uses sign language interpreter for communication.
– Fred (29), mild cognitive disability. Have some experience with computing, but easily overwhelmed by too complex systems.

To facilitate the heuristic evaluation, we will perform tasks from the user testing script.

4 Results

In the following, we will present the results of the tests that were performed, first the results of the user testing, then the heuristics testing.

4.1 User Testing

The results of running the user tests are shown in Table 2. The column titles consist of set of tasks and sub-tasks no. 1–5 as explained in Sect. 3. The testers are listed in the first column, while the second column shows if the testers were in the first, second or third round, and in which table (Left - L or Right - R). We see that there is a clear progress from the first to the second round in all testers even if the tasks are slightly different between the right and left side scripts. While some of the testers needed some assistance in the first round, this was not needed in later rounds. The feedback from the testers also confirmed that the system has an initial learning curve but is relatively easy to operate after the initial confusion is overcome. Note that there was an error in the equipment not allowing the enlargement across screens (used in task 3b) to be performed after the first round.

After two series of the operational testing, we conducted an intensive discussion (video recorded, annotated). The results are as follow:

On the information overload: we posed questions whether the testers felt information overload during the testing. Apparently, there was no such information overload issue among the testers, but rather the barrier issue when using multiple information sources. In other words, they consider it was manageable. But in testing, there was no crisis situation so that we can also say that the testing results are limited to “experi-

Table 2. Results

Tester	Round/Place	1a	1b	1c	2a	2b	2c	2d	3a	3b	4	5	Total
T1	1/L	15 s	35 s	20 s	1 m 55 s	30 s	30 s	15 s	55 s	35 s	2 m 35 s	1 m 5 s	12 m 30 s
T1	3/R	10 s	15 s	35 s	15 s	15 s	1 m 30 s	5 s	10 s	Err	30 s	55 s	7 m 20 s
T2	1/R	22 s	3 m	1 m 8 s	1 m 55 s	55 s	20 s	20 s	1 min 45 s	1 min 30 s	2 m	2 m 30 s	15 m 40 s
T2	2/L	15 s	40 s	30 s	15 s	15 s	1 m 20 s	5 s	10 s	Err	10 s	35 s	6 m 30 s
T3	2/R	25 s	35 s	25 s	40 s	35 s	2 m 20 s	10 s	15 s	Err	1 m 50 s	30 s	8 m 30 s
T3	3/L	10 s	15 s	35 s	10 s	10 s	50 s	5 s	10 s	Err	25 s	15 s	5 m 40 s

mental setting" rather than real crisis situation. While the sources of barriers mostly come from not knowing which sources come from which PCs and visualize in which screens.

On complexity of the user interface: we discussed whether or not the user interface of the display system and operator desk was too complicated to use/understand. All the testers agreed that it was not a problem when one had got to know how the system worked. The confusion on relationship between sources, screens and which PCs to control was mentioned again.

On the most difficult task: (please also refer to our script for the task descriptions): It was mentioned that 3b was difficult because the press-and-hold gesture was a bit difficult to do correctly, an did not work correctly after the first round. In addition, it was pointed out that 5A right: « check for related… » had difficult to understand instructions, and since sources had been moved around in the meantime, the website was not where expected.

On the easiest task: it was agreed that opening a website in a new tab (2c–d) was very easy, and also swapping sources between screens (3a) was very easy.

On the second round: all testers agreed that the second round was easier or much easier. On of the testers also found the first round to be relatively easy too, except for the confusion concerning sources, screens and PCs. They all agreed that if working regularly with the equipment, it would be easy. It was also mentioned that if two people were working together regularly, they will want to split the resources between them.

Other comments or recommendations: The confusion concerning sources, screens and PCs could be mitigated by renaming sources, use logical naming convention, and all it output instead of the current naming, to avoid confusion e.g. PC1-Output1, PC1-Output2, PC2-Output1. It was also suggested to add an always on top ID-note in the corner of each source, showing which source is on which screen. In addition, it would be good to be able to automatically change sources on desktop monitors to the PC you control. Concerning user interactions, it was recommended to enable the use of two touchscreen presses as Select and Apply as an alternative to drag-and-drop. One tester would also like to see an overview display on the control panel, allowing to see video wall layout while controlling the desktop PCs. It was finally suggested to have a separate preview screen showing a grid of all active Sources next to the two main desk screens, to mitigate the first-row-in-cinema effect having to bend the neck backwards to look up at the top wall screens.

4.2 Heuristic Testing

The heuristic testing in particular focused on the control panel user interface, as this turns out to be an important element of the dynamic use of the control room.

From the perspective of Nielsen's 10 heuristics, the following issues were found:

- *User control and freedom*: No undo available. However, actions are reversible.
- *Consistency and standards*: Inconsistent behavior concerning desktop control not automatically providing (or preselecting) the Sources (graphical outputs) belonging to the PC that is controlled, and no connection between PCs and Sources except for an external map printed on paper.
- *Error prevention*: Limited functionality means limited opportunity for creating error situations.
- *Recognition rather than recall*: User needs to remember which Sources belongs to which PC.
- *Flexibility and efficiency of use*: Allows saving and recalling commonly used presets. No alternative ways to perform commonly used actions.
- *Aesthetic and minimalist design*: *Yes*.
- *Help users recognize, diagnose, and recover from errors*: No error message observed during error.
- *Help and documentation*: Not available.

Most of the personas and in particular the ones with disabilities may face minor or major barriers, particularly in the interaction with the control tablet.

- *John (55), blind. Experienced computer user with diverse assistive technologies.*
  - Main barrier: control tablet. No voice output, no way to attach AT.
  - Several of the web sites used as part of the information stream are not accessible, because of lack of alternative presentation for visualizations and maps, and other issues as detailed in [26].
- *Linda (25). Experienced computer user, used to (fixed) multiple monitor setups.*
  - No obvious barriers.
- *Tom (33), motoric disability affecting dexterity of hands. Uses switch control as assistive technology.*
  - Main barrier: control tablet drag-and-drop with no alternative way to control the system.
- *Rita (42), hard of hearing. Uses sign language interpreter for communication.*
  - Main barrier: verbal communication with other operators.
- *Fred (29), mild cognitive disability. Have some experience with computers, but easily overwhelmed by too complex systems.*
  - Main barriers: Risk of information overload.

4.3 Recommendations

Based on the input from the user testing and the heuristic evaluation, the following recommendations are highlighted.

- Introduce a naming convention for Sources making it clear which PC each source belongs to, e.g. *PC1-Output1, PC1-Output2, PC2-Output1*.
- Always-on-top ID information in corner of each Source desktop to make it easy to see which PC/Source any given view belongs to.
- The next generation control tablet should allow connection of mouse/keyboard and assistive technologies for more flexible control methods.
- The next generation control tablet should allow other methods of assigning sources using the touchscreen than drag-and-drop, such as select-and-apply (press-to-select, press again to assign).
- Make sure that the different visualizations and maps that form part of the information stream are accessible to all potential users.

5 Discussions

Since we only had a quite small number of test users (three), and the heuristic evaluation was primarily focused on the control tablet, we cannot claim to have discovered all barriers and usability issues. However, the testers were highly motivated and also provided several very useful comments and suggestions in the free discussion following the questionnaire questions.

We intentionally had two test users active at a time to highlight the collaborative aspects as well as potential competing for resources. However, timing was not so accurate since the testers often forgot to say when they had finished a task, and sometimes delay was caused by waiting for access to the control panel or competing for controlling sources from the same PC.

6 Conclusions and Future Works

The user testing as well as the heuristic evaluation has provided us with a good set of recommendations that will enable the improvement of the control room usability significantly, lowering the threshold of entry for new operators. Not all issues can be solved immediately, as the proprietary software of the control tablet is out of our hands, but the issues will still be noted and worked around as far as possible – and noted as requirements for future upgrades. It was also encouraging that the testers found it easy to perform the test tasks in the second round. The testers also found it enjoyable and interesting to test the control room, and were very positive concerning its potential for training, experiments and research on future directions in situational awareness technology. This is a great opportunity to nudge tomorrow's control rooms towards more focus on inclusive design, usability and accessibility.

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Design Guidelines for Adaptable Videos and Video Players on the Web

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Abstract. Videos are embedded everywhere on the Web these days. They are becoming increasingly important to many people regardless of age, culture or individual capabilities. Unfortunately, not everyone benefits equally from online videos. There is often a big difference regarding the accessibility, usability and the resulting user experience. To close these gaps, occurring everywhere on the internet, dynamic user interfaces adapting to diverse user needs have received more attention recently. Therefore, users can meanwhile adapt a couple of sites according to their personal preferences by either switching between presentation modes or by adjusting some site settings. Taking up this idea, in this paper we examine the adaptability of online video players by focussing on two user groups: elderly people and deaf people. Based on our empirical research, we discuss issues reported by these groups and present abstract and concrete recommendations on how to realize personalized and adaptive video user interfaces for them.

Keywords: Accessibility · Adaptability · Online video · Personalization Usability · User experience · User interface · Adaptation · User research

1 Motivation

Multimedia content and in particular video content, is constantly increasing on the Web. Since Internet users can easily produce them with their mobile devices and upload them to the network, online videos are booming even more.

Unquestionable, videos play a major role for Internet users, including users in Germany [1]. Especially the younger generation consumes them via the Internet [2, 3]. Recently, YouTube stars were announced to be the idols children like most in Germany [4]. With this increasing importance, it is vital that online videos are accessible to everyone, especially when used as a stand-alone medium.

The assumption of this paper is that video players on the Web are still upgradeable, in particular regarding diverse needs of different internet users.

Responding to diverse user needs, personalization and the adaptation of the user interface (UI) have been considered as key for many use cases. Today's software applications offer several customization options with settings that allow users to tailor

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for example their appearance and behavior. Therefore, in this research, we have examined the adaptation of online videos and video players and have investigated how to improve the user experience through personalization.

We have focused on two groups who face specific barriers when using modern Information and Communication Technology (ICT): elderly people and deaf people.

Elderly People. Elderly people represent a challenging user group with varying special needs and abilities. They are often (highly) inexperienced with computers and the Internet and therefore they have more issues while using the Web. Some of them may have difficulties to concentrate or to remember information and how to handle processes. As ageing may bring impairments in vision, hearing, mobility, cognitive and other skills, older adults face a variety of barriers on the internet [5]. They make up a heterogeneous group with diverse and rapidly changing characteristics and requirements. Precisely because of this heterogeneity and their different needs, older ones are viewed as an important group when regarding usability [6].

Deaf People. The World Wide Web has changed a lot in the last few years. Hypertext documents, which used to be mainly textual, became a network that nowadays increasingly conveys multimedia content. What seems to be an advantage for many people is a risk of excluding the deaf people [7], because they do not have an auditory feedback. However, text-based content can be a barrier as well, as the mother tongue of the deaf people is sign language and so they always have to cope with an interface presented in a "foreign" language. Obviously, multimedia content without closed captions or sign language translations is inaccessible to them. As deaf people usually have a lower level of written language understanding, and sometimes do have other disabilities (cognitive, emotional or social) [8], some of them need content in easy language and a clear structure of applications and websites. Further, it is important that websites offer some content in a sign language (translation) video, especially when the content is quite difficult to understand and it is not easy to put it in easy words and language [9].

Research. Aiming to find parameters for adaptation, we searched for other preference dialogs that help a user to tailor a video interface. Additionally, we did a literature research to get to know, what deaf people and older adults might need and demand. However, to identify appropriate items to determine parameters affecting the UI and video content, we did our own research.

In this research, we conducted interviews with older people and an online survey with deaf people to ask them for their problems and requirements in the context of videos. We investigated how far personalization can help to solve the reported issues.

The purpose of this paper is to present guidelines and preference dialogs that help to create and deploy videos and players that are tailored to this particular user groups.

2 Related Work: Video Usability and Accessibility

In the past, there have been some approaches aiming to improve the usability and accessibility of multimedia. As a result, a few standardized sets of guidelines for designing online videos and video players do exist.

Over the last years, the Web Content Accessibility Guidelines (WCAG), standardized by the W3C (World Wide Web Consortium), have gained importance. They aim to make the Web accessible for people with disabilities. These guidelines include several important recommendations for making multimedia content accessible [10]. For example, they emphasize that text alternatives have to be available for non-text content (descriptions, transcripts, subtitles, closed captions, audio descriptions and sign language translation) or that foreground information must be distinguishable from the background information (visual or auditory).

Developers and designers can further use the UAAG (User Agent Accessibility Guidelines) when creating videos and websites with videos [11]. The UAAG, also published by the W3C, describe how to make web browsers, media players and assistive technologies accessible on the web. Very interesting regarding personalization are the guidelines “Provide access to alternative content” and “Provide controls of time-based media”.

3 Examination of Existing Video Adaptation Concepts

Preference dialogs serve to get to know a user’s needs and preferences to adjust a system according to these data. We identified some types of dialogs available to adjust online videos. Most of them are restricted to a special platform.

- *Context-Sensitive Settings.* Users often have the option to adjust settings on the player to affect the playback directly (e.g. select languages and subtitles, change caption settings, adjust speed and volume). Although these settings may vary from video to video and thus are dynamic, there are people who may want to save some settings as preferences. However, context-sensitive personal preference settings are often limited to one-time use and must be re-adjusted each time the user encounters a video player.
- *User Account Settings.* This gets much more comfortable on a video platform where users often have an account (e.g. Vimeo, YouTube or even Facebook). When logged in, the advantage is that the platforms save several playback options and user settings. Thus, the user does not have to adjust them every time. Besides a preference dialog at the player, this offerings do often provide another account settings dialog, which asks for general issues regarding videos (preferred quality, preferred caption presentation, autoplay etc.). As these preferences are limited to the platform, they are not ubiquitous available as well.
- *Browser Settings Dialog.* User settings gained in browsers are at least cross-page and cross-platform available, if the browsers on the different devices are linked to a user profile. However, even this is severely limited in terms of different platforms.

4 Consideration of Other Existing Preference Settings Dialogs

In the section before, we looked at the currently existing preference settings dialogs and explained that the user's preferences are limited to their scope. As the adjustment of such settings might be very exhausting and mean a barrier to some people, there has to be another solution, which tends to minimize the effort for a user.

Therefore, we have considered approaches that aim to store user preferences in one place to use it for many different use cases on different devices. For example, the global open-source initiative GPII (Global Public Inclusive Infrastructure) is working on that issue [12]. Its goal is that users' preferences are not limited to specific applications or platforms, but that they are available to all applications and devices. Therefore, the contributors of GPII develop cross-platform user profiles that can be stored on a server in the cloud or on a portable medium such as an USB stick.

Several Preference Setting Dialogs. There have been several projects, somehow related to GPII (aiming to store user settings in a GPII profile), which have shown panels that allow adjusting websites directly to user preferences. The ones listed in this section are very interesting for designing a preference dialog in the context of videos regarding elderly people and deaf people.

The "Preferences Exploration Tool" [13], which has been developed under the Fluid Project is interesting because of its explorative character and its simplicity, see Fig. 1. It focuses on conveying the information through simple icons and well-chosen keywords. While exploring the tool, we have figured out that a preference dialog for video settings could look similar, regarding some individuals from our user groups (deaf people and elderly people).

The "Floe" project [14] (also part of the Fluid project) presents a HTML5 video player that directly adapts to changes in a user settings panel. In the panel (see Fig. 2), users decide e.g. if they want to see captions or transcripts every time by default. They can decide which language they prefer. Besides, they can adjust their personal default volume for audio content the Look of the player (controls size, color and text size) depends on a user's settings for "Text and Display", "Layout and Navigation" and "Links and Buttons". This panel shows a text-based solution that explains the customization and the effects rather in detail. It provides transparency, suitability for learning and self-descriptiveness. These aspects are also very important for inexperienced users.

Fig. 1. Because of its simplicity, the settings dialog of the preference exploration tool is very interesting for the design of a preference dialog for inexperienced people.

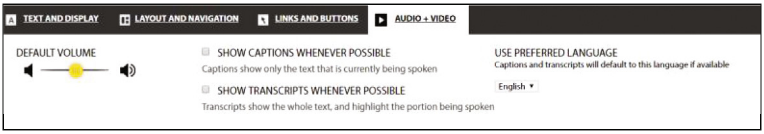

Fig. 2. Floe project preference dialog to adjust the HTML5 video player.

Another interesting application regarding video preferences is the ASPanel (Accessibility Support Panel) [15], developed at Stuttgart Media University. This so-called “Signlanguage-Support” addresses deaf people by embedding sign language videos in a website. Users can use the panel to choose the sign language, the type of interpreter (human or avatar) and a specific character that does the translation.

5 Study: Requirements Analysis in the Context of Online Videos

As mentioned before, we used the instrument of questioning to analyze the requirements for an online video player. On the one hand, we utilized an online survey addressing the deaf people and on the other hand, we went through interviews and a focus group to explore the needs of older adults.

5.1 Goals

Central questions have been: Which *preference parameters* can designers and developers use to provide videos and players that adapt to personal needs? What are the *personal preferences* of the individuals? To what extent is adaptation even necessary or desired from the users’ perspective (*relevance*)?

We concentrated on finding personalization features focusing on the modification of the presentation and functionally of online videos. In other words, our goal was to detect parameters to individualize the user interface according to a user’s needs. We did not investigate the concept of adapting to the equipment (computer, smartphone, screen size, operating system, etc.) and adapting to the environment (date, time, location, ambient light, noise, earphones, speakers, screen position, movement, etc.). We only asked for the context of task when watching online videos (information, learning, entertainment, sign language translation, etc.).

Additionally we searched for special needs we could collect in predefined user profiles (personas). Our goal was to find parameters and preferences that are suitable for many people belonging to a special group (elderly people and deaf people), as predefined profiles allow to start with a set of preferences that almost fits a user’s needs. They can be adjusted bit by bit. A predefined user profile also allows making suggestions. Systems can automatically recommend preference settings in comparison with saved profiles and other data.

5.2 Online Survey Addressing Deaf People

The online survey reached 26 deaf people. The group was quite heterogeneous (literacy competence, level of education, sex [65% women, 31% men], level of web experience). However, nearly all of them used the internet to communicate. It got obvious that videos on the web are not that important, but all of the participants did use online videos before, especially to inform themselves and to learn with videos.

Results. In the following section, we would like to summarize our findings.

- *Difference Between Videos With and Without Sign Language.* This survey should show if there is a difference for the deaf people in watching videos with sign language and without. The results given from our data do not show big differences regarding functionalities but there are apparently few differences on the importance of (additional) information to a video. A short description is supposed to be a little more important on a video with sign language. This also applies for the time position status with a progress bar. The same is for tags. For a sign language video, more participants want to know the size of data. The note of the quality seems to be as well more important for a sign language video. However, the creator's name is not as important as on a video without sign language.
- *Importance of Functionalities*[1]. Most items have been rated as important. Not surprisingly, the following three functionalities have been rated as not important: audio on, change volume, toggle off close captions. The most important functionality or setting is to activate closed captions. Other functionalities that seem to be more important than the rest are the customization of closed captions, the possibility to pause the video, the full screen option and the adjustment of the player's size.
- *Look and Layout.* Many of the participants wish to have in and output with clear borders and frames. Half of them would like to have labeled buttons and symbols. Half of them would like to have different colors for different functionalities. Many participants wish for high contrasts and some would like to delete the transparence of UI elements.
- *Content.* A few participants want to have "useless" animations deactivated. Half of the participants would like to face an easy language.
- *Video Controls.* The authors asked the participants if they prefer the YouTube video controls or an alternative shown on a website for deaf people and hard of hearing persons (imh plus[2]). Half of the participants preferred the YouTube controls. Four people preferred the other option and four persons said, they did not like both solutions. The rest did not know. One question of the survey asked for alternative signs for the player controls. Most of the participants prefer the standard symbols (YouTube) but the data shows that some people wish for others, like sign language, or other proposed sign and symbols.

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[1] In complete, we asked for the importance of 28 different functionalities. To give an input, we used YouTube as an example.

[2] http://www.imhplus.de/.

- *Filtering and Sorting.* On a video platform 46% would like to see only content, which has sign language somehow included or has closed captions. 27% additionally want to see videos with a transcript available. One person only wants to see videos with sign language and three participants would like to see all videos. Another three want to see all types of videos being sorted the way that videos without a text alternative show up at the end of a page.

Requirements for sign language translations and other alternatives for videos:

- *Size of the Translation.* Most of the participants (16 people) prefer sign language translations to be bigger than the original video. Three participants would like them to be the same size and six wish that the original video is bigger than the translation.
- *Showing the Interpreter from Different Perspectives.* The data shows no preference for showing the interpreter from different perspectives but the standard deviation shows, that some do not like the idea and some like it (much).
- *Human Versus Avatar.* Most of the asked deaf people prefer human interpreters but nearly as much of them say that both, human and avatar interpreters, are adequate. After giving information about avatars and their advantages, still most people have answered to prefer a human being (54%), 12% would like to design an own avatar which is always used, 37% would like to see avatars which have been adapted to speakers or actors in a video.
- *Showing Alternatives Automatically.* As alternatives are very important for the deaf people, one questionnaire item asked for how to present these alternatives, automatically or by clicking a button. Most people would like to have the closed captions automatically activated (20 participants). Sixteen participants would like to see the sign language translation directly. Only four persons would like to see the transcript automatically.
- *Position of Alternatives.* According to the majority, closed captions should be displayed under a video. Many participants prefer the placement of sign language translations and transcripts next to the video. However, the opinions are diverging.
- *Technically Created Alternatives.* This applies as well for the acceptance of automatically (technically) created alternatives (speech recognition, time synchronization and avatar technology). There is no consensus on whether to like automatically created alternatives, ignoring or accepting bugs, or to reject it. Half of the group prefers to have faulty alternatives rather than having none. Half of the group does not want to have alternatives, which are faulty.

Integration of sign language translation to explain elements or a whole website:

- *Size.* 20% want to have an explanation video, which they cannot move or resize. 80% prefer a flexible moveable and resizable window.
- *Initial Visibility.* When it comes to the initial visibility of an explanation video, 16% of the group want to see the videos in a small preview in the page, 24% want to have the sign language translation for example as a tooltip. The majority of the participants (60%) want have the videos indicated by an indicator button with which they can access the content.

In conclusion, the participants have been a very heterogeneous user group. The results of the questionnaire items have shown light tendencies to some preference values. However, the resulting data did not allow creating a predefined user profile (persona) that is adequate for most of the participants. It indicated that there are many varying preferences regarding the UI of a video and sign language translation on a webpage. Hence, many parameters (for a preference dialog) to adapt the UI have been discovered, which you can find in Table 1.

5.3 Interviews with Older Adults

In complete, we interviewed three men and five women, all in between 58 and 89 years old with a median of 64. The participants had a few sensory impairments but besides one person with Parkinson's disease, they did not have other disabilities. They had different experiences with the Internet and videos on the Web before. Some did not even remember that they have used online videos before the interviews. However, in the discussion (regarding online video sites like YouTube, Amazon Video or tagesschau.de) they recognized that they had few experiences.

Results. This section contains several outcomes from the interviews:

- *Uncertain on the Web.* When speaking about the Internet a few participants mentioned the fear of doing anything wrong. Some of them made weird experiences (landing on sex pages or advertisements) and thus feel unconfident.
- *Little experienced with online video functionality.* None of them used much functionality of a video player until the interviews. Before, they were happy to use the basic features like start, pause, stop or adjust the volume settings.
- *Open minded for new features.* However, they were interested in other features. A feature they found quite interesting was to go back in the video to see parts again. One woman mentioned that she would like to have a feature to zoom into the video. During the discussion, more and more ideas came up. One elderly person mentioned a repeat function. Another described a feature similar to chapters, which allows skipping content very easily. Not all of them have used or have seen the playback progress bar before but after exploring, they liked it. One of the interviewed persons has known the concept of rating a video. Few of them said that they think video annotations or other information on the video itself could be confusing but after regarding an example on Amazon, the group could at least imagine how this works. No participant has used closed captions, even if they have experienced to miss speech because of the background music. They were amazed by the idea of turning off the sounds and the music or adjusting the volume.
- *Storing is important.* To download a video seems to be more important for the elderly as it is for other users. The participants said, downloading and storing makes it possible to recover interesting contents on their computers.
- *Missing suitability for the task, conformity with user expectations, self-descriptiveness and suitability for learning.* Many of the participants have used YouTube before. However, none of them did know exactly what the settings were for or rather what the benefits of adjusting some settings could be. The participants had some problems understanding and recognizing the symbols on the YouTube video

controls. Hence, they emphasized the importance of tooltips. Some of the controls reminded the group of buttons on their TV remote control or video recorder. As the effect of the associated feature differed from what they expected, they got confused.

- *Labeling and Language.* They experienced the labeling of functions as very helpful. However, the wording of the functionalities and the content language is an important issue. They prefer content in their mother language and wish that foreign languages are avoided. For example, they compared sites on English with a site full of hieroglyphics that they do not want to see.
- *High Contrast and Bigger Buttons.* Sometimes the elderly had problems to notice or perceive functionality because of missing contrasts or because of simultaneous openings. Many of them welcome bigger buttons. One person was not sure if preferring a change or an on/off toggle button. Some of them liked the idea of placing the controls at the top of the video where they found it more visible. They were happy with a proposal of bigger labeled controls displayed in an obvious list next to the video. Three persons mentioned that they do not like menus, that are picture in picture with the video.
- *Enough Time.* Very important was the aspect of getting enough time for a task. No content should disappear without being regarded completely. They made the experience to miss what is going on because the system was too fast.
- *More Feedback.* In this context, feedback is also very important. The participants wished for more text messages that explain what is automatically done from the system, like processing, loading data, changing quality etc.

In general, our interviews showed that older adults are still inexperienced users in the context of online videos. They need additional support to fully profit from the offers. Asking for solutions was not as profitable as offering and discussing alternatives and giving them input to imagine the benefits.

While talking about different video player scribbles, they did realize that a change of the position of the controller or the button size and the labeling of the tools would be beneficial for them.

The research revealed their unawareness of personalization options. Elderly may technically be able to customize some video settings, but they are unaware of the possibilities and they often do not know how their adjustments affect their video user experience.

5.4 Parameters for a Video Preference Dialog

The goal of the survey was to determine the needs and preferences for videos on the Web. We questioned deaf people and older persons and asked them for requirements on different tasks (information videos, entertainment videos, videos without sign language, videos with sign language, video platforms, translations, etc.).

To give an overview of some interesting preference settings, we combined our research findings in a list of parameters with several values, see Table 1.

Table 1. Parameters and possible values, resulting from the authors' requirements analysis.

Parameter name	Possible values
Easy language	True/false
Framing	True/false
High contrast	True/false
Labeling	True/false
Player skin	Simple, extended, complete, create your own {player functionality (play/pause, stop, volume, closed captions, rewind)}
Save player skin	True {save for special task (entertainment, information, sing language, …)}/false
Preview skin	Simple, extended, complete
Replace control symbols	True (sing language, drawing, photos, …)/false
Support control	True (another symbol as tooltip, drawing as tooltip, sign language as tooltip, …)/false
Show all videos	True {show all videos with (closed captions, transcript, sign language translation, …) first}/False {show only videos with (closed captions, transcript, sign language translation, …)}
Size of sign language translation	>, < , = original video
Position of sign language translation	Right side, left side, up, down, picture in picture with the original video
Preferred interpreter	Human, own avatar {design dialog}, avatar designed by the video creator
Show interpreter from different perspectives	True/false
Show automatically created captions/transcripts/translations	True/false
Preferred indicator for sign language translation/explanation video	Small preview, indicator button, in a tooltip
Volume	Volume off → maximum
Hide background music	True/false
Show chapters	True/false
Set default playback rate	Very slowly → very fast
Avoid foreign words	True/false
Position of control buttons	Top, bottom, left, right, picture in picture
Avoid picture in picture	True/false
Always show control buttons	True/false
Show help dialog	True {type {function explanation, control explanation, accelerator key explanation)}/false
Show context-sensitive help explaining features	True {position (pop-up on the video, pop-up on the page under the video, tooltip}
Accept sliders	True/false
Prefer on/off toggles	True/false

(*continued*)

Table 1. (*continued*)

Parameter name	Possible values
Button size	Mini → very big
Button margin	Mini → very big
Show tooltip	True/false
Customize keyboard shortcuts	True {set shortcuts}/false
Show keyboard shortcuts	True {position (tooltips, labels of the control buttons, extra element on the page, in an extra window, pop-up on the video)}/false

6 Conclusion

In summary, the research showed that the different user groups, deaf people and elderly people, face similar but also different problems.

Both groups were open-minded for an adaptation to their needs. However, they like to use standard players and controls others use. Nevertheless, they accept adaptation when registering a personal benefit in the deviant adjusted UI.

On the one hand, we have captured preferences most members of a group share. On the other hand, we have figured out preferences for which the opinions differ widely. Thus, to create and to provide a pre-defined user profile can be very helpful for some individuals, while others have to fine-tune the preference settings a lot.

There are already many adaptation decisions that a user can make in the context of videos and as shown in this research, there could be even more parameters to adjust the UI. Therefore, the system should support the users by recommending settings when they change their preferences.

Besides, the preference dialog has to be suitable. When starting the dialog with few questions to filter the settings, not everyone has to cope with each parameter item.

We recommend to provide some video player themes or so called skins, which are either prepared according to the personas of the group or designed for a special task of use. Themes allow to adjust the UI fast and easily. Giving users the opportunity to save own skins and switch them when using videos, can be a big advantage for them.

To minimize the effort of the users, preference settings and dialogs should be linked so that preferences can be retrieved from other already existing profile settings (video sites, browsers, user accounts). As GPII aims to collect and save the preferences of a user in a standardized format, developers of a video player should think of embedding associated APIs.

Some adaptation features like filtering and sorting videos and multimedia, which are particularly interesting for the deaf people, only can be realized if there is some metadata about the videos. Videos have to be tagged for example according to their role on a site (stand-alone or alternative), according to their content (sign language translation or a video with sign language) and their tasks (information, entertainment).

To achieve adaptable videos and video players on the web, there is a lot of work to do. For this vision to come true developers and designers have to work on appropriate user dialogs. They have to specify the parameters in detail and transfer them to standards. Furthermore, they have to improve content tagging and realize the connection of metadata and the composition of a web page.

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Social Inclusion and Territorial Enhancement: A Project of Tourism Interactive Information System for Bike Users

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Abstract. Social inclusion and territorial enhancement: these are two aspects that can be closely related, especially through relational networks and information systems. In this the new technologies offer a fundamental contribution, both to encourage the involvement, monitoring and relationships between people, and to improve the fruition of the territory and of the resources it can offer. This contribution shows the results of a research project aimed at demonstrating the feasibility of a tourism interactive information system, referring in particular to a specific category of users: cyclists crossing a specific coastal area, in central Italy, rich in natural, historical, artistic resources and food and wine. In particular, the research focuses initially on the project of the information service, identifying the possible relationships and interactive connections between the cyclotourists, the territory and the different communities and stakeholders involved in the service. Subsequently, the research deepens the possible development of an information device that, inserted in specific points of the cycle path, becomes the privileged tool of interaction of the bike users with the territory and its resources.

Keywords: Smart information system · Cyclotourism
Territorial enhancement · Design for inclusion

1 Introduction

The territorial enhancement is one of the themes that has developed in the last decades as a consequence of the international reflections and debates on the significant importance that is attributed to the process of conservation and enhancement of cultural heritage through strategies and systems for the preservation of resources and cultural identities. This not only for the purpose of preservation of territorial assets but also as a promotion and support for the economic development of the communities belonging to it. The social involvement and the involvement of the institutions that manage the territories through the development of new local activities and new communities that are created around them, enhances the competitiveness of the territories themselves. In this sense, the cyclotourist communities become the territorial promoters as they, constantly increasing every year, face the national scene and feed the financial flows and resources.

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Cyclotourism is one of the most widespread forms of tourism and is able to combine sustainable development with the environmental, historical, artistic and food and wine resources that the territories can offer, especially in coastal areas. Italy offers a very wide panorama from the point of view of territorial resources: for this reason a regional project called “Bike to coast” has recently been promoted [1]. The project, promoted by the Abruzzo Region, involves the construction of a cycle path that runs along the Abruzzo coast, in connection with a national scale project and integrating itself with the wider European cycle network called Eurovelo. This great cycle path will connect the coast with the Abruzzo hinterland using the river valleys of which the region is rich [2]. The territory of Abruzzo, in fact, offers a wealth of local attractions that is articulated on different levels of interest, from nature to food and wine: each of them contributes to the enhancement of the territory, bringing with it a wealth of information that must be conveyed to the cyclist during his journey. The increase in cyclists who choose a route along the coast, the need to be always connected and informed about the opportunities provided by the territory and the need to access information at any time without getting off the bike, brings with it the problem of managing the big amount of information that link the territory and the community of cyclists.

2 Objectives

The aim of the research is to design an integrated system consisting of an interactive information service and a product connected to it, aiming to promote communication and the conscious interaction between the cyclist and the territory he crosses. In fact, it is believed that through the start of virtuous processes based on the continuous and systematic flow of information, knowledge, products, human activities, we can create a new community including users and service providers, for the cultural and socio-economic enhancement of the several territorial resources.

3 Method

The study was divided into three different phases: analysis and definition of the scenario; service design; product design. It provides for the application of the MSDS methodology (Method for System Design for Sustainability).

3.1 Scenario Analysis

In the analysis phase, it was possible to choose the most promising project orientation scenario with respect to the research strategies, considered as the set of configuration possibilities that the Tourism interactive information system for bike users can assume.

Using the polarity diagram that relates the degree of innovation of the system (traditional and smart) and the hambit of intervention (city and outside the city), four visions were identified (Fig. 1). The chosen vision, to generate ideas and system solutions, is the *Smart information system,* characterized by an information service for

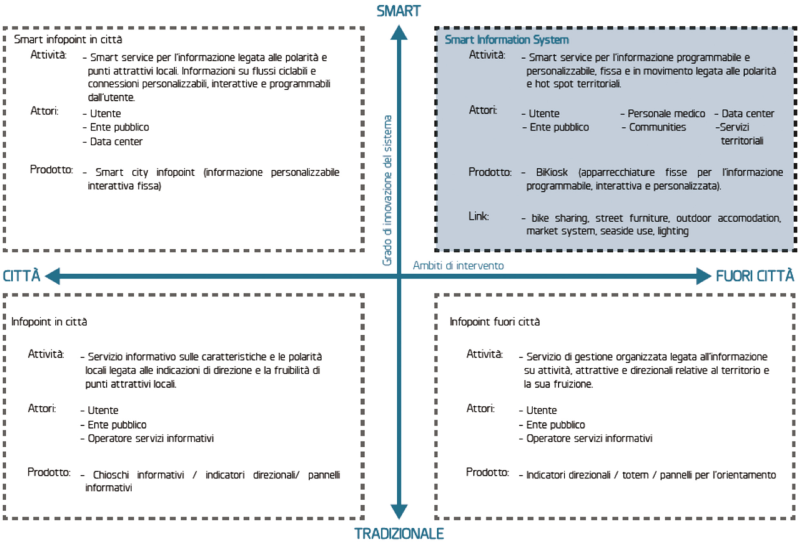

Fig. 1. Design orienting scenario

the user in relation to the different actors operating in the territory: data centers, territorial management bodies, associations, public bodies, communities.

3.2 Service Design

Service design is based on the application of four different tools.

Stakeholders Motivation Matrix. It is a visualization tool aimed at representing the solution from the point of view of the motivations that the individual actors have in taking part in the system. It is a tool useful to define what is the role and the contributions that each actor can provide to the partnership in general, and to each individual actor in particular.

System Map. It is a graphical representation whose purpose is to support the design and visualization of the proposed system structure. It describes which actors are involved and what are the different interactions, distinguishing material and/or product and/or people, information, financial and work (Fig. 2).

Offering Diagram. It is a static representation that describes the functionalities offered by the system to the user, differentiating them into main functionality, basic functionality, value-added functionality and sub-functionality.

Interaction Table. It is a storyboard where the main user actions are displayed during the service delivery through frames that evoke the context in which the action takes place, the actors involved and is completed with descriptive didactic texts that comment on what the actors do and why.

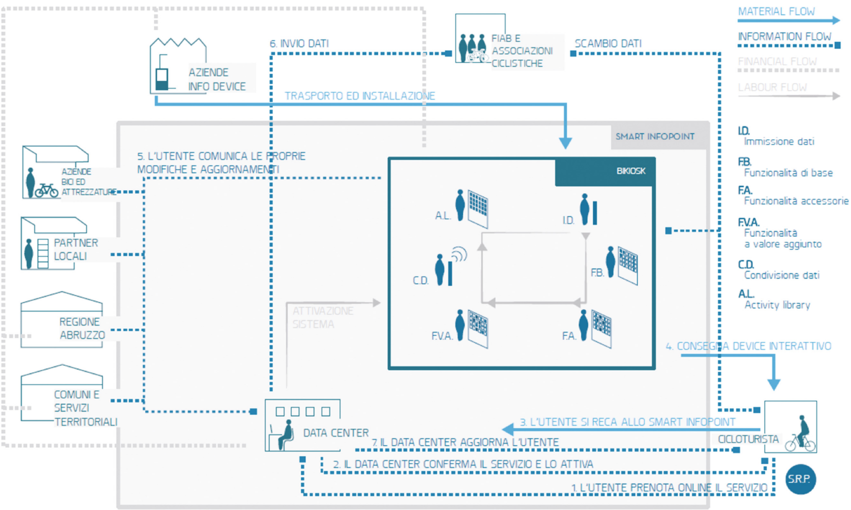

Fig. 2. System map.

Later, the information has been distinguished in flows related to the actors, distinguishing connections and opportunities in a further tool, the **information flow** (Fig. 3).

It explains the trend of information flows and the possible creation of virtual communities, as well as the relationships and actual opportunities that each actor can

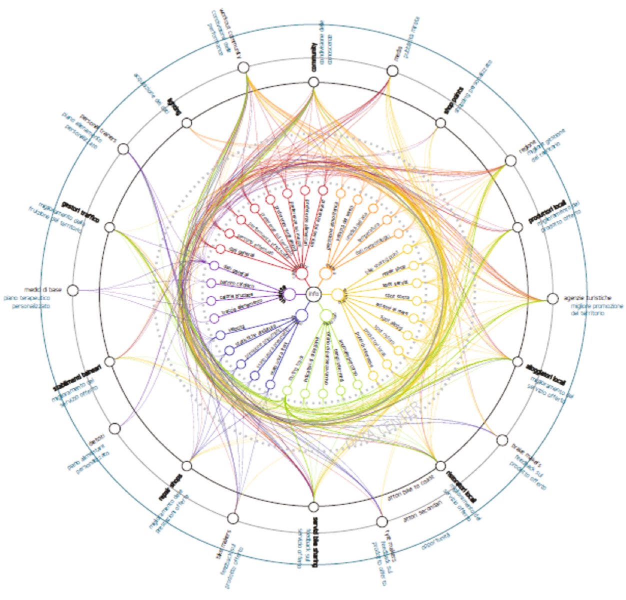

Fig. 3. Information flow

derive from information connections, and that the service can create and manage through a data center that processes and manages the information flows.

On the other side, the **information access mode** (Fig. 4) shows how the information is conveyed to the user and through which support, differentiating into four different possibilities of use of information: through a mobile device (provided at the entrance of the route) an application for smartphones, a traditional signage system side by side to a “smart” one, and the product developed in this research: the Bikiosk. It is a digital support, useful for the management of information related to the territory, to the local communities, to the virtual communities and to itself.

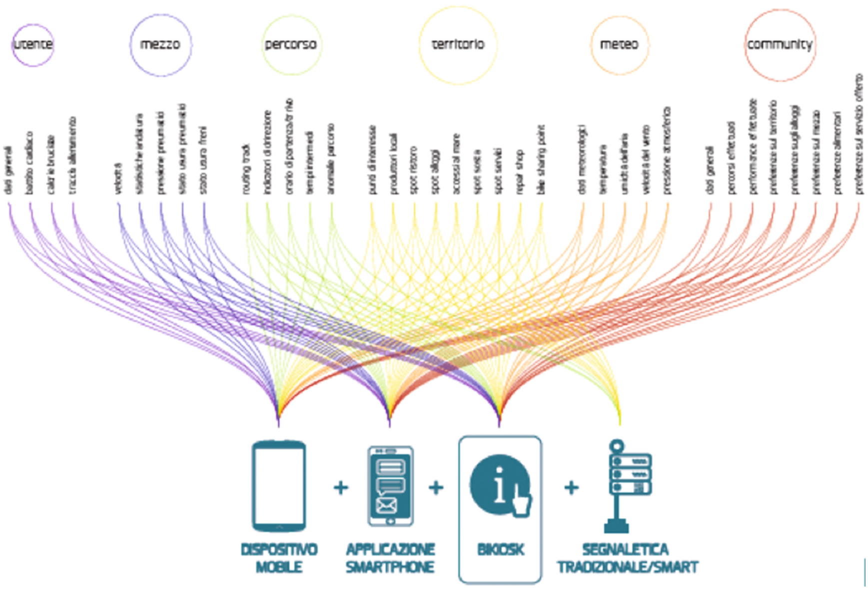

Fig. 4. Information access mode

3.3 Product Design: The Bikiosk

In the development phase of the product, various concepts were developed and among those possible, the one that seemed most suited to the different needs of the user, called “Bikiosk”, was chosen. It is a digital information element, powered by solar energy, which allows the cyclist to acquire the necessary information without necessarily getting off his bicycle (Figs. 5, 6 and 7).

Anthropometric Checks. The Bikiosk concept has been subjected to anthropometric checks, also using specific tables referring to cycling users [3]. These checks made it possible to relate the product to the users anthropometric data (heights, lengths and visual angles), for a correct sizing referring to the multiplicity of body dimensions and the relative bicycles of potential users.

In particular, three main postures concerning the use of the product were taken into consideration: standing, sitting on a bicycle and on a wheelchair.

The check covered the possibility that users can interact with the system in the three postures considered, as the size of the overall dimensions of the different elements that constitute the Bikiosk, as well as the visual angles resulting therefrom have been verified on the basis of the three different reqirements.

The anthropometric verification, therefore, has paid particular attention to the relationship between Bikiosk/bicycle/cyclist, starting from the dimensions of the bicycle for men (28″) and that for women (26″) [4] and inserting the dimensions of all the additional elements that can be added to the vehicle, such as a handlebar with armrest or a storage basket.

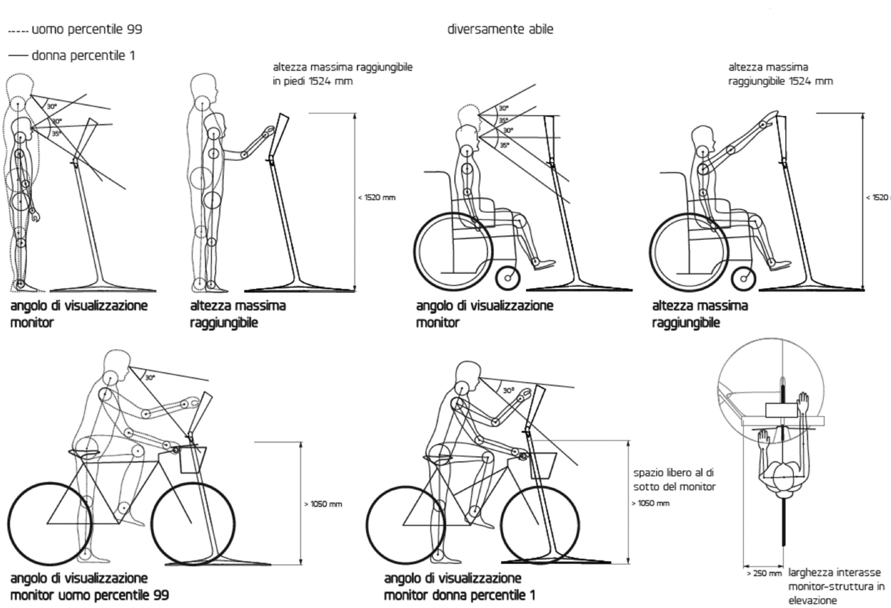

Fig. 5. Anthropometric checks of users while using the Bikiosk

Technological Applications. The product has been broken down into its parts and analyzed from the technological point of view, focusing on the dimensions, functional spaces, regulations and technologies applied to it, distinguishing the technical elements that make the system work and feed and the structural elements that make it possible to guarantee its stability. In particular, the Bikiosk has a solar power system, a motor to allow it to rotate according to the sun, a monitor with touch-screen, a wireless charging system for mobile devices, a USB connection system for mobile devices, a analogue navigator, an anti-glare protection carter.

The Study of Materials. All the materials chosen for the definition of the product meet the requirements of environmental sustainability and minimization of the environmental impact, both from the point of view of recyclability and non-toxicity, and from the point of view of product simplification, reducing the number of parts and avoiding the formal obsolescence.

In particular, the search for a sustainable and autonomous outdoor supply system has led to the choice of a solar power system that proposes the use of a cover for the support base in amorphous silicon that captures the sun's rays, which are so transformed into electrical energy that feeds not only the movement but also the functioning of the system itself [5]. The structural elements of the product have instead been defined morphologically and dimensionally to ensure its stability. The materials used are: steel for the technical compartment; molded aluminum for the rotation base, for the elements for access to the technical compartment and for the monitor supporting case. For the structure in elevation, however, the aluminum was chosen too, but with a glossy finish, to give it a character not only of structural stability but also of aesthetic value.

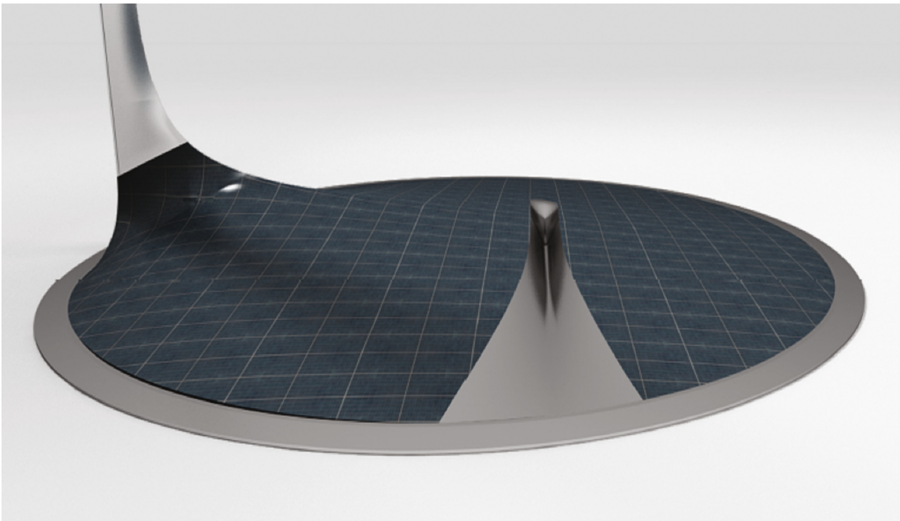

Fig. 6. Detail of the support base

4 Principal Results

The research has led as a result the Bikiosk, a digital information interface powered by solar energy, equipped with a rotating system at the base that allows, in its rotary configuration, a rotation on its central axis to limit the glare phenomena due to solar radiation.

In particular, the solar power system is connected to a motor which, by rotating the base of the system on a ring nut, allows its 360° rotation on its central axis.

The base also contains a "wheel stop", a thin groove which limits the movement of the front wheel of the bicycle so to facilitate user interaction with the bikiosk while sitting in the saddle of the bicycle. The structure in elevation is equipped with LED lighting, and is completed with a shelf under the monitor for small objects that also incorporates a wireless charging system for mobile devices. The monitor, which is hooked to the elevated structure by means of hinges to allow a different set-up/inclination according to the use requirements, also includes an analogic navigator to help the user in consulting and managing information.

The monitor also accommodates a USB connection system for mobile devices, and is contained inside an external protective case with a small visor, which limits glare phenomena due to sunlight.

The bikiosk provides two different arrangements (rotating and fixed) also based on the space available around the system. In fact, the automatic rotation of the bikiosk according to the position of the sun, allows the user to never be directly dazzled. This therefore requires a large amount of space around the location of the Bikiosk, which is generally located next to the cycle path. Since, however, not always along the entire path of the cycle path there is a space available to allow access to the Bikiosk by bicycle from any direction around it, there is also the possibility that the system remains fixed: in this case, the final Bikiosk orientation *in situ* is defined according to the best exposure respect to the sun, for a optimal visibility and consultation of the information displayed on the screen.

Fig. 7. Visualization of the product and hypothetical position along a stretch of cycle path

5 Conclusions

The research has developed a new service that not only connects the territory and its most varied resources with the community of cyclists traveling along the coast, but it also generate a series of new communities, thanks to new virtual connections that the service itself makes available. The bikiosk is also proposed as a project that offers solutions that adapt to the different needs of the user but also to the space and interactions that are created with it. All this to provide a link between the user and the territory and that could become an additional attraction for the enhancement of a territory that already has so much to offer.

6 Credits

The research was developed as part of a thesis in industrial design at the Department of Architecture of Pescara (University of Chieti-Pescara, Italy). Thesis title: *Bike to coast Smart Information System. Information system for assistance to the cyclist*: supervisor prof. G. Di Bucchianico, correlators prof. A. Marano, prof. S. Camplone, graduating E. A. Villani.

This paper, which summarizes the objectives, the phases of implementation and the main results obtained, was written by G. Di Bucchianico (Sects. 1 and 2), A. Marano (Sects. 3.1 and 3.2), S. Camplone (Sect. 3.3), E. A. Villani (Sects. 4 and 5).

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Understanding the Experience of Teenagers as Bus Passengers for the Design of a More Inclusive Bus Service

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Abstract. The aim of this study was to understand the teenagers experience when using the bus service in Guadalajara City, Mexico. A total of thirty four teenagers aged from fifteen to nineteen participated in four structured focus groups. A previously designed service blueprint was used to show to participants the different stages and user actions of a door-to-door experience. They were asked to rate every interaction with the service according to the level of difficulty that they had experienced, after that each member of the group shared their views and reasons behind the assigned rating. Discussions were aimed at eliciting their views on those interactions where the bus service could be better. The most outstanding findings were that teenagers were able to identify issues and opportunity areas that could help to improve the service to be safer and more usable for other groups of users as the older people.

Keywords: Ergonomics · Inclusive Service Design · Teenagers Public transport

1 Introduction

1.1 Context

The bus service in Guadalajara operates in lack of regulatory and legislative regimes, which means that there are few incentives for transport operators to provide what passengers need or expect. It is common for bus operators to compete with each other to maximize the number of passengers per bus. Such a situation, in general, causes buses to be crowded and driving styles are unsafe and uncomfortable for passengers [1, 2].

In a recent study on the urban mobility problems in the city, Martín-Covarrubias [2] concluded that the problem of the public transport service is due to the fact that it currently has approximately 5000 vehicles that translate approximately 70% of the population; This author states that it is insufficient to cover the demand for mobility in the area, causing a service of poor quality, inefficient and unsafe.

Aceves-Gonzalez [3] conducted a research of the public transport using individual and group interviews with a range of stakeholders and a document analysis strategy of

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relevant documents in the public domain. It was concluded that the main problems of public transport in the city are: (1) the urban investment has not favoured public transport as a mobility option; (2) there is a lack of a regulatory and legislative regime to incentivize the provision of a good quality transport system; (3) buses are designed above of a truck chassis due to the lower cost; (4) the bus service is an informal organisation comprising people who own their own bus and who work in competition with others; (5) there is a lack of support from service operators towards drivers; (6) the fact that drivers are paid directly out of the fares they collect, and therefore pressurised to pick up as many passengers, as quickly as possible; (7) Drivers work shifts of up to 13 h without fixed breaks, and do not receive proper training for doing their job; and (8) there is a poor public perception of the quality of the service [1, 3].

Research in the use of public transport is usually focused on populations considered vulnerable, such older and disabled people [3, 4]. However, it has been observed that the use of public transport by teenagers has not been the main object of study. This general lack of teenagers-centred studies provides an interesting opportunity for research. To try to understand teenagers when using the public transport, because during this period of life, individuals assume increasing levels of independence and responsibility.

The World Health Organization defines the period of adolescence from ten to nineteen years. The adolescent is breakdown in three stages: early adolescence from ten to fourteen years, this stage is pubertal development; mid adolescence from fifteen to seventeen years, it is the peer orientation, access to greater freedom of activity and independence; and late adolescence from eighteen to twenty, it is the transition made to adulthood [5, 6].

McDonagh [7] mentions that adolescence encompasses aspects of physical and cognitive maturity and the accomplishment of task such as definition of his/her identify, construction of own relationships outside the family and achievement of independence from parents. Elliott and Feldman [8] mention that adolescence is outside of infancy, the period of life characterised by more change and development than any other at no other point in our lives. Teenagers go through such a dynamic transformation, where they evolve from dependent child to autonomous adult, adapting to physical and psychological development [6]. These transformations that happen in adolescence are important to consider for the design of the public transport service; because the degree to which people feel safe using public transport has been shown to have a significant effect on their willingness to use products or services [6, 9], which would favor independence with respect to mobility in adolescents.

1.2 Approach

This research was guided by two complementary approaches: Ergonomics and Inclusive Service Design. Dul et al. [10] affirm that Ergonomics and Human Factors has potential to contribute to the design of all kind of systems with people, as work systems, product or service systems and it focuses on two outcomes: performance and well-being. Inclusive Service Design (ISD) is an approach that integrates theory and methods from Ergonomics and Service Design and Inclusive Design perspectives [3]. This approach aims that services address the needs of the widest possible audience

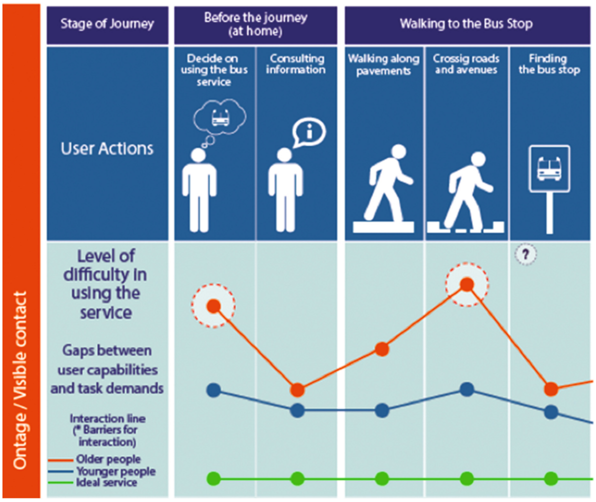

Fig. 1. Small part of the Inclusive Service Blueprint of the bus service in Guadalajara [3].

regardless of their age or ability, through (re) designing more accessible and user-friendly. It also considers the user experience based on the complete tour of the user, during all stages of the user's interaction within the service, as defined by Aceves-Gonzalez as a door to door journey [3].

As part of ISD it is proposed the use of an Inclusive Service Blueprint [3] to guide the assessment and re-design of the bus service in Guadalajara (Fig. 1). With the use of the tool and approach it was possible to get a better understanding of the service operation; the identification of the main barriers for interaction with the service along a door-to-door journey; and the determination of the gap between what younger and older users needed and desired and what bus operators actually was providing [1]. However, that research was focuses in younger adults and older passengers leaving out other populations as teenagers who compound part of the daily users of the transport system. Given this the aim of this study was twofold (1) to understand the teenagers experience when using the bus service in Guadalajara City, Mexico, and (2) to compare these results with those provided previously by younger adults and older people.

2 Methods and Materials

2.1 Overview

For this study, a structured version of the focus groups method was used to understand the teenagers experience using the bus and rate the level of difficulty that they find when interacting with the service. Focus groups were planned to provide a creative environment for the participants to express their views and experiences but without deviating from the research aim. The four focus group sessions were conducted within a high school in Guadalajara, Mexico.

2.2 Participants

Participant recruitment was undertaken through a public high school. A total of 34 teenagers were part of the study; the inclusion criterion was that the adolescents were currently users of the bus. The ages of the participants were in average of 16 years (SD: ±1.30). Table 1 shows the age range and distribution of participants for each focus group session.

Table 1. Focus group characteristics

Focus group	Gender	Range of age
1	9 female	15–18
2	5 female-3 male	17–19
3	4 female-4 male	15–18
4	4 female-4 male	17–19

2.3 Procedure

At the start of the focus groups, they were welcomed and the dynamic of the focus group was explained. Also, participants were informed that this activity was not mandatory for their curricular activities. Students provided their consent to be part of the study.

After, researchers provided cards to the participants, each card comprised a user action (as in the Fig. 1) in a bus journey from home to destination. These actions and images were taken from the Inclusive Blueprint developed by Aceves-Gonzalez [3]. For each action, participants were asked to rate from 0 (no difficulties at all) to 10 (very difficult) the level of difficulty that they perceived as bus users. As following action, participants have some time to express the reasons behind the numbers they had assigned for every interaction with the service. Sessions were recorded in audio. The quantitative data were analyzed descriptively and the qualitative data were grouped in categories according to the frequency in which were mentioned.

3 Results

3.1 Focus Group

Table 2 displays the results of the focus groups. In the table it is presented the stages of the journey, the user action, the average of the score obtained from all the participants regarding the level of difficulty in every action, and finally, the perceived issues following by the number of participant who raised each of the issues. Some participants identified more than one issue per action and some participants did not identify any issues in some actions.

Table 2. Rating of level of difficulty and raised issues (n = 34)

Stage	User action	Score	Raised issues
Before the journey	1. Decide on using the bus service	3.41	Vague information about the bus routes and stops. n = 25 It is hard to identify the right bus route at the first time. n = 13 The people at the bus stop give wrong information about the routes. n = 4
	2. Consulting information	5.76	Imprecise information about routes online. n = 33
Walking to the bus stop	3. Walking along pavements	5.9	There is not a crosswalk. n = 18 The streets has not lighting. n = 11 Feelings of insecurity on the streets due to crime. n = 8 The car drivers do not respect traffic lights. n = 7 Lack of respect to the pedestrians. n = 6 Long distances between one bus stop and the other. n = 2
	4. Crossing roads and avenues	6.47	There's no respect from the drivers to pedestrians. n = 20 Lack of pedestrians traffic lights. n = 14 Very short time for crossing. n = 2 There is not a crosswalk. n = 13
	5. Finding the bus stop	5.29	No signs for the bus stops. n = 30 The signs are not sharply defined. Where there is a crowd waiting means that the bus stop it is there. n = 2 It is a matter of experience to know the right bus route. n = 5
Waiting for the bus	6. Access to the bus stop	3.88	The bus drivers do not respect the bus stop. n = 6 There is not sings to indicate where the bus stops are. n = 27
	7. Waiting for the bus	7.74	The bus takes a long time to pass. n = 29 The buses not always stop in the same spot. n = 4 Sometimes the buses do not stop. n = 8
	8. Identifying correct oncoming bus	5.88	It is hard to identify the route number because of the small size of signs. n = 15 Some buses do not have route number. n = 6 The route number cannot be distingue because of the color and material of the sign. n = 4 The letters in the signs are not clear. n = 8 Sometimes during the night bus drivers turn the lights off, therefore it is hard to visualise the route number from the bus stop. n = 8
	9. Being detected by the driver	3.42	The bus drivers usually turn the lights off Sometimes the buses does not stop. n = 8

(*continued*)

Table 2. (*continued*)

Stage	User action	Score	Raised issues
Boarding	10. Climbing the steps	5.64	It is hard to climb up to the bus due to the shape of the stairs. n = 3 The stairs floor is slippery. n = 9 The height of the stairs is too high. n = 12 The bus does not stop completely. n = 2 It is hard to climb up because of the darkness (at night). n = 2 The bus driver close the doors while people are still trying to get on the bus. n = 2
	11. Grabbing the handrails	4.58	Some buses do not have handrails. n = 10 Some handrails are very high. n = 2 Loose handrails or broken. n = 6
	12. Paying to the driver	5.17	The bus drivers request the ID to make valid the *transvales* o *bienevales* (student discount). n = 25 Bus drivers not always accept the student's payment method). n = 6 It is expensive. n = 6
	13. Receiving the ticket	4.83	Bus drivers do not give you the corresponding ticket. n = 18
	14. Identifying a free seat	5.52	Not available seats. n = 13 It's hard to look for a seat because buses are crowded. n = 3
Travelling	15. Moving to a seat	5.76	The bus is always in movement so gets tricky reaching a seat. n = 14 There is no seats left and due to the crowd it gets complicated just to walk in there. n = 13 Someone else gets it. n = 3
	16. Getting in of seat	4.82	Lack of balance. n = 12 It is hard to find a seat. n = 3 It is hard to getting into a seat. n = 6 The seats are small. n = 6
	17. Maintaining seating position	5.05	Usually the bus goes very fast so it is difficult to maintain balance. n = 19 People lean against one to another. n = 7
	18. Maintaining standing position	6.94	It is crowded, there is always someone pushing. n = 15 The people get annoyed because of the extra space students need due to the backpack. n = 9 Height of the handrails. n = 3 Lack of balance. n = 3 High speed what makes it difficult to maintain standing posture. n = 2 High level of insecurity on the bus (people get too close with each other due to the lack of space). n = 6

(*continued*)

Table 2. (*continued*)

Stage	User action	Score	Raised issues
	19. Identifying arrival point	6.11	It is a matter of experience to know the right bus stop for alighting. n = 13 There are no signs to identify the bus stops. n = 11 The bus drivers not always stops where he is supposed to. n = 8 Without identifying the right stop it gets harder to ask for it in time. n = 2
Alighting	20. Standing up	6.47	The bus do not stop moving/lack of balance. n = 4 It is hard to stand up of the seat because of the crowd. n = 25
	21. Getting out of sea	6.35	It is crowded and it difficult to get out of the seat n = 16 Lack of balance. n = 8 Usually the bus goes very fast. n = 8
	22. Moving to the exit door	5.88	The bus goes fast and it is difficult to maintain balance. n = 23 The bus keeps the doors wide open on almost all of the journey. n = 7 The bus drivers not always stops where it is supposed to. n = 8
	23. Ringing the bell	4.70	Sometimes the ring bell does not work. n = 23 The knowledge of the ring bell is given by watching what others do. n = 12
	24. Climbing down the steps	5.64	The bus does not fully stop. n = 20 Slippery stairs. n = 5
Walking the destination	25. Walking along pavements	3.88	The bus stops far away from the sidewalk. n = 4 Long distances between one bus stop and the other. n = 8 There is not a crosswalk. n = 3 No street lighting. n = 19
	26. Crossing roads and avenues	4.94	There is not a crosswalk. n = 16 There is no traffic light for pedestrians. n = 16 There is no respect from the cars to pedestrians. n = 10

3.2 Comparing Difficulty Levels Among Teenagers, Younger and Older Adults

A comparison was made of the three group of users studied from this perspective. On the one hand, the groups investigated previously by Aceves-Gonzalez [3], young and older adults; On the other hand, the adolescents investigated in this study. This comparison can be made because the response of the participants was rated on the same scale from 0 to 10 points, 0 being perceived as non-problematic and 10 very problematic. The Fig. 2 shows the scores for each group along the whole journey. Each point corresponds to one action listed in Table 2.

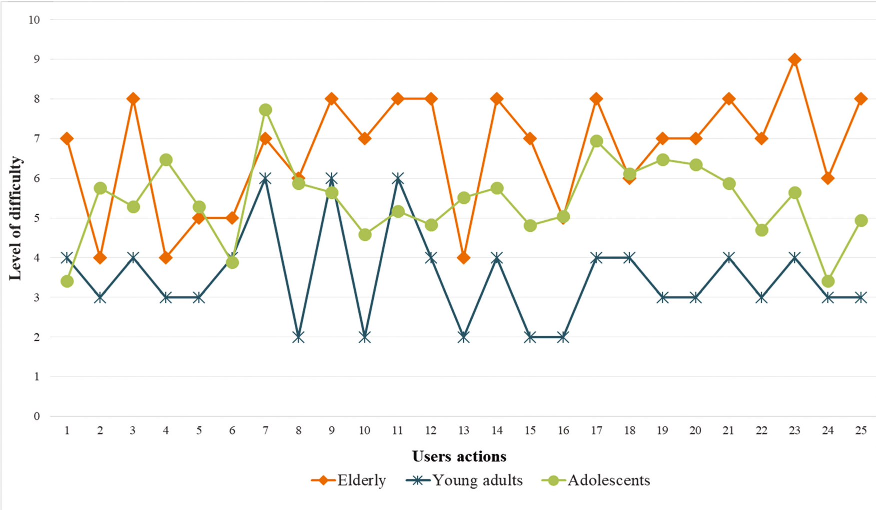

Fig. 2. Comparison of the scores given by teenagers, younger and older adults.

4 Discussion

This study contributes to understanding the teenagers experience using the bus service. A number of problems have been identified from a door-to-door journey related to the teenagers' experience using the public transport. It should be highlighted that participants raised similar issues than those that older passengers have raised previously using this transport service. For instance, in his study Aceves-Gonzalez [3] found that older people raised three main issues, namely attitudes and behaviours of the bus drivers, design of the buses, and the high levels of crowding.

It is known that older people are less stable and do not respond as well as younger people to postural perturbation. This could be a concern when boarding the bus since the height of the first step is 40 cm, but also when older people need to keep balance as while they were moving to a seat [1]. Older passengers presents these problems due to their gradual loss of capacity and it is expected that the response of the younger ones will be much better with respect to these obstacles. However, with the adolescent population it is often not counted that the backpack loads produce changes in standing posture [11], posterior loads will necessarily change body posture because of changes to the centre of gravity [11, 12]. Furthermore, the weight of the backpack is associated a more limited physical functioning, and more bodily pain [13]. Considering the previous fact, bus design based on converted truck chassis [1] is probably one of the causes for which teenagers considered that boarding the bus is a difficult task.

The attitudes of the drivers regarding the use of transvales o bienevales and the lack of information about the routes are problems that are shared among teenagers, younger and older adults. This is a problem prior to the use of the bus, but it is still part of the public transportation service. From the perspective of service design the focus is on the full customer journey experience, including the experiences before and after the service encounters [14].

5 Conclusion

Results from this study suggest that travelling by bus in the studied context is problematic not only for older people but also for younger passengers. There is much room for improving the bus service to make it more usable, desirable and safe. The areas of opportunity regard to bus design, areas designated for pedestrians and information received by passengers with respect to bus stops, routes and the use of payment methods.

As a conclusion, it can be pointed that to provide better solutions for service improvement it is needed to understand the needs and capabilities of a more diverse group of users. It is especially important to understand the conditions of those users under vulnerability conditions, either an older user with reduced physical capabilities or a teenager with a big and heavy backpack. Both under the stigma of using a discount as a payment method. This must be considered if a more inclusive bus service is expected to be delivered in the city.

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Inclusive Smart Parking: Usability Analysis of Digital Parking Meter for Younger and Older Users

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Abstract. When technological advances include the interaction with interfaces through smartphones in order to access a service, some older adults may be left behind because their learning abilities are not taken into account. This research aimed to perform a usability evaluation of the digital parking meter service in Guadalajara, Mexico. Nineteen people participated in this study, divided into two age groups, older adults and younger people. The main evaluated task was to make the payment of 30 min of parking using any of the three methods offered by the system. It was observed that eight older adults decided to pay at a participating store. Half of the nineteen participants rated the system as regular based on the interaction they had with it. In general, the participants pointed out that it is not easy to use the system and a lot of time has to be spent to use it.

Keywords: Usability · Parking meters · Human factors · Interface Inclusive design · Special populations

1 Introduction

The technological development propitiated by the process of globalization, establishes a marked tendency towards the design of services interfaces, in which users become managers of their own transactions. The objective of this technology is to increase control in the contracting process of services, make operations faster and increase saving in terms of cost and times [1, 2].

However, if these technological interactions are inadequately designed, they may leave certain sectors of the population excluded; this is the case of older adults, who are disadvantaged especially in those technological applications where greater cognitive capacity is required [3, 4] which is diminished due to the natural aging process. In addition to this vision, hearing and locomotion problems make it difficult for older adults to relate to their context and, therefore, to technology itself.

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These disadvantages can cause anxiety and encourage a rejection of the interaction with technological advances, since the pressure to complete the task, the lack of training and the hostility of the context [5] which make difficult the satisfaction experience that these technologies intend to contribute or the desire to use them.

If it is taken into account that the population of older adults continues to increase and it is expected that by 2050 they will represent 22.3% of the total population worldwide, while for Mexico it is predicted that it will be 21.5% [6]. Given this situation, it is necessary that designers take into account the qualities of product and systems usability [7]. Currently, the concept of usability has evolved; according to ISO 9241, it emphasizes the effectiveness, efficiency and satisfaction with which users reach the objectives when performing tasks in a specific environments [8].

It is necessary to carry out usability assessments in real environments where the users interactions include new technologies [4] to generate developments that take into account the abilities of the different age groups; where the simplicity avoid the existence of tasks or excessive pre-requisites that cause learning difficulties in the users when using the products and giving them two alternatives: depend on technical advice or refrain from using them [9].

1.1 Parking Meters in Guadalajara

In 2017, a new program of virtual parking meters "Parkimovil" was released in the city of Guadalajara in order to replace those parking meters that used coins as a way to pay; the implementation of the program includes a new self-service payment system in which users can opt for three different modes of payment: cash payment in a commercial establishment, payment either through an App or by sending a text message [10]. Figure 1 shows a picture with the information (in Spanish) provided to users on the modes of payment.

Fig. 1. Picture of the instructions for the digital parking.

Theoretically, this system provides some positive characteristics to the users, such as: a less expensive payment model; the possibility to consult the availability of parking spaces in real time; a system feedback of alerts sent to the user cell phone (five minutes before the payment for the service has expired); and a theft insurance for the vehicle. However, there has not been any evaluation that allows knowing the user's experience with the new system. For this reason, the aim of this research was to undertake a usability evaluation of the digital parking meter service in the ZMG, Mexico; in order to explore if this interface is suitable for users, especially for the older ones.

2 Method

This research evaluated the new parking meter payment system implemented in the City of Guadalajara. The participants in this research were nineteen people divided into two groups; group A included nine older people aged 65–72; group B consisted of ten younger people between the ages of 19 and 35; an inclusion criteria for participants was that they still drive a vehicle regularly.

To evaluate the use of the virtual parking meter an usability test was carried out by applying three different tools of analysis: (1) a checklist of the tasks that integrated the interaction process, (2) a structured interview to address each task of the participants and their opinions of the system, and (3) a questionnaire with a five point Likert scale to assess their degree of satisfaction, which was rated from 1 = very good to 5 = very bad.

2.1 Apparatus and Materials

To carry out the usability test, the following tools were used:

- Reflex camera, to videotape the users interaction with the service.
- Two smartphones, one to take the time and the other to record the participants' comments.
- A questionnaire of a 5 point Likert scale.
- An interview format.
- A checklist.

2.2 Procedure

All the participants were cited in the same place, which was chosen by convenience according to the requirements to perform the payment task. A consent form was given to the participants. After this, participants were asked to pay 30 min of parking using the new parking meter system; they were told they could not get help from the researchers.

The payment activity was divided into three main tasks: (1) searching the virtual parking meter (instruction poster), (2) reading the instructions, and (3) making the payment using any of the three methods offered by the system.

Each main task was divided into subtasks which include the steps required by the system to make the parking payment effective; In all the tasks and subtasks the time of realization and the number of errors presented were collected through a checklist, likewise the sum of interactions between the participants and the system was recorded. Also, an interview was conducted with each participant and finally, they were asked to answer a satisfaction questionnaire about the smart parking system.

3 Results

Data of user characteristics are described in Table 1. It can be seen that in the group of older adults some of the participants did not have a smartphone or available credit on their cell phones, while this condition was not present in the group of younger users.

Table 1. User characteristics

Characteristics	Older group	Younger group
Age	67.1 (SD ± 3.6)	27.9 (SD ± 4.8)
Gender		
Female	4	4
Male	5	6
Number of days per week in which they drive	$\bar{X}$ 6	$\bar{X}$ 6
Smartphone		
Yes	6	10
No	3	0
Credit on the cell phone		
Yes	5	10
No	4	0
3G		
Yes	6	9
No	3	1

Considering the time that was taken by participants in finishing the tasks, it can be noticed that older adults in average took longer to complete the payment activity (13.11 min), while in the group of younger users it was reported an average of 9.2 min. Only one participant of the younger group did not complete the task as he could not make the payment using any of the three modalities.

Regarding the chosen method of payment. Within the group of older participants only one person was able to complete the task using the app, while the remaining eight chose a commercial establishment to pay. It should be noted that three of the participants in this group tried first to pay by text message and another one with the app. However, they did not succeed, therefore they had to select another method to complete the task.

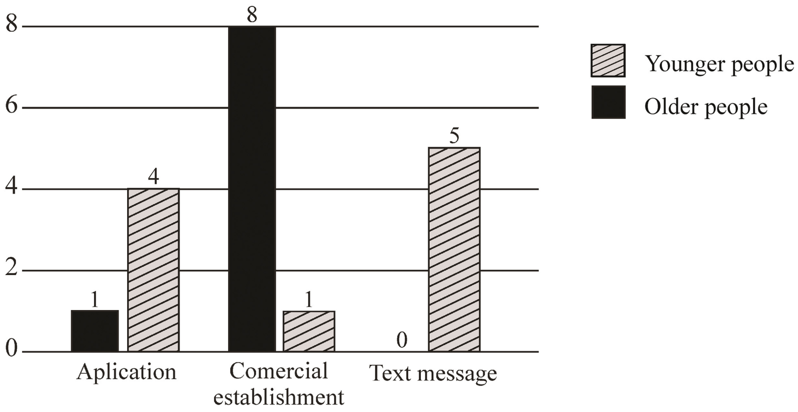

Fig. 2. Participant's final choice of payment method

In contrast, participants in the younger users group preferred to pay by their cell phone; three of them tried to pay at first by a text message and two by the cell phone app, but as they did not succeed they chose another modality. The participants' final choice for payment is shown in Fig. 2.

During the interview, members of both groups were questioned if they considered that the new payment system was suitable for older users. Five elder people answered affirmatively, while most of the younger people thought otherwise. The digital parking meter system in general was rated as "average" by 44% of older people and 50% of participants in the young group shared the same opinion.

Table 2 shows the results of the assessment on the visibility and location of the informative posters. It was rated as "good" by four of the elderly while four of the young users rated it as "average". Additionally, five of seniors reported that the satisfaction generated by the new parking meters was good while most of the young people disagreed with this opinion and they rated this category as "average" and "bad".

Observing the interaction of the participants with the virtual parking meters, several errors were identified, which are shown in Table 3. In this section, it can be identified that the most recurrent error is related to the task of "identification of the new parking meters", as the participants were looking for the old parking meters that were closed but still on the roads. This situation encouraged them to present a higher request for help with respect to that specific task.

4 Discussion

It was found that more than a half of older adults are optimistic with respect of the new technologies and they perceive themselves capable of using them. However, some of them refer that they are not able to use easily the digital parking meters yet and they find it more difficult than the previous ones. This assertion can be better perceived in the selection of the payment method, where the majority of older adults was inclined to

Table 2. Assessment of the system characteristics

Evaluated characteristics of the system	Older people	Younger people
Qualification of the smart parking system		
Very good	1	0
Good	1	1
Average	4	5
Bad	3	4
Very bad	0	0
Way to spread the information		
Very good	1	0
Good	5	1
Average	3	5
Bad	0	4
Very bad	0	0
Ease of location for instructions the smart parking		
Very good	0	0
Good	4	3
Average	2	4
Bad	3	2
Very bad	0	1
Satisfaction of the smart parking compared to the previus ones		
Very good	0	1
Good	5	2
Average	3	3
Bad	1	3
Very bad	0	1

Note: Older group n = 9, Younger people n = 10

pay within the commercial establishments. This is consistent with the results found by Meuter et al. [5] where older adults were perceived to avoid using new technologies.

According to the established definition by the ISO 9241-11 [11], where the efficiency is established to be measured by the effectiveness divided by time. It was observed that this quality was poor when interacting with the parking meter, because only two participants (one of each group) were able to pay before the 5 min, which is the limit established by the informative poster of the parking meter. In the interaction process it was proved that accomplishing the task and subtasks was feasible in less time if there were no mistakes made during the process.

However, it was observed that several participants experimented errors while interacting with this new system. Especially with the text message method, due to they were trying to use this mode, many of them did not succeed because they had budget limitations because their cell phone contract, or caused by an interface error. It is worth mentioning that the system does not allow making the payment for those people who

Table 3. Frequency of mistakes made during the process of interaction with the smart parking meters, older people and younger people

Mistakes made when performing the task	Older people			Younger people		
	Number of mistakes	Asked for help		Number of mistakes	Asked for help	
		Yes	No		Yes	No
Located smart parking						
Went to the previous parking meter	7	4	5	6	3	2
Login in the site of the smart parking meter that is indicate in the closed parking meter	1	1	0	1	1	0
Read the instruction						
Read only the first payment option	4	2	2	2	1	9
Paid in an authorized establishment						
Did not locate the authorized establishment	4	4	0	0	0	0
Did not have number of car plates	2	2	0	0	0	0
Paid whit text message						
Couldn't write the message	3	3	0	2	2	4
Paid whit APP						
Fill in data requested for the app	1	1	0	0	0	0
Couldn't download app	0	1	0	2	1	1
Scan QR code	0	0	0	1	0	1

Note: The number of mistakes corresponds to the number of users who made a procedural mistake during the interaction with the parking meter

had a prepaid cell phone plan. This information was not mentioned in the poster where the payment modes are explained.

In regard to the user's reported perceived satisfaction to the virtual parking meter. It was found that the system does not fulfills user expectations. Although, they expressed this might be caused by their condition of first time users, and they considered they could perform better the next time. This makes evident the lack of an adequate design from the usability perspective since it has left aside characteristics such as effectiveness, efficiency and satisfaction. This new system prevents the easy accomplishment of the goal of the interaction and promotes the existence of multiple errors [8, 12].

Regarding the task of reading instructions, it was observed that some of the participants found difficulties with the task, mostly in the young users group, who reported to only have read the first payment option. This behavior can be explained due to the lack of habit of reading and interpretation [13] and coupled with the fact that poster design might hinder some information.

One of the limitations of this project was that the usability analysis was carried out only once per participant, for future research it would be necessary to evaluate the participants who have previous experience using the system.

5 Conclusions

Although the digital parking meters might represent an alternative to improve the payment on public road. Results from this assessment suggest that this new system was not considered to facilitate its use for new users, or users with different characteristics, especially for the population of older adults. This group of users are under pressure of using new technologies that do not consider their capabilities. This study showed that older participants avoid the use of the digital options and chose making the payment through a commercial establishment, which provides greater comfort for the older users.

As conclusion, it can be emphasized that it is needed more diffusion of the system among the potential users in the city along with strategies of support for new users. In addition, a deeper assessment should be done in order to address all the issues that should be redesigned in order to provide a useful parking meter system for the diversity of potential users.

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Design of a Low-Cost Wheelchair for Open-Source Platform: First Phase

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Abstract. According to World Health Organization report approximately 111 million people in the world needs a wheelchair. In order to solve this problem, around the world, are developed open-source products. The first phase of the present project includes the review of state-art and evaluation of similar design proposals around the world. As a result of a search for similar projects, we found some proposals that could be adapted to México, and we decided to analyze two of them; the first one is a proposal made of PVC pipes. The second proposal to analyze is an active-type wheelchair made of plywood. The goal of this first project phase is to reproduce both chairs with the objectives: Check if the open-source platform is clear and it is feasible to manufacture the wheelchairs in a different environment to where they have been designed and check the stability, comfort, and maneuverability.

Keywords: Product design · Wheelchairs · Open source

1 Introduction

Derived from a project entitled: "Design of technological assistance for prevention, reduction and inhibition of spasms in patients with spinal cord injury", which consists in a mechanical holders for the patients legs that fits standard wheelchairs, we obtained as a result of project research that, the purchase of a wheelchair is unattainable for many patients in developing countries, like our country and all Latinamerica.

The General Law for the inclusion of persons with disabilities in Mexico in 2011, defines persons with disabilities as: Any person who, by congenital or acquired reason, has one or more deficiencies of a physical, mental, intellectual or sensory nature, whether permanent or temporary and that when interacting with the barriers imposed by the social environment, may reduce their full and effective inclusion, on equal terms with others (DOF, May 30, 2011) [1]. Official data (2014) indicate that approximately 6% of the population lives with a disability (7.2 million inhabitants), motor disability

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being the most frequent (57.5%). The same official data show that, among the aids used by people with motor disabilities, the use of wheelchairs is the most common (37%). Although there are no precise data on the number of people who can not afford a wheelchair in Mexico, following the figures of the WHO, [2, 3] this amount can be significant. As an example of this, we will say that the cost of an average wheelchair in Mexico is the highest for a worker's average salary during a month. ($ 160 USD). Additionally it is the case that some people with disabilities save "for years" and when it is possible to buy a wheelchair, they acquire a not suitable one for them (In size or anatomy) but it is the one that should last them all their lives When the ideal would be to change it according to the needs of the user and their physical changes.

For the preparation of this proposal, alternatives have been sought for the design of low-cost wheelchairs with open-source criteria, [4–6] a term that is usually applied to both software and free hardware and now, by extension, to consumer products and industrial machinery. Thus, when we speak of open-source software, we refer to the set of data and programs of a computer system that are designed publicly. This means that the author has published the source code so that anyone who wants to modify it can do so without having to pay since it is exempt from paying copyright. Thanks to this, thousands of people can participate in a free project where everyone can add their improvements and updates. The same happens when we talk about hardware or free products, in which the drawings, the assembly process, and the operation are explained in detail by the creators of the device so that any person is able to assemble it and make it work by following the instructions.

Regarding the use of product development criteria under open source, we consider that, within its social function, the University should participate in this type of initiatives that make available to the neediest the knowledge generated in the classrooms, by what we add to this type of initiatives that increasingly gain strength globally.

To be considered open-source, a product must met the following parameters:

(a) Free redistribution: The product design must be able to be freely given or sold.
(b) Construction plans: They must be included or obtained freely.
(c) Derived works: the redistribution of modifications must be allowed.
(d) No discrimination of persons or groups: No one can be left out.
(e) No discrimination in areas of the initiative: Commercial users can not be excluded.
(f) Design distribution: The same rights should apply to everyone who receives the design of the product.
(g) The license must be technologically neutral: Acceptance of the license must not be required by means of an access by mouse click or other specific means of support of the product design.

2 Project Goals

Design and development of a low-cost wheelchair under the open source criteria for reproduction by any interested part.

Particular goals:

(a) Evaluation of existing open source products.
(b) Identification of specific needs of low-income people with motor disabilities in our country and region.
(c) Design and development of prototypes suited to these needs.
(d) Evaluation of the proposed alternatives.
(e) Development of technical documentation for the free distribution of the same.

2.1 Wheelchair Design Selection Process [7]

A wheelchair user is strongly encouraged to be involved in the design and selection process. From experience, users are the most knowledgeable about their own physical, social and cultural needs (Fig. 1).

The steps in wheelchair design process are:

Step 1: Design the brief. This is a written statement of the needs and criteria for the wheelchair. the criteria include: User constraints (physical, cultural, social) local production resources, such as materials and human resources, performance requirements, and target price (for project goal, the maximum amount price for our proposal is $ 80 USD).

Step 2: Design/select wheelchair. After the design brief is written, design ideas are developed and prototypes are built and tested in the workshop. The process of designing, prototyping and testing may need to be repeated several times until the prototype meets the performance requirements of the brief. A design brief can also be helpful in selecting a wheelchair.

Step 3: Product testing. When a prototype meets the performance criteria, it should be tested to ensure it meets strength and durability requirements. If the wheelchair fails the tests, the design may need to be changed.

Step 4: User trials. Once the prototype has met all the performance, strength, durability and safety requirements, it should be tested by users who live in the environment the wheelchair is designed for. User trials allow for feedback from users, who are the most knowledgeable about the performance of the device.

Step 5: Production and supply. If the user trials are successful, production and supply of the wheelchair may begin.

Step 6: Long-term follow-up. At this point, long-term follow-up should be used to assess the performance of the wheelchair over time (for example, over several months). The feedback thus obtained should then be used to improve the design.

Local production resources

As highlighted above in the design brief, an important element of the design process is to identify local production and repair resources. The number of factors determines whether a particular design of wheelchair can be produced or repaired in a particular region, including: the materials and spare parts available in that region; the human resources and skilled technical labor available; and the production equipment available.

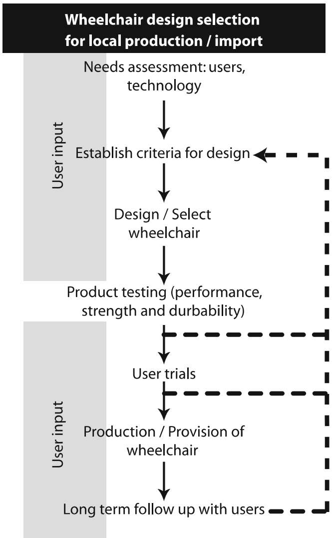

Fig. 1. Wheelchair design selection process (WHO, 2008)

3 Analysis of Existing Products

After a search for similar products, three low-cost wheelchairs were detected; the first one is the project called "Safari seat", developed by Janna Deeble for Kenya and other East African countries, this proposal consists of an "all-terrain" chair made from bicycle parts (Fig. 2). The proposal is novel, however, it determines to find bicycle parts and welding equipment for its manufacture in areas where it is not necessarily feasible to find these supplies. It does not report its manufacturing costs.

Fig. 2. Safari seat concept, created for East Africa countries (2016)

The second proposal has been developed at the School of Industrial Engineering and Aeronautics of Terrasa of the Polytechnic University of Catalonia and consists of the design of a chair based on PVC pipes and connections (Fig. 3). The design of this proposal is an adaptation of the traditional wheelchair where only structural materials have been changed by a low-cost material available in most developing countries. The cost estimated by the creators is $ 80 USD and works well in urban areas. It is expected that our design proposal is below the cost of this concept.

Fig. 3. Concept developed by Polytechenic University of Catalonia students (2015)

The third and final proposal is the concept called "Too wheels" and has been created by Fabrizio Alessio from Italy. This proposal bases its design on sports chairs and uses wood as a constructive element (Fig. 4). Although of novel design, the fact that the open-source platform requires laser cutting of wood, limits the reproduction of the chair in areas where this technology is not available.

Fig. 4. Concept "Two wheels" developed by Fabrizio Alessio (2015)

4 Project Development

As a first point, we carry out the evaluation of existing open source products, for which we download the instructions given by the authors. The metal chair "Safari Seat" was discarded to be used as a model, since, due to its design, it is presented as very complex and with a lot of pieces that from its beginning would exceed the cost limit that we have set for this project.

Starting, with the other two models, we noticed the confusing of the instructions for its assembly, even for us who, in theory, have knowledge of design and engineering, which would imply more confusion for people without this prior knowledge.

Once the instructions were understood, we proceeded to the reproduction of the chairs at a 2:1 scale, this in order to ensure the correct understanding of the instructions and to start with the evaluation of the designs (Fig. 5).

Fig. 5. Scale model of the PVC wheelchair.

From the manufacture of the models, we could appreciate some structural inconsistencies in both models. Then we proceed to reproduce the models at scale 1:1, according to the instructions. From the construction, we could notice that the chair made of PVC pipes presented structural problems in certain critical areas. At the time the prototype was developed, a model for simulation of efforts by finite element (FEA) was carried out to validate the tests performed [8]. Both in the simulation and in the final model we find flaws, so we modify the design adding structural elements to reinforce the body of the chair (Fig. 6).

In the model of the active wooden chair, we also had to make some adjustments to the original design, on the other hand, the use of a lot of screws for the assembly increases the weight of the chair, as well as, we find other parts of it very fragile and that required structural reinforcement, either with more screws (and more weight) or with the use of additional pieces of wood for reinforcement (Fig. 7).

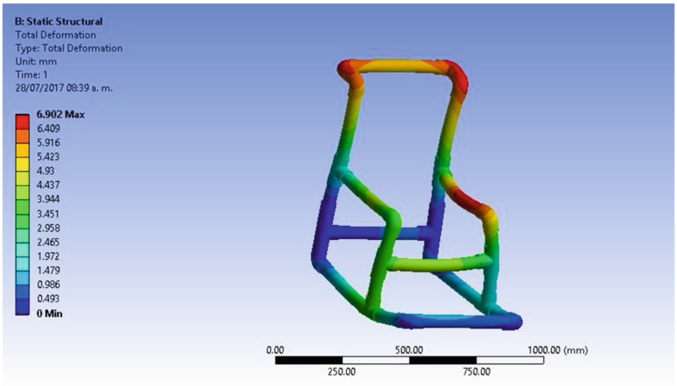

Fig. 6. Maximum deformation results for a 60 kg load. The maximum deformation is high which means that the chair has little rigidity and is a factor to consider.

Fig. 7. Measurements and adaptations (left) and final model of active wheelchair concept.

Finally, once the chairs were assembled, they were used and tested with the intention of evaluating their ease of use and the sense of safety during use by the users. For this purpose, a circuit was drawn with straight areas, turns left and right, as well as a reverse route. Both chairs were tested alternately by 20 University students (women and men between 18 and 22 years of age, average build and the average height of 1.65 m). The time spent on the route was timed and a questionnaire was prepared to ask about the comfort, safety, and ease of use of both chairs [9–12].

5 Results

The use of both chairs is complicated according to the appreciation of the users, is the chair made of PVC tubes the most difficult to control, this due to the position of the arms, far behind the middle line of the body, which hinders traction and control of the chair. Although this is reported more comfortable, the perceived sensation is insecurity, since, as the chair moves through the type of manufacturing material, users find it more insecure and unreliable. For its part, the active wooden chair is more robust in its manufacture, allows better mobility and maneuverability. The main criticism focuses on that, the front casters are very close to the rear and sometimes to get stuck with irregularities of the terrain cause the user to lean dangerously forward. As it was commented during its construction, some pieces had to be reinforced, which during the tests were broken, so during its test period, we had to make constant repairs to the structure. The feeling of use is better than on the tube chair, and timed times at all times are less than with the first chair tested (Fig. 8).

Fig. 8. Participant using the PVC pipes chair during a usability test.

5.1 Future Works

The product of this first phase, learning was obtained in the understanding and interpretation of instructions, use of materials and construction types of chairs. Also, the evaluation stage of the chairs built allowed us to establish design guidelines for the creation of our proposal, which we hope will improve the current ones and can meet the needs of the growing number of people with disabilities with low resources in our country and worldwide. In the testing phase, we did not want to evaluate the seats with real disabled users for fear of suffering some type of accident, a situation that we must comply with the design we perform. We hope for the next edition of the Congress to present to you the final proposal of a low-cost wheelchair, already evaluated by users and ready for its production and distribution.

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Inclusive Service Design for Education and Learning

An Eye-Tracking Study on Usability and Efficiency of Blackboard Platform

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Abstract. Learning management platforms are widely used in the courses in different levels. The goal of this research is to investigate the usability of the Blackboard platform a popular learning management platform. We use an eye-tracking method to investigate the usability of the platform. The analysis provided information about the points where students had difficulty interacting. The results of this experiment are intended to be used for designing a visual user interface for the instructors and students to improve the usability and user-friendliness of the learning platforms.

Keywords: Blackboard platform · Learning management · Eye-tracking Cognitive load · Visualization

1 Introduction

The Blackboard platform is an online application developed by Blackboard Company that provides a “curriculum-oriented” digital learning management platform [1]. It has been one of the most popular learning management tools for the past fifteen years. Blackboard and other e-learning platforms allow instructors to monitor the learning process and compare students’ performance in every task [2]. Although e-learning platforms provide excellent tools for both the instructors and learners by integrating multimedia material, by creating a virtual learning environment, and by providing an interactive communication, prior research indicates users find it generally hard to use its interface. This interface issue could be very important in hybrid teaching environments that combine traditional teaching and online platforms. Xiomara et al. in their study on the comparison and analysis of learning management platforms concluded that based on the interviews done with teachers, the most important problem with Blackboard and Moodle is the “lack of the interactivity” of the platforms and their “unfriendly interfaces” [3]. The online learning requires the learners to be “self-directed” and “to take responsibility” for their learning [4]. However, if the users find it difficult to use a website, they will leave it as, a design is only useful if it has both utility and usability parameters [5]. Thus, this study, aims to investigate the quality components of the Usability of the blackboard platform through eye-tracking, and user responses. According to Nielsen’s explanation, usability is a quality that describes how easy a user

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is able to interact with an interface [5]. According to Nielsen [6] usability has several dimensions: “Learnability”, “Efficiency”, “Memorability”, “Errors” and “satisfaction”. The eye-tracking methods used in this study provide excellent tools for passive estimation of some of these dimensions. Investigating and improving the learnability of a platform, is only possible by knowing what users want to do, and helping them to do it [7].

According to the expectancy-value x theory, users balance out the value they expect to get from their actions [7]. For example, users encountering a complicated interface or task, may consider this question that if they can handle the task or not [8]. Therefore, we need to pay attention to the learnability component of usability. The efficiency aspect of usability investigates how quickly users can perform tasks. In this case, the tasks are limited to the activities that a student is required to perform on an online learning management platform, such as completing assignments in the Blackboard platform. The cognitive burden while completing complex tasks could lead to significantly longer performance time and increased error probability. Memorability identifies how easily the users can reestablish proficiency. It investigates the improvement in proficiency level of the novice users after each experiment. The error component describes the errors that users frequently make, and how they can be prevented. And lastly, it is the satisfaction component that studies how pleasant the design has been for the users. Studying each of the usability components is important for a higher-level synthesis towards the universal goal of “enhancement of a mental model of data” (p. 6) [9], meaning that every single one of usability components are effective in enhancing the internal formation of knowledge in the memory of the users.

The application of eye-tracking methods in usability analysis has gained popularity during the past two decades, facilitated by the rapid improvement in the modern techniques and data analysis software [10]. Eye-tracking methods provide precise information regarding some of the components of the usability such as learnability, efficiency and error detection [10]. The metrics such as satisfaction and learnability can be measured using other parallel methods such as surveys or think aloud methods.

Eye-tracking devices provide information about the gaze of the participants in the experiment. These data include, saccades (duration, speed, acceleration and position), fixations (duration and position), blinks and pupil dilation [11].

The research on the effect of cognitive burden and increase in the short term memory on the pupil dilation has been known for over half a century [12]. There is also evidence on the direct relation between cognitive load and each one of the gaze metrics. Several attempts are made in the past decades to investigate the cognitive load using a combination of changes in the gaze data [13–16].

The usability of the learning platform with eye-tracking has been studied from various aspects such as gender effect and learning platforms [17], advanced e-learning systems [18] and real-time adaptable platforms [19]. The present study tries to highlight the difficulties user’s face while interacting with Blackboard in to provide a roadmap for a visual e-learning platform.

2 Objectives and Research Questions

The main objective of this study is to investigate the user experience of the Blackboard platform to identify the particularly challenging points for students who are completing general tasks on the Blackboard platform. We also want to examine effect of external consistency in different sections of the Blackboard platform by the aid of eye-tracking and survey. We use the concept of external consistency [20], referring to the similarity between the component of a design with other popular designs. General tasks such as, "sign in", "sign out", "navigation between pages", "uploading" and "downloading files" are similar in various platforms, and are studied in each task. In many cases the issue of frequent user errors are caused by lack of external and internal inconsistency of a design [21]. Thus, the research questions of this study are stated as below as:

Primary Question: "what are the most challenging phases for students interacting with the platform?"
Secondary Question: Does external consistency affect usability and cognitive load of the users while completing the tasks? If so what are the most frequent user errors while completing a complicated task?"

This study aims to identify the bottlenecks in the practical application of the online e-learning platform. The Blackboard platform is selected as the case study for this research and the eye-tracking methods are used as a measure of usability.

3 Methods

This study aims to investigate the usability measures of the Blackboard platform with the goal of future improvements using information visualization methods. The platform consists of multiple sections that allow instructors and learners conduct a variety of tasks in the scope of an e-learning system. The tasks vary from sending message to all students, providing overall syllabus of the course, to viewing the grades and completing assignments online. In this research, the gaze data of the participants are recorded when they complete a set of tasks that usually users perform on Blackboard platform. The recorded gaze data are then evaluated using attention path methods and statistical analysis. In addition, the participants of the study are asked to answer questions regarding the difficulties they had during completion of the tasks.

The participants are categorized according to their skill levels, prior to the experiments. They are then provided with a list of tasks that need to be completed in an assigned time. The time limitation depends on the skill level and proficiency of the participants. After completing each task, the participants rate the difficulty of the task and express the challenges they had while completing the task. The second phase of the experiment aims to investigate the cognitive load of the users performing the tasks. The results of the analysis are used to identify the usability problems experienced by participants while completing the tasks assigned to them. The outcome of this study can provide insight into improving the layout and interface design of the Blackboard or other similar tools such as Moodle and Canvas [22]. In addition, the results will be used as a guideline to design an interactive visual user interface add-on for Blackboard platform in the future.

There are several parameters that could affect the results of the study, such as user related variables, course related variables, environment, tasks and the measurement devices. We introduced a pre-test assessing prior knowledge to limit intervening parameters, such as diversity in the student's proficiency and knowledge about the courses, and environment related issues. The participants of the experiments are categorized based on their skills and their prior knowledge about the software and the course. Also, we have tried to limit the environmental parameters by omitting distracting elements, by providing quiet and uniform conditions.

3.1 Apparatus

In this experiment gaze Tobii X60 eye tracker with accuracy of 0.5° of visual angle was used. This device has a sampling rate of 60 Hz, meaning that the gaze data including coordinates and pupil size are recorded every 20 ms with a recording resolution of 1920×1200. In addition to the eye-tracking data, each task of the experiment was followed by a short set of questions regarding the difficulty of the task which will be used for a parallel evaluation.

3.2 Tasks

In this preliminary study, first the participants are asked to answer questions about their previous experiments with Blackboard Platform and their frequency of usage of the platform. Then they are provided with brief information about the process of the experiment and the apparatus. Then the participants are asked to go through a predefined scenario of the questions which required completing a task in each phase. The tasks include, "finding a particular course from a list of the courses", "identify a predefined course material from the course", "find the course syllabus", "look up latest assignment uploaded by the instructor and download it", "upload a completed sample assignment to the system" and several other simple tasks. Each one of the tasks is very abstract for the sake of comparability. Every task is followed by a multiple-choice question regarding the experience of the user from the task. The tasks were sorted from easier to harder, therefore it was possible to monitor the user's effort in completing the tasks by the aid of variation in the pupil dilation and the number and duration of the fixations.

3.3 Procedures

Each one of the tasks require the participants to look for a section in the Blackboard platform and in some cases, upload one or several files. The tasks in the experiment are categorized based on their difficulty. For instance, finding the login page and logging into the system is considered a simple single layer task whereas finding an "assignment upload page" inside a course and uploading the assignment is considered as a complex (multi-layer) task. Accordingly, the time and effort are measured by the number of fixations, dwell time, pupil dilation, number of saccades and saccades lengths. In addition to the gaze data the answer to the survey questions provide a dependent variable.

Figure 1 provides a schematic workflow of the experiment. To examine the research questions, each task has been designed to work as a collection of phases (interactions), so that we could compare the difficulty of each phase during each task. The later tasks included interactions that were required in the earlier tasks, which provide information on the effect of internal consistency and learned skills. In addition, the mouse clicks of the participant were also recorded, in order to examine the error rate of the participants during the experiment.

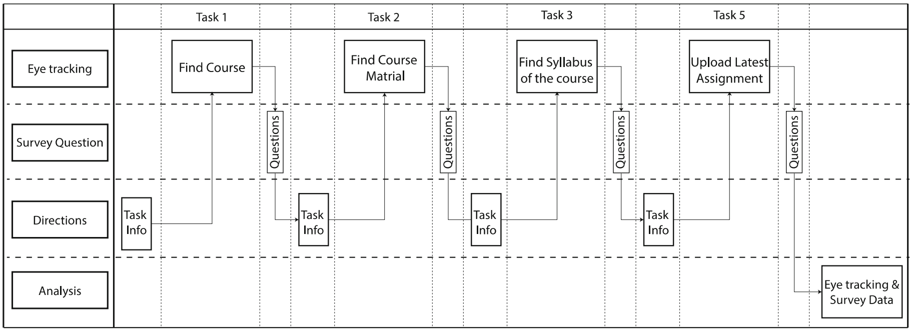

Fig. 1. Workflow of the experiment.

Nielsen and Pernice [23] point out the three major issues that are usually neglected in eye-tracking study design: “representative users”, “realistic task performance” and “a wide variety of web sites”. Therefore, in this research we decided to choose the participants from the postgraduate students that have used the Blackboard platform in their study.

4 Results and Discussion

The experiment has been conducted as a pilot study yet, however the results of the pilot study was analyzed in this section. The recorded Eye-tracking data, include the gaze data of the users while completing tasks. The tasks require the users to navigate between different pages, therefore, in the analysis of the results we have separately investigated the gaze data for each page and area of interest on every single page. The in-depth analysis of the gaze data helps us answer the research questions of the study. The most challenging part of any task, can be identified using eye-tracking measures, number of fixations, duration of the fixations, number of saccades, vertical length of saccades, horizontal length of saccades, pupil dilation and the number of the blinks per minute [24–27]. In this pilot study only the fixations, scan-path and the pupil dilation has been analyzed. In the future studies the classification of the saccade lengths, fixations and pupil dilation will be used for cognitive load analysis.

Fixation: Fixations are usually presented by the aid of the density diagram. A density diagram which is also known as heatmap, provides visual information about the number and duration of eye fixations on different parts of a stimuli [28]. In the density diagram the longer fixations are represented by warmer colors, whereas blue and green colors represent less attention and shorter fixation time. However, the longer fixations do not always represent difficulty of understanding. In some cases, the users may spend longer time on an element without much cognitive load imposed. One of the ways to examine the cognitive load of the users on longer fixations is by the aid of calculation of pupil dilation ratio during the fixations.

Pupil Dilation: Numerous studies in the field of human-computer interaction research groups have shown existence of relation between the pupillary response and cognitive load [29, 30]. Klingner et al. [30] suggested a new method based on the analysis of short pupillary responses to the tasks rather than aggregated measurement over a long period of time. In this study, the same concept is applied and the variation diameter per fixation is investigated instead of overall pupil dilation aggregation for one single task. The right image in Fig. 2 provides a visual representation of fixations and pupil dilation. Each one of the circles represent one fixation and the diameter of the circles represent the duration of the fixation. Also, the color coding of the figure demonstrates the pupil dilation ratio normalized between the minimum and maximum pupil diameter. The red colors indicate a rapid increase in the pupil diameter in one fixation only. The result that indicate longer fixations are not always a sign of higher cognitive workload.

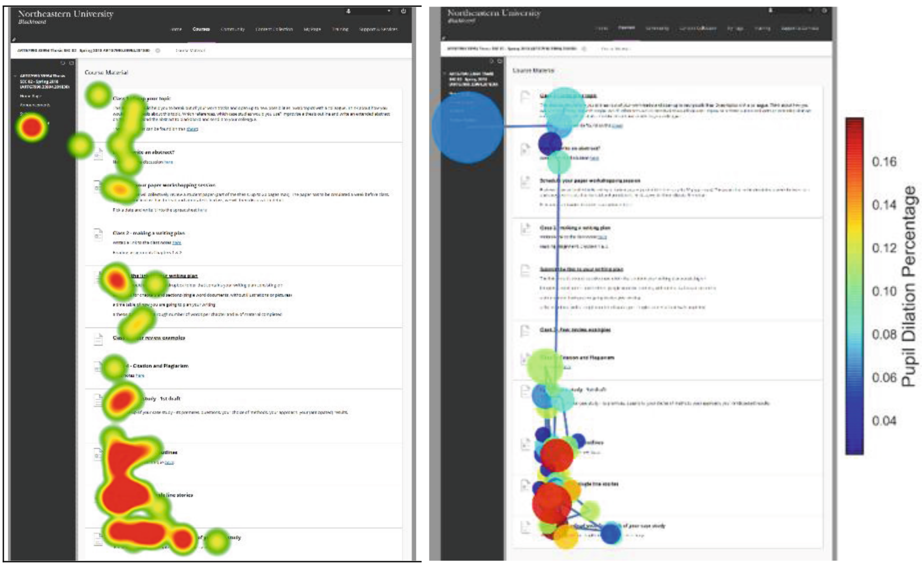

Fig. 2. (Left) Heatmap demonstrating the density of the fixations. (Right) Scan-path color-coded by Pupil Dilation Percentage.

The pupillary response of one participant during completion of “Course Material Finding” task is presented in Fig. 3. The annotations indicate the index of the fixations, and the vertical axis shows the normalized ratio of the pupil dilation. The point to point study of fixations and pupil dilations allows us to investigate the answer for primary research question about the most challenging parts for the participants. Based on the results of the analysis on the gaze data, the users have difficulty to finding a textual item in long pages with numerous similar items.

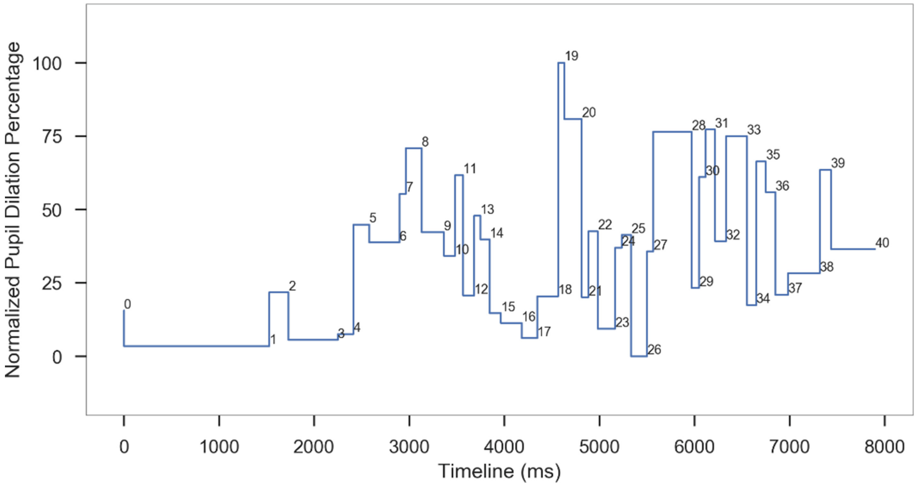

Fig. 3. Pupil diameter during “Course Material” look up task.

The sub-questions of this study require a general inspection of the arrangement of the elements in the platform in correlation with other popular websites that users usually interact with. Therefore, common activities such as, “signing in” to the system, “uploading file” and “Navigation” between pages that are included inside the tasks are studied separately. After each task the participants were asked if they experienced any completing these tasks, almost all the participant had not experienced any difficulty in completing these tasks.

5 Conclusion and Future Work

The eLearning platforms provide a wide range of tools for instructors and the students. The present study aims to investigate the interaction of the students with these tools and identify the entities that were difficult to look up and interact with. The Blackboard platform has been chosen for the case study and several tasks related to a hybrid course were assigned to the participants. The eye movements of the participants indicated good internal and external consistency of the design which helped the students while looking up a section, however, fixations and pupil dilations indicate that students had difficulty finding a specific material or course from a long list of courses or materials. In addition, eye-tracking results demonstrated that there are usually several ways to access a page, for example, a course or an assignment, which is confusing for novice users. A short informal interview with participants after experiment confirmed the results of the eye-tracking analysis. The participants also expressed that the older courses are usually listed along with the current courses, which make it hard for them to lookup a course.

The in-depth analysis of eye-tracking data is intended to guide, in future work, the design of a visual interface for the Blackboard platform mainly based on graphical elements rather than fully textual data.

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Supporting Inclusive Approaches in Service Design with Netnography

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Abstract. This work is a part of a wider research about the inclusion in the Sharing-Based Services conceptual framework. The research presented in this paper was driven from a reflection on the ability of this kind of services to be inclusive. The main objective was discovering design domains for inclusive Sharing-Based Services detecting problems, needs and peculiar cases of online communities engaged in these services. For this reason, the netnography method was adopted to conduct a qualitative research with the aim to gain insights about inclusion and exclusion concepts on selected online forums related to platform in the Sharing-Based Services conceptual framework. The research insights were reported in the paper and they were used as a first reflection to conceptualize five design domains for inclusive services.

Keywords: Design for inclusion · Design for services · Sharing economy Inclusive services

1 Introduction

In recent decades the Web has become one of the most interesting fields of work and study. First of all, it is the most frequented virtual space. At the same time, it is becoming a field of work for ethnographic researches. "Virtual ethnography" [1] and "netnography" [2–4] are two of the most used and debated terms in literature to indicate ethnographic approaches for qualitative research on the Web. "Virtual ethnography" is a term introduced in the last two decades (see [5]) and developed as a research topic [6] by Hine [1, 7]. Also it is recently considered by designers as one of the methods for data collection in service design [8]. In the same theoretical framework 'netnography' is a qualitative research method "that adapts ethnographic research techniques to study the cultures and communities that are emerging through computer-mediated communications" [2]. As Kozinets point out, a crucial difference between netnography and traditional ethnography is that the data collection and analysis refers to the "online community's communicative acts rather than the complete set observed acts of consumers in a particular community" [2]. Netnography is substantially an internet-based

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method for marketing research; "it is ethnography adapted to the complexities of our contemporary, technologically mediated social world" [3]. The authors of this paper used the netnography rather than the online, digital, cyber or virtual ethnography because it refers to a specific set of online ethnographic procedures [9].

This method was adopted to conduct a qualitative research with the aim to gain insights about inclusion and exclusion concepts on the so called Sharing-Based Services (SBS) conceptual framework [10]. Most of this kind of services are web-based and contain online forums where the users share a wide range of experiences, information and opinions even beyond the main functionality of the platform. For this reason, the author of this paper considered this kind of virtual spaces as a field to observe through the threads and comments written by the platform's users. The main objective of this research was discovering design domains for inclusive sharing-based services. The specific objective was detecting problems, needs and peculiar cases of online communities engaged in sharing-based services with the aim to understand the inclusion and exclusion states in this kind of services. For example, cases where users expressed problems, difficulties and needs about the access to and the use of a sharing-based service both in its tangible and intangible components. Or better, cases where users expressed problems and needs related to the capacity of the SBS to be inclusive.[1]

1.1 The Background

This paper presents a part of a wider research about the inclusion in the SBS conceptual framework. According to the authors, a SBS could be described as the overall service activities provided in, for, or through a sharing-based context. Also, the SBS conceptual framework does not identify new definitions of some types of services. It is a concept that the authors used to study and analyse the structure of services 'in' or 'for' collaborative activities. The hypothesis is that studying and analysing the structure of services in the SBS framework can underline interesting aspects about the concept of inclusion and exclusion. In particular, the work presented in this paper was driven from questions concerning a reflection on the ability of the services in the SBS conceptual framework to be inclusive; if they are able to enhance human diversity; if they are able to respect human diversity, different values and ways of living. Also, the research was oriented to understand what kind of factors compromise the use of and the access to this kind of services. The qualitative study presented in this paper supports the exploration of these topics in the context of the SBS conceptual framework. The research was conducted in unobtrusive manner by observing and studying threads on online forums of well-known and highly frequented platforms such as Airbnb, Couchsurfing and Uber.

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[1] The authors argue that it is necessary to reflect upon different human dimensions to consider what kind of factors compromise the usage of and the access to a service in all its tangible and intangible parts included aspects that affect the system around the service. Therefore, the authors proposed a first consideration that regards the usage of, the access to, and the participation in the activities provided through a service. According to these premises, they may be affected by individuals' physical and cognitive capacities and needs, economical status, cultural and political factors [10].

2 Methodological Approach

According to the netnography methodology the research question was identified as a primary element of the research. What kind of design domains related to the inclusion and exclusion concepts is possible to identify in the SBS framework? This was the main question and the process adopted has been divided into three main steps; (i) selecting representative online platforms and the related forums as the research field in the SBS framework; (ii) collecting relevant data and summarising insights; (iii) discussing the insights and identifying a set of design domains for inclusive SBS.

2.1 The Research Field: Selecting Platforms

Services on the SBS conceptual framework [10, 11]. can be identified according to four macro-groups; (i) services that describe activities based on a person-to-person relations (very close to the real meaning of sharing) and mainly regulated on non-profit business (e.g. Couchsurfing); (ii) services that describe activities based on person-to-person relations and mainly regulated on profit business (e.g. Airbnb, Uber, etc.); (iii) collaborative services where the final user is actively involved and assumes the role of service co-designer and co-producer [12, 13]; (iv) services that describe activities based on a 'person-to-system', 'pseudo-sharing' [14], and mainly regulated on profit business (e.g. short-term renting). Selecting at least one platform and the related forum for each macro-group could be the best methodological solution. However, not all the platforms in the groups have large forums where observing the user's discussions. In addition, some of this kind of services are not worldwide diffused and in a few cases they assume a local scale. This represents their value but at the same time a potential disadvantage for this research. For these reasons the authors selected only a small number of worldwide diffused services and easy to access platforms. They generally have large forums where the users open a wide number of threads with several topics. The selected platforms were Airbnb, Couchsurfing and Uber. They are platforms with millions of users and they have related forums where the users open a large number of different discussions.

For Airbnb there was selected the Community Center (www.community.withairbnb.com) with more than 300.000 members and 100.000 posts. It is the proper Airbnb forum that addresses mainly to users with role of 'host'. The Community Center is open to every web user and do not require an Airbnb account to read the posts. For Couchsurfing it was selected the inner forum that works through the creation of 'groups'. This is the virtual space where all the Couchsurfers[2] can open a thematic group. It is necessary to be registered as a member of the community to read the discussions inside the groups. Finally, for Uber it was selected a not affiliated forum named Uberpeople (www.uberpeople.net) mainly frequented by the Uber drivers. It currently counts more than 120,000 members and the reading of the threads it is open to every web user.

[2] This is the word to identify the Couchsurfing's users both with the role of guest and hosts. Couchsurfing is actually a global community of 14 million people in more than 200,000 cities.

2.2 The Data Collection and Insights

This part of the research[3] was conducted on the selected forums and according to the following phases; (i) filtering hundreds of threads for each forum according to a set of keywords related to the inclusion and exclusion concepts; (ii) selecting relevant discussions; (iii) summarising the insights and detecting design domains.

2.2.1 Filtering Threads

The authors used a set of keywords with the aim to filter relevant discussions by using the search function in every selected forum. The used keywords were ‘accessibility’, ‘disability’ and ‘discrimination’ because they are highly related to the inclusion and exclusions concepts. The words were used one at time in each forum. The threads that reported the single keyword were ordered by relevance. The results of the first search were analysed by reading the contents of the threads. If the selected thread was considered relevant by the authors it was reported in a specific table (see the next paragraph for the details of the table).

2.2.2 Collecting Relevant Threads

After a first analysis, the most relevant threads were archived in a table by reporting (i) the title of the thread and the link; (ii) the number of the comments for each discussion; (iii) the relevant contents of the discussion and any relevant comments that are considered useful to understand the topic; (iv) a synthesis by short sentences; (vi) the main results.

2.2.3 Summarising Insights and Detecting Design Domains

Every relevant thread reported in a row of the table presents an analysis about the specific results. For this reason, all collected threads in the result section of the table report (i) what is the general reason because the user opened the thread (e.g. for sharing a personal experience; reporting specific problems; requesting opinions or suggestions); (ii) the category of the main topic (e.g. spaces accessibility; gender discrimination; service provider policy); (iii) the specific content of the thread, the interesting and relevant data for the research. Finally, the insights were analysed, discussed and summarised by creating short reports for each keyword related to the selected forum. This process allowed the authors to identify a set of design domains.

3 Results

The main results of this research are related to (i) an overview on what, why and how the users shared information in the threads; (ii) a summary of the main relevant topics and insights; (iii) the identification of the design domains. Table 1 resumes the findings highlighting the selected numbers of threads and the main topics explored for each keyword in every forum.

[3] The data collection was made between the middle of 2016 and the middle of 2017. The data was reviewed and upgraded during the first months of 2018.

Table 1. The results of the netnography; a summary.

Keyword	Platform	Threads n.	Relevant threads n.	Main topic
Accessibility	Airbnb	246	26	Accessible accommodations. Tool to match the needs. Mobility disability
	Couchsurfing	481	10 (groups) 69 (discussions)	Accessible couches. Accessible cities and transportations. Accessible travel experience
	Uber	100	22	Accessible cars. Lack of equipment and support. Discrimination
Disability	Airbnb	158	39	Not really accessible accommodations. Nondiscrimation policy
	Couchsurfing	64	12 (groups) 66 (discussions)	Not accessible travel experience. Personal care support request
	Uber	100	30	Local government policies. Discrimination. Lack of inclusive attitude
Discrimination	Airbnb	454	53	Nondiscrimantion Policy. Community Commitment process. Indirect discriminations
	Couchsurfing	71	25 (groups)	Stigmatizations. Groups as labels. Diversity with diversity
	Uber	137	35	Not equipment and approach for special needs. Discrimination against disability, age and weight

The observed threads revealed that the selected forums were mainly used for (i) sharing personal experiences about specific problems and needs in real life with the aim to have suggestions; (ii) requesting opinions and suggestions from experienced users with the aim to prevent some uncontrollable situation in the real life; (iii) reporting inconvenience with the aim to catch the attention of the service provider; (iv) sharing media, academics and public opinions information related to the platform with the aim to open discussion on specific topics. Also, the summaries of the findings for each keyword and forum are discussed in the following paragraphs reporting the most interesting insights.

Accessibility in Airbnb. One of most relevant topic detected with this keyword is related to the accessibility level of the accommodations because it seems to affect a wide part of the platform organization. A few users point out that Airbnb could be considered a great tool to match the needs of guests and hosts; and it would be good to extend this feature to all the travelers with very different needs (such as persons with disabilities). It means for example that the host should organize the house as a fully accessible accommodation and it should communicate to all the potential guests that this house is accessible according to a set of parameters. The service provider recently added this feature. In addition, several comments on the Community Center about this keyword are related to the accessibility of the physical spaces especially for people that use a wheelchair or people that have needs about mobility. For this reason, these topics are discussed in the paragraph that focuses on the 'disability' keyword.

Accessibility in Couchsurfing. The most relevant problem detected by this keyword in the Couchsurfing group center was the difficulty for people with different capabilities, impairments and specific needs to find accessible 'couches', houses and places. Also, according to the selected discussions, it is difficult to have a whole accessible experience during the travel because there are multiple factors that affect the entire trip. And it is difficult to find all the accessible factors in cities or places they want to visit. The detected groups and discussions were mainly frequented by people with specific needs and mainly with mobility impairments. They discussed the accessibility of the whole trip in terms of difficulty in finding (i) accessible transportation everywhere; (ii) accessible couches, houses (included specific furniture, or rooms such as accessible bathrooms and bedrooms), and in general physical places (e.g. accessible route and outdoor paths); (iii) fully secure cities to visit; (iv) persons that can help guests for daily function such as cooking, washing, cleaning during the travel due to specific needs (e.g. movements impairment); (v) persons with similar needs in terms of compromised mobility or specific age (e.g. elderly) with the aim to share travel. All these aspects reduce the freedom in taking advantage of the service and the possibilities for these users to have a wide range of choice. A few users proposed to brainstorm with the aim to find new ideas to improve the condition of disabled couchsurfers. Others proposed to create filters and sub-filters in the platform interfaces with the aim to select the best conditions for their needs.

Accessibility in Uber. One of the most discussed issues detected with this keyword is about the accessibility of the cars and the relation with the local institutions policy. Drivers often reported that especially in the U.S. Uber was subjected to complaints because it did not guarantee solutions for riders with specific needs related to people with mobility disability, overweight or elderly. However, Uber is promoting suggestions, guidelines and specific solutions such as Uber Access with the aim to prevent the exclusions of a few riders; especially those with mobility impairments. But at the same time and for the same topics, drivers advanced issues and doubts. It is not clear if the service provider is trying to bypass local disability protection policy because it is not prepared to face these kind of needs for all. This is one of the doubts. In addition, some drivers discussed (i) perplexities on who will pay if a driver wants to shift from a traditional car to accessible car, and what about the ownership of the car; (ii) what happens if an unprepared and unequipped driver needs to support riders with specific needs (e.g. riders that use a wheelchair; or riders with service animals); (iii) how to change their labor in terms of costs and resources if they should provide specific support for people with disabilities, elderly people or with other specific needs. In summary, a few drivers are not ready to support different riders' needs also in terms of nondiscrimination approach. A few of them would like to help all kind of people but they do not know how to do it. In general, a good part of them seem to be too unprepared to be inclusive.

Disability in Airbnb. According to this keyword one of the most relevant set of discussions was related to the needs of people with disabilities. They expressed the difficulty in finding really accessible accommodation. This means doors, floors, rooms and outdoor spaces completely accessible both for people that use the wheelchair and for people with other kinds of needs (e.g. blind people; people with mental disorders). At the same time hosts that have accessible houses would like to communicate that they are ready to host a lot of different guests with any needs. Some of these Airbnb users, both guests and hosts, expressed the need to have a set of items in the platform with the aim to filter several accessible features. A few of these kinds of requests are actually satisfied by the accessibility filter[4] designed by the service provider. However, a few hosts do not want to discriminate people but they also would like to communicate that their house is not accessible for all despite the fact they had guests with disabilities. A few of these kinds of hosts also reported problems with these guests. It is difficult to understand if they are not prepared to host different kinds of guests with an inclusive approach or if they are trying to discriminate or if they have a bias. In addition, some discussions underline how much the relation between local institutions policies and the platform policies is crucial for the general accessibility and the efficiency of the service. Finally, one more topic is that a few hosts do not want to feel forced to accept all the different people by the nondiscrimination policy. They would like to filter the request or at least they would like to try to match the different needs and see if the guest is compatible with their ways of living. For this reason, a few of them directly expressed that they do not want to accept the terms of the nondiscrimination policy of the service provider.

Disability in Couchsurfing. Most of the detected groups with this keyword were created by disabled 'couchsurfer' with the aim to share information about different elements that affect the accessibility of the whole travel experience. Indeed, some of them created the groups with the aim to find shared and accessible accommodations, also because not all the hosts tend to accept disabled guests; others with the aim to find people that can assist others with personal care (such as bathing, dressing, toileting, etc.). One of the most frequented and interesting groups detected by this keyword addresses 'couchsurfer with disability' with the aim to discuss the needs of blind and disabled couchsurfers. According to one of the members travelling is a challenge for people with disabilities and they can easily find themselves in a very high risk situation if information concerning the transportation, the accommodations and other factors about the places and the culture is incorrect or lacking. In addition, according to a few other couchsurfer topics that affect the accessibility of a trip are related to the public transportation accessibility, the management of the time, the quality of the information resources and the presence of health care shops. Also, the members used these groups to request mutual help in specific trips. Finally, a few discussions were about specific requests to adapt places for people with allergies; hosts that can accept service animals; and hosts that can help other people with daily operations assistance such as cooking and bathing.

[4] Please see www.airbnb.design/designing-for-access.

Disability in Uber. According to this keyword, there were discussions found that highlighted the lack of information about regulations for people that are under social security disability programs and are using or would like to use Uber as drivers. Also, there were discussions found related to the suspect that the service provider does not guarantee the ridesharing for all and in particular in poor neighborhoods and for people with disability. About this topic Uber recently launched the Uber Access program. But at the same time a few drivers in the forum observed that this kind of service is not world-wide assured and in a few U.S. states is still not available.

Also, one of the most discussed questions is about the cost estimations for drivers that are considering upgrades for the cars with the aim to provide a fully accessible service. The majority of Uber drivers are not equipped to support people with special needs and the costs to upgrade the existing car or to buy a new accessible car are very high. In addition, a few stories reported drivers that refused to pick up disabled people because they were not equipped or prepared to do that; or drivers that do not refuse anyone and that complain a loss of time and money because not prepared to assist people with different needs (e.g. disabled, elderly). This generally highlights that not all the drivers have the approach, the attitude, the equipment, the qualification or the preparation to assist, support and transport different people with different needs.

Discrimination in Airbnb. According to this keyword, the most relevant discussions were related to hosts that do not want to accept the nondiscrimination policy of the service provider. One of the reasons is that they do not want to feel forced by this policy to accept all the different potential guests. This kind of host wants to be sure about the way of living and the manners of the potential guests before the booking. A few hosts do not want the service provider to influence the matching of the needs with the guests. Also they consider the nondiscrimination policy a discriminative act against the hosts. These points are often related with topics such as the "instant book" feature, the acceptance of the service animals and the Community Commitment[5] process. In short, it is as if the nondiscrimination policy undermines the freedom of the parts in matching their needs. They do not want to feel like hotels. These problems do not touch those that that are instead comfortable with the nondiscrimination policy. In addition, a few hosts and guests also reported personal experience of what they judge as race discrimination. In most of the cases it is very difficult to understand if it is really an indirect discrimination by the race, ethnicity, nationality, gender and sexuality; or if it is a lack of feeling and trust between host and guest. However, a few selected discussions are related to personal experience of the hosts and guests that are judged, offended and negatively rated; they suspected that was a consequence of showing their sexual orientation. Also, the rating system in a few cases was considered a discriminatory act. This is because it is perceived as a superficial judge and not able to describe the complexity of the behavior of a person.

Discrimination in Couchsurfing. The search of this keyword lead to detect a set of couchsurfer groups addressed to stateless culture, queer, homosexual, LGBT, specific cultures or nationalities and feminists. Inside these groups were opened an

[5] It is a commitment by Airbnb that invite the hosts to accept the nondiscrimination policy or cancel the profile.

extraordinary numbers of discussions with a lot of different topics; from couchsurfers that look for hospitality in a specific city with people with same needs and ways of living, to couchsurfers that started discussions on the social rights and socio-political situation of a specific nation or region of the world. However, as a few couchsurfers point out, creating groups lead to labels. This can lead to discrimination or stigmatizing a culture, a need or a way of living. The attitude seems to be ‘diversity with diversity’, ‘specific needs with specific needs’. Is the creation of the group the best solution to enhance human diversity and different ways of living in this kind of services?

Discrimination in Uber. According to this keyword, there were detected discussions related to a few drivers that would like to filter the requests especially when the rider has something that does not fit with their optimal conditions. Indeed, there were reported a few cases where the riders directly or indirectly refused or had problems with elderly, obese or disabled people; with service animals or with the destination that it could be considered not convenient. The reasons are various and when they cannot be considered a direct discrimination, the drivers report reason like that they are not prepared and equipped for special requests or needs. A few of them directly declared that they would like to have the power to discriminate mainly because they want to be sure that the riders condition is matching with their needs. About direct discrimination, a few drivers reported that they knew cases of racism but without a direct experience. Also, some drivers manifests dissatisfaction versus the service provider complaining for the inefficiency of the ranking system; the unequal cost of a ride due to the geographical area; and the disadvantageous costs for the maintenance of the cars as a private car.

3.1 Design Domains for Inclusive SBS

A set of five design domains were identified with the aim to support approaches in designing inclusive services. According the premises presented in the introduction of this paper, the usage of, the access to, and the participation in the activities provided through a service may be affected by individuals’ physical and cognitive capacities and needs, economical status, cultural and political factors. These aspects are detected as particularly inherent in the SBS conceptual framework. What is remarked by this research is that due to the complexity of the relations and the interactions in these services, a multi-domain design attitude could be required in applying inclusive approaches in these contexts. For this reason, designing inclusive SBS means taking into consideration the following five design domains with a holistic approach. The hypotheses of the five design domains are described by the following paragraphs.

Physical and Digital. This domain concerns physical and cognitive factors of the individuals and considers aspects such as how people physically and cognitively interact with physical objects and spaces, physical and digital systems inherent to the services considering aspects such as vision, hearing, thinking, dexterity, and locomotion. This domain focuses mainly on inclusive approaches for designing physical and digital products and spaces.

Cultural. This domain concerns cultural factors of the individuals and considers how these factors influence the service and how the diversity, different ways of living, and different values are treated. This domain focuses mainly on inclusive approaches for designing solutions with a strong impact on the knowledge, the training and the education of all the stakeholders involved in the service.

Social. This domain concerns social factors of the individuals and considers how they affect the possibility to create relationships, social support, and solidarity through the service. This domain focuses mainly on inclusive approaches for designing solutions that enhance the support, the mutual help, the solidarity and the collaboration among the stakeholders and the society.

Political. This domain concerns political factors and considers how legislation, policies and practices affect the level of the democracy and the opportunity of participating in public life through the service. This domain focuses mainly on inclusive approaches for designing solutions related to the policies of the service and how these aspects can be integrated or can influence governments and policy makers.

Economical. This domain concerns economical factors and considers how the economical status, the costs, the labor condition and the economical sustainability is considered in the service. This domain focuses mainly on inclusive approaches for designing solutions related to the management and the distribution of the resources, and aspects such as the labor conditions and the redistributions of the roles (especially in shared contexts where a part of the service is provided by the final users).

These domains are not design principles. They do not represent new design theories or new design disciplines. They are just domains that should be considered in designing inclusive solutions for services, especially for services based on sharing contexts such as the SBS. They should be considered as reference points that interact each other in a holistic manner.

4 Conclusions

The five domains were used to design the I-SBS Toolkit and to conduct the related design workshops [10, 11]. The I-SBS Toolkit is a direct result of a first investigation of the five domains for designing inclusive services in the SBS conceptual framework. This research opened a reflection upon elements that can compromise the use of and the access to sharing-based services. But, the reported data by the netnography cannot be considered as evidence about the lack of accessibility or a proof of discrimination. They can be treated as qualitative data to reflect on the debate[6] that consider multiple aspects of the platforms involved in the sharing economy. The point is that an inclusive service system should guarantees inclusiveness without the suspicions of exclusions or discrimination. It does mean that these aspects should be considered during all the phases of the service design because a good service design enables society and disables

[6] For more details on the debate about the evidence for the selected keywords in relation to the platforms involved in sharing economy please see [15–19].

exclusions. In designing inclusive services one of the principles should be to prevent any kind of potential exclusions. Also, this means that it is necessary to adopt a systemic approach where the service is a dynamic, under changeable, human-centered, open and co-designed part of the system. Finally, this study should be constantly upgraded and compared with more ethnographic researches. Also, the authors argue that the netnography methodology as used in this work and the five design domains can positively influence inclusive service design [20] conceptual frameworks.

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Braille Cursor: An Innovative and Affordable Refreshable Braille Display Designed for Inclusion

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Abstract. In this work we present an innovative, low-cost Refreshable Braille Display (RBD): the key feature of the developed method is represented by a single actuated cursor that refreshes Braille cells composed of mechanically simple, passive pins. In particular, a single electromagnetic actuator, moved on a linear slider, is capable of refreshing a full row of passive pins: each pin consists in a simple metal cylinder and can be reconfigured in a low or high state by an external magnetic field. The design based on passive pins, operated by a single moving actuator, makes the cost of the device almost independent on the number of Braille cells. This is suitable for application in either portable (up to 40 Braille cells) or desktop use (more than 40 Braille cells). Moreover, once the line is refreshed, the pins require no energy to hold their configuration and can withstand very high forces applied by the reading fingers. Finally, dimensions of the passive pins, differently from traditional piezo-actuated RBDs, allow for implementation in matrices of tactile pins displaying not only Braille characters but also generic two dimensional shapes.

Keywords: Braille · Refreshable · Display · Haptics · Visually impaired

1 Introduction

Unfortunately, many people still do not have access to information, with specific regard to reading and writing. Among them, blind and visually impaired have serious difficulties in getting access to the world. Nowadays, commercial assistive devices, enabling dynamic reading and writing (also of personal notes) such as Refreshable Braille Displays (RBDs), are still expensive. Affordability of the assistive technology is a fundamental design requirement in supporting the visually impaired in communication, learning, and social inclusion. This, in turn, has serious consequences in terms of equal access to opportunities, freedom of expression, and actual and independent participation to a society designed for the sighted.

RBDs render Braille characters that can be dynamically refreshed over time. They offer the useful and unique advantage of a temporary fruition of written information

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that needs to be available fast, i.e. during navigation and search of web contents, without the need of being printed on a physical sheet of paper.

Commercially available Braille displays are nowadays a consolidated technology, although offering features somehow limited: their cost rapidly increases depending on the number of Braille cells, also, they render just a single row of characters. Such limitations is due both to the cost of the actuators, and to the limits in miniaturization of the implemented technology.

At present, piezo actuators are the most common technology used in commercially available RBDs (Fig. 1). Piezo actuated Braille cells can achieve reasonable reliability due to the moderate complexity of mechanical elements, fast refresh rate and low power consumption, yet at the cost of design solutions that increase overall dimensions of the cell, of relatively high operating voltages and high final costs of the product.

Due to high forces with low displacements actuated by piezoelectric materials, piezolectric bimorphs are usually implemented in Braille Displays. Although bending is limited with respect to the aspect ratio of the bimorph, it is possible to achieve displacement of the height of a Braille dot with actuators of a few centimeters length [1, 2]. Dimensions of the bi-morphs allow implementation for single row of Braille cells and not for an extended matrix of high resolution, refreshable pins displaying tactile features beyond Braille code. An attempt was made in [3] presenting a high resolution, piezo actuated matrix of 8 by 8 pins.

Scientific literature is also rich of alternative design and technologies that have been proposed for actuating Braille pins (a comprhensive survey is presented in [4]), including innovation in mechanical solutions applied to Braille displays, different typologies of actuators, and innovative materials used to create actuators specifically designed for rendering Braille.

Electromagnetic actuators have been proposed with a new optimized design and actuators arrangement for Braille rendering [5] with a solution that can be applied also to two dimensional tactile displays. They are limited by the maximum blocking force with respect to dimensions, weight, and power consumption.

Innovative materials, applied in general for development of new typologies of actuators, have shown promising results for specific application to the Braille rendering. Refreshable Braille cells prototypes based on electro-active polymers (EAP) have shown a simple mechanical construction, low continuous power consumption, and dimensions compatible to the small distances of Braille dots, thus resulting suitable also for extended two dimensional tactile displays [6]. However improvements have to be performed regarding operating voltages, construction defects, and maximum blocking force of the raised dots.

At the cost of a more complex design of the whole device, prototypes of refreshable Braille cells based on electro rheological fluids have been presented. These devices operate at relatively high voltages (comparable to piezo actuators) and reasonable power consumption, and might show promising developments in the near future. Finally, actuators based on heating elements that can change phase or physical properties of the actuating element have been applied to Braille rendering in the form of SMA actuators [7], thermopneumatic actuators [8, 9], and BSEP [10, 11]. Similarly to EAP actuators, these typologies of actuators have in general a simple mechanical design and can achieve very compact dimensions and aspect ratio, compatible for application into a refreshable Braille cell or even two dimensional tactile displays. Yet, the main issue is the high power consumption (due to the heating of the actuating element) and the fast cooling required during normal operation with repeated switching of the dots state.

In this work we present a patent-pending innovative low-cost RBD, developed within the Braille Lab project and named “Braille Cursor”. The key feature of the technology is represented by a single actuated cursor that refreshes the Braille cells, which in turn are constituted by simple passive pins in the shape of bare metal cylinders. Such design limits the number of actuators regardless of the number of Braille cells.

In the following sections we present the working principle of the proposed method, and experimental results related to the operation of the implemented prototype.

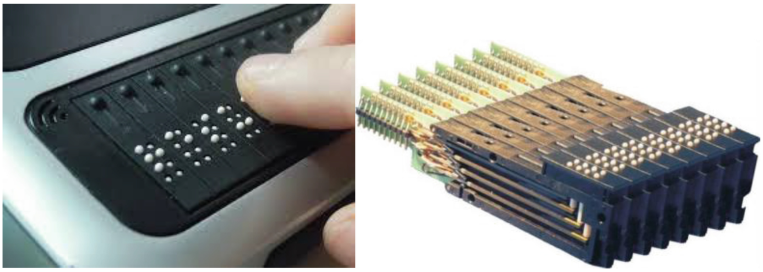

Fig. 1. Commercially available refreshable Braille display (left) and view of the piezo actuators (right) mounteed internally below the reading surface of the device.

2 Design of the Refreshable Braille Display Based on Simple Passive Pins

In detail, a single, actuated sliding “cursor” allows the device to independently raise or lower the passive pins constituting each Braille cell. To refresh the cells, the cursor is moved along the Braille display, and pins are reconfigured by means of miniaturized electromagnetic actuators mounted inside the cursor. The pins are completely passive and no complex mechanism is used for changing the pin configuration. Moreover, once the line is refreshed, the pins require no energy to hold their configuration and can withstand very high forces applied by the reading fingers.

Each pin is constituted by a bare steel cylinder. The substrate of the reading surface contains pin housing shaped with a peculiar profile: each housing contains two slots with different depths the pin can be settled in (Fig. 2). Such shape allows for two possible states the pin can settles in the substrate, corresponding to two different heights the pin is raised over the reading surface. One slot is configured in order to position the upper tip of the pin just below the reading substrate ("low" state); while the other slot is configured in order to raise the upper tip of the pin 0.5 mm above the reading surface ("high" state). Physical constraints created by the shape of the pin housing are designed to hold the state of pin with respect to external forces applied by the user's finger, scanning the reading surface.

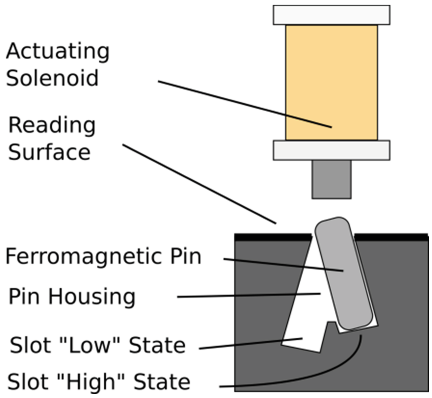

Fig. 2. Scheme of the mechanical components of the proposed RBD technology.

Reconfiguration of each pin is performed through magnetic fields induced by external coils. Magnetic fields generate forces due to interaction with the ferromagnetic material of the pin. Such electromagnetic actuators are designed to be mounted on a moving carriage that scans the surface of the display, in order to refresh the state of the full row of pins. Two different actuating methods have been developed, using a group of three external coils or just a single external coil respectively. The actuating methods are described in details hereafter.

2.1 Actuation Method Using Three Solenoids

The method uses a group of three solenoids, one above the reading surface, and two below the substrate, all mounted on a single moving carriage. The actuation phases are depicted in Fig. 3.

- In the first phase, the group of solenoids is aligned by the moving carriage with the midline of the pin housing.
- In the second phase, the upper coil is powered, and the induced magnetic field raises the pin toward the upper coil.

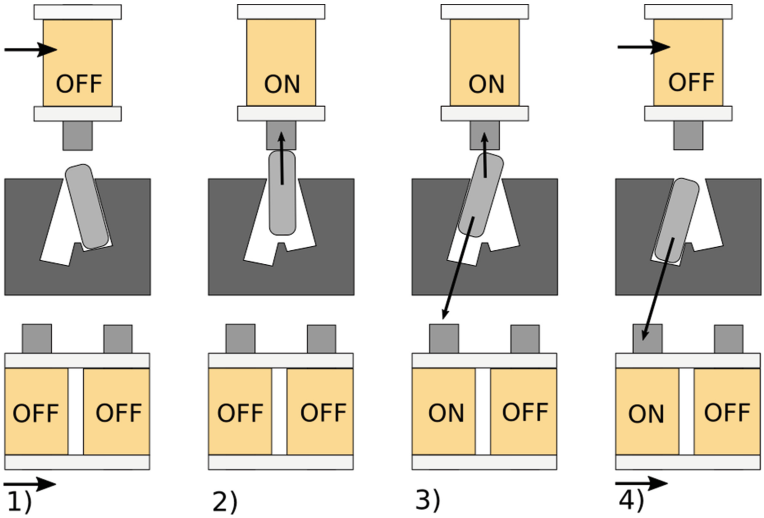

Fig. 3. Sequence of the actuation method based on three solenoids.

- In the third phase, the upper coil is turned off, and at the same time one of the two lower coils, each one corresponding to a different desired status of the pin, is powered.
- In the fourth phase, the pin falls in the slot corresponding to the powere coil and the actuated cursor is moved to the next pin.

2.2 Actuation Method Using a Single Solenoid

This actuation method uses just a single coil in order to reconfigure the pin state. With respect to the previous method, it requires two movements (back and forth) for refreshing a full row of Braille cells (Fig. 4).

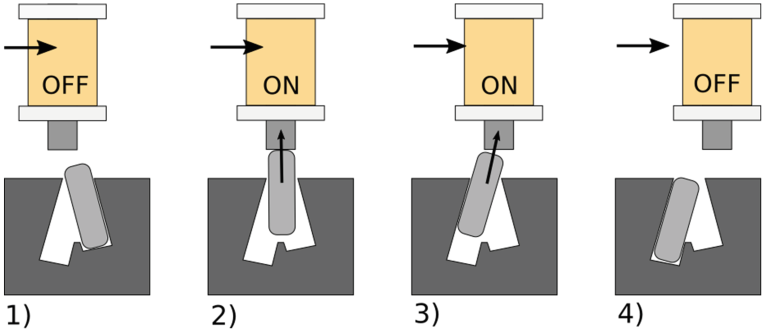

Fig. 4. Sequence of the actuation method based on a single solenoid.

- In the first phase, the coil is aligned with the pin.
- In the second phase, the coil is powered and the induced magnetic field raises the pin outside the occupied slot.
- In the third phase, the coil is still powered and it is moved by the carriage in one direction, left or right, according to the desired pin configuration.
- In the fourth phase, the coil is turned off and the pin falls in the slot corresponding to the desired configuration ('low' or 'high').

3 Experimental Results and Discussions

The following sections describe the implementation of the proposed method in a working prototype of Braille Cursor and the experimental results obtained for its validation.

3.1 Implementation of the Prototype

A preliminary prototype of the proposed device has been developed implementing a row of four working Braille cells. The reason of implementing a limited number of Braille cells is due to the experimental purposes of the prototype and does not limit scalability of the device up to, or over, the standard line of 40 Braille cells. Moreover, during the experimental activity the dimensions of the cell has been varied and optimized, thus requiring several prototypes of the Braille cell to be built and tested.

The moving carriage with actuators of the RBD prototype has been implementend using a linear ball bearing slide, actuated by a stepper motor (Sanyo Denki Nema 14 stepper motor, resolution of 1.8°/step). The rotary movement of the stepper motor shaft was trasnformed to linear motion by means of a timing belt.

On the moving carriage, four miniaturized solenoids were positioned, each corresponding to a different row of pins. The miniaturized solenoids had a diamter of 6 mm and height of 10 mm. The solenoids were placed at 1 mm clearance from the upper surface of the Braille cell. A H-bridge IC (Texas Instruments DRV8833) was used to drive each solenoid through a microcontroller board (Teensy 3.2 microcontroller carrier board). The stepper motor was driven by a dedicated Stepper driver IC (Allegro Microsystems A4988) and controlled by the same microcontroller board.

Supply voltage provided to the H-bridge and to the stepper motor driver was 9 V DC, resulting in a low voltage device (Fig. 5).

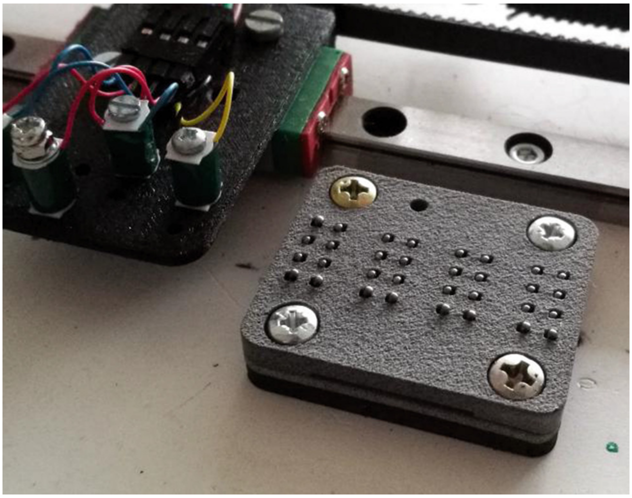

Fig. 5. The developed prototype implementing a sample row of four Braille cells

3.2 Experimental Results

The device was operated through the second working modality, presented in Sect. 2.2, consisting in the use of just one solenoid for each row of pins (4 rows in total in order to actuate a full row of Braille cells). The moving carriage was moved through the stepper motor at a velocity of 10 mm/s over the row of four Braille cells. According to the operation modality described in Sect. 2.2, a two phases forth and back sliding movement was needed in order to refresh the row of Braille cells. During the scanning in one direction (from left to right), pins can be updated from 'low' to 'high' state, conversely during the scanning in the opposite direction (from right to left), pins can be updated from high to low state (Fig. 6).

Alternated or continuous patterns of low/high pin status have been tested in order to validate device operation. Such regular patterns have been chosen in order both to use patterns that can be easily reckgnized and validated by eye, and to test any magnetic interference eventually occurring between neighbouring pins configured in different states.

In the final setup, the implemented device was able to render the reference pin configuration with an estimated error below 5% (tested over one hundred repetitions of different reference patterns). Most of the errors in pin reconfiguration were produced by the same subset of pins, indicating that errors were probably generated by different mechanical features of those pins. Higher precision in mechanical tolerances during fabrication of the plastic substrate could then improve reliability of the device.

We also measured power consumption of the device: reconfiguration of a single pin needed an electrical energy consumption of the actuated solenoid below 0.1 mWh. In addition to the relatively low energy consumption, it is worth to note that the passive pin design requires power only for changing the state of each pin, and no power is required during reading.

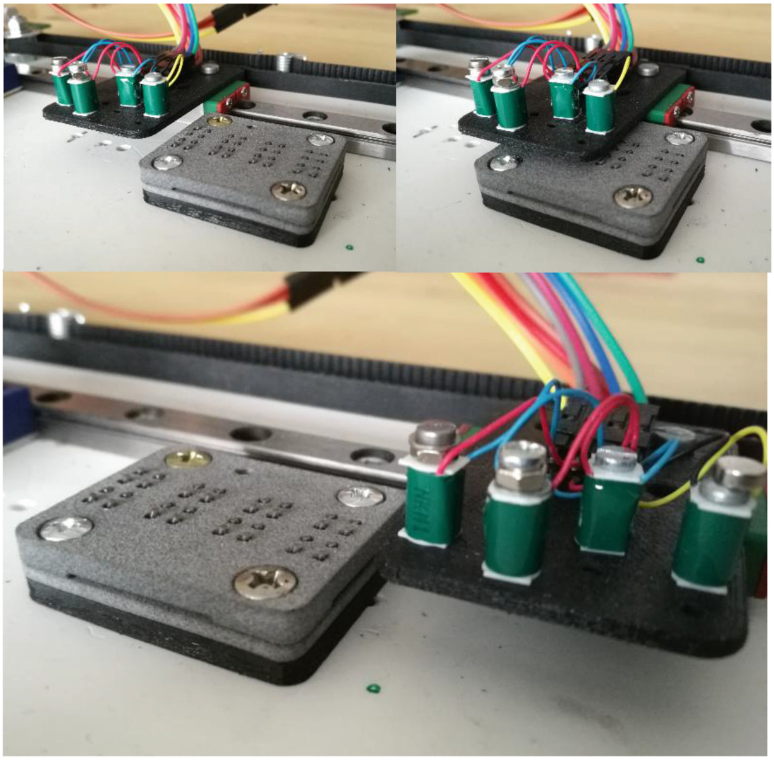

Fig. 6. Actuation sequence raising the full second row (from above) of pins from low to high state.

4 Discussion and Conclusions

In this paper we have presented a novel method for implementing a Refreshable Braille Display. With respect to other technologies already proposed in literature, the presented method makes use of a matrix of simple passive pins, and of a single actuating cursor. The single actuated unit and the simple design of the passive pins solves the issue of high production costs needed for RBDs using one actuator for each pin. In fact, considering features of a medium size RBD, it is composed of about 40 Braille cells, resulting in hundreds of actuated pins. The potential intrinsic scalability of the proposed system makes production cost almost not dependent on the number of Braille cells, in case of either portable (up to 40 cells) or desktop use (more than 40 cells) devices.

Another important aspect to be considered, is that the consolidated technology of piezo actuators is able to actuate separate rows of Braille cells and not a full matrix of tactile pins. This is due to the shape of piezo bending actuators that require room to be implemented around the actuated row of Braille cells. This prevents the possibility of developing tactile devices rendering not only Braille cells but also other tactile shapes and information (i.e. geometrical shapes, maps, graphs). Conversely, the proposed method is suitable for implementing a full matrix of passive tactile pins, since no additional space is required around each passive pin.

The implemented first prototype showed good results in terms of reliability (rendering errors below 5%) and power consumption: electromagnetic actuators required pulses with power below 1 W and energy below 0.1 mWh for re-configuring each pin, at a low voltage power supply (9 V). Also, the design of the passive pin allowed for very high blocking forces and no power consumption once the pin has been reconfigured by the actuated moving cursor.

Future research activities will be focused on the refreshing velocity of the row of Braille cells, by minimizing clearances and stroke of the pins movements. Also, experiments evaluating usability of the system by visually impaired people have to be carried on in order to assess quality of reading and overall usability of the proposed RBD design.

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Case Studies of Inclusive Higher Education in Norway, Sweden and Slovakia

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Abstract. The case studies of inclusive higher education in selected European countries are one of the outputs of the European project: *UNIALL - Accessibility of Higher Education for Students with Special Needs*, co-funded by the Erasmus + Program of the European Union. This output is focused on the analysis and transfer of good practices of designing inclusive environment at selected universities in Europe, as well as the systemic policy and legislation configuration for inclusive design and education in selected European countries. The aim of these case studies is to present national legislative framework and solutions for comprehensive universal accessibility of higher education covering all aspects of accessibility and usability for wide spectrum of students, including those with special needs.

Keywords: Accessibility · Inclusive environment · Universal Design Design for All

1 Introduction

The UNIALL project: *Accessibility of Higher Education for Students with Special Needs* is conducted in frame of the Erasmus+ programme, Key action 2 – Cooperation for Innovation and the Exchange of Good Practices, Strategic Partnerships for higher education. The aim of this project, realised in 2015–2018, is to support the equity and inclusion of all students in higher education (HE) by creating an inclusive educational environment for diverse students.

The case studies of inclusive HE in selected European countries are one of the outputs of the UNIALL project. This output is focus on the analysis of inclusive practices at selected European universities within the framework of national policy and legislation. The analysis covers all relevant documents concerning the accessibility and human-centred methods (e.g. Universal Design, Inclusive Design, Design for All), as well as the solutions and innovative practices adopted at selected universities. These case studies present comprehensive accessibility solutions, including physical accessibility of university buildings, accessibility of information and communication technologies (ICT), inclusive educational methods and support services offered to students with special/specific needs.

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2 Methodology

Each participating partner of the UNIALL project elaborated the case studies representing the best practices of inclusive HE from their home country/university (the Czech Republic/Italy/Slovakia) and plus two other European countries. Slovak team, from the Centre of Design for All (CEDA) at the Faculty of Architecture, Slovak University of Technology, processed the case studies from Slovakia and Nordic countries (Norway, Sweden) in 2017. Nordic countries are excellent in implementation of inclusive methods covering all societal aspects, e.g. the built environment, education, and public services.

The first period of the output was focused on collecting, analysing and selection of innovative and effective examples of inclusive HE environment in Europe. The main methods for collecting the case studies were: (1) on-sites surveys of selected universities, and (2) direct personal contact/interview with university staff and experts on accessibility and disability issues. The contact persons at selected universities cooperated in revising of the collected data and information, including national and institutional documents.

The second period of the output was aimed at the synthesis of selected examples, data and information. Giuseppe Di Bucchianico and Zuzana Ceresnova prepared the structure of the final report for each case study, which consists of the following parts:

- Part 1 Synthetic framework for accessibility of university environments and services:
  - Descriptive sheet presenting the summary of the university and its locations, total number of employees, all students and students with special needs, institutional documents related to accessibility;
  - Brief description of the national legislative framework and the main design solutions related to the accessibility of following areas: (1) physical environment; (2) support services; (3) information and communication; (4) study materials; (5) methods and tools for monitoring accessibility; and (6) training activities on accessibility issues;
- Part 2 Good design practices for environments and services:
  - Detailed description of selected solutions related to one of the following types that is considered to be the most innovative one to encourage inclusive accessibility of HE to students with special needs:
  - (1) Accessibility of physical environment (outdoor and indoor environment for teaching and socialization), including way-finding system, etc.;
  - (2) Accessibility and availability of the support services for students with special needs (counselling services, sign language interpreting, etc.);
  - (3) Information and communication accessibility (ICT systems, assistive technology, university web pages, and academic information system);
  - (4) Accessibility of study materials for students with sensory impairments and students with specific learning disorders;
  - (5) Methods and tools for monitoring accessibility;

– (6) Training activities on accessibility issues (staff training or compulsory curricular activities related to inclusive methods - Universal Design, Inclusive Design, and Design for All).

3 Case Study of Inclusive Higher Education in Norway

3.1 National Legislative Framework in Norway

Norway is one of the leaders in implementing the accessibility and Universal Design (UD) into the legislation and governmental programmes (e.g. national strategies and action plans). The process has started since the mid 1960-ties. In 1976, the Norwegian building regulations were revised concerning the accessibility and usability of the public buildings.

Early after the creation of the UD principles (1997, USA), Norway started testing this concept in 1998. The first action programme for UD was completed in 2002–2004 [1]. Very important *Action Plan 2009–2013: Norway Universally Designed by 2025* [2] helped to support the creation of Anti-Discrimination and Accessibility Act, which came into force in January 2009 (revised in 2013). This act ensures the implementation of UD in all areas of society and defines UD as "*the design or the adaption of the main solution in the physical world, including information and communication technology (ICT), in such a way that it can be used by as many people as possible*" [3]. The universities have to respond to this act, including the following areas: (1) buildings and outdoor areas; (2) ICT solutions (e.g. websites, e-learning systems and pedagogical applications - apps); and (3) students with disabilities shall have a right to suitable individual accommodation of the place of learning, teaching, teaching aids and examinations to ensure equal training and education opportunities [4].

In 2013, Norway ratified UN Convention on the Rights of Persons with Disabilities (UNCRPD), which is the basic legislative document for ensuring the rights of all people with disabilities.

At present, Norway has the *Action Plan for Universal Design 2015–2019* with the aim to create "*a society in which everyone can participate*" [5]. This action plan highlights that UD benefits both individuals and society.

Accessibility of Physical Environment. The Planning and Building Act (1997, revised in 2008) specifies the requirements for accessibility of physical environment [6]. *Universal design* as a main goal to achieve overall accessibility, usability and safety for all people replaced the term "*accessibility*" in 2008. UD is about everybody being able to use a building or an area. The key word is "*everybody*" [7].

The more detailed rules regarding accessibility and UD can be found in the Regulations on technical requirements for building works (Technical Regulations, TEK10) set by the Ministry of Local Government and Regional Development in March 2010 [8]. Norway also has several national standards specifically for universal design of public buildings, housing, outdoor areas and tourist destinations [9].

Accessibility of Higher Education. Since 1999, all higher education institutions (HEIs) in Norway are required to have a contact person for students with disabilities, and an action plan to make each HEI more accessible. In accordance with overall national policy "*to make each person to be part of the community*", services for students with disabilities should be integrated within the services to all students; it means "*support services supposed to be a natural part of the student counselling services – inclusive to all students*" [10].

Higher Education Act (2005) clearly defines that the HEIs are responsible for the overall accessible learning environment. This act specifies that the learning environment should follow the guidelines of UD; this includes buildings and outdoor facilities, but also teaching materials [11].

Accessibility of ICT and Study Materials. In Norway, accessibility of ICT is being mandated by the Regulation regarding Universal Design of ICT solutions, which came in force in July 2013 [12]. In the Norwegian Digital Agenda: ICT for a simpler everyday life and increased productivity, the government has stated that accessibility and UD is considered a prerequisite for successful digitization. The Government's ICT policy has two main objectives (1) a user-centric and efficient public administration, and (2) value creation and inclusion [13].

Norwegian Library of Talking Books and Braille (NLB) is a state library that provides free services for people and students with problems reading text. NLB works to ensure that everyone has equal access to literature and information. NLB produces and lends out electronic and braille books to students who are blind, visually impaired and others with problems reading ordinary text [14].

3.2 Methods and Tools for Monitoring Accessibility in Norway

According to Antidiscrimination and Accessibility Act (2009), all enterprises in Norway (including HEIs) are required to implement UD and provide reasonable adjustments to assure that students with special needs have equal access to HE. All HEIs are obligated to report about activities and progress in these matters to the Ministry of Education and Research. In addition, this act is monitored by the Equality and anti-discrimination commission (LDO, www.ldo.no), and a student can address a complaint about discrimination to this commission. In case of a complaint, the LDO will collect information about the specific case, and make a statement about whether or not discrimination has taken place. The student can bring the case to the court of law if a HEI that has been found guilty of discrimination does not take remedial measures [10].

3.3 Training Activities on Accessibility Issues in Norway

The first national project focused on training and educational activities on UD was organised by the Norwegian Building Research Institute and funded by the Norwegian State Housing Bank in 1997–2002. The aim of the project was to reinforce the integration of UD into the courses offered by schools, colleges and universities, including relevant health education, technological and design education in Norway (e.g. architects, urban planners, designers, engineers, occupational therapists and managers of the building trades). The goal was to achieve that subjects relevant to UD will be included in the curriculum of the schools and universities by the end of 2001. This project has also contributed to making the term *Universal Design* widely known in Norway [15].

3.4 Norwegian University of Science and Technology

The Norwegian University of Science and Technology (NTNU) is the largest university in Norway. The NTNU headquarter is in Trondheim, with campuses in Gjøvik and Ålesund. Sustainability, innovation and Universal Design are the three important, strategic focus areas in education and research at NTNU [16].

NTNU is a leader in the field of accessibility to HE in Norway. This university is the National Coordinator of Accessibility in Higher Education (*Universell*) and provides information and networking for all universities in Norway. From 2007, the National Coordinator has conducted several national projects on Universal Design and inclusive learning environment, as well as the international Erasmus+ Programme: *Universal Design for Learning in Higher Education – License to Learn* (UDLL) in 2014–2016 [17]. This project aimed to demonstrate how Universal Design for Learning (UDL) could be the best solution to develop an inclusive learning environment to benefit of all students. One of the project outputs is a publication: "*Universal Design for Learning. Best Practice Guideline*" [18].

NTNU provides for students with disabilities various services integrated within Student Services Division in line with national inclusive policy in Norway. The main idea is that: "*disability shouldn't prevent you from studying what interests you – and what you have the ability to achieve*" [19]. NTNU offers support services, for example: mentoring, borrowing audio or Braille textbooks, sound recordings (lectures), help with taking notes, courses for students with dyslexia, study techniques and motivation.

NTNU has also excellent research and educational activities on UD, thanks to the Norwegian Research Laboratory for Universal Design in Gjøvik, which is a unique laboratory focused on the relationship between humans and the built environment, including the aspects of accessibility. This laboratory is the largest of its kind in Europe and consists of three main parts: (1) Full Scale Lab, which is equipped with building elements for various types of construction; (2) The Lecture Room; and (3) Human Senses Lab, which offers different conditions and simulations for various visual and auditory experiments. The interdisciplinary research is based on the cooperation of the various NTNU departments towards a common goal: a universally designed society [20].

In 1997–2002, NTNU in Trondheim participated in the first national educational project on UD focused on implementation of the UD courses into the curriculum of Norwegian universities. The School of Architecture NTNU developed and implemented in curricula the course module on UD in 1999 (this course has been made compulsory for second year students of architecture from the year 2000) [15]. NTNU in Gjøvik also offers courses on UD in the curriculum of the third year of bachelor programs, for example: (1) "*Universal Design and welfare technology*" within the Occupational Therapy Program, and (2) "*Universal Design*" within the Technology Design and Management Program [16].

4 Case Study of Inclusive Higher Education in Sweden

4.1 National Legislative Framework in Sweden

In Sweden, the national goals of the accessibility policy are diversity, full participation and equal opportunities for all people. One of the government initiatives was an action plan: "*From Patient to Citizen – a national action plan for disability policy*", adopted in 2000 [21].

The Swedish Government ratified UNCRPD in 2008. Therefore, Sweden has committed to ensuring that national legislation does not discriminate against people with disabilities. According to UNCRPD, the new Non-Discrimination Act (SFS 2008:567) came into force in 2009 and replaced many of the previous laws regulated discrimination. In January 2015, the new law point in this act was added, which classifies inadequate accessibility in all types of school as discrimination. The provisions include both pedagogical availability and physical accessibility [4].

Sweden focuses on the inclusive method *Design for All* rather than UD, which is preferred in Norway. According to EIDD Stockholm Declaration, *Design for All* is design for "*human diversity, social inclusion and equality*" [22].

Accessibility of Physical Environment. The public buildings and outdoor areas must be accessible and usable for people with impaired mobility and orientation according to Swedish legislation: Planning and Building Act (2010:900), Planning and Building Ordinance (2011:338) and other similar legislation. Each government institution is obliged to adopt the Action plan for accessibility and to report regularly about the implementation of this plan [23].

Accessibility of Higher Education. In Sweden, there is no legal definition of special educational needs (SEN). Education follows the principle of "*school for all*" and the focus is on what type of the support the student actually needs [24]. This means that students in need of special support should not be treated or defined as a group that is any different from other students. This is the basic principle of an inclusive education system.

According to the Equal Treatment of Students at Universities Act, no student at university or other institution of HE in Sweden should be discriminated [25]. All universities in Sweden are required to have one contact person (co-ordinator) for students with disabilities. Since 1993, Stockholm University has been assigned as the National coordinator for accessibility of HE and has created the national network for cooperation between the co-ordinators for students with disabilities. This network serves as a forum for experience exchange and education/training [4].

Accessibility of ICT and Study Materials. The Swedish Agency for Participation (MFD) publishes accessibility guidelines that include also requirements for accessibility of ICT, which covers the international and European standard on web-accessibility with requirements to be used in procurement of ICT [26].

The Swedish Agency for Accessible Media (MTM) serves as a library of talking books and Braille books to ensure that all persons with reading impairments (e.g. visual impairment, dyslexia, ADHD) can access literature through media appropriate to them.

This library also provides access to required study materials and produces course literature in alternative formats for students [27].

4.2 Methods and Tools for Monitoring Accessibility in Sweden

The Swedish Agency for Participation (MFD) is monitoring how government institutions are progressing in their efforts to improve accessibility (physical, sensory, ICT, etc.). MFD works according to the principle that everyone has the right to full participation in society, regardless of functional capacity [27]. MFD also produces various checklist protocols as an evaluation tool to assess the accessibility of the built environment in accordance with the Swedish legal framework. The checklist protocol consists of various question themes focused on general information about the object and the physical accessibility requirements, but also visual, acoustic, climatic (anti-allergic) accessibility and emergency and evacuation precautions [28].

The National Board of Housing, Building and Planning drafts the regulations that define the functioning of the control system for accessibility assessment, as well as the requirements that apply for certification as an expert in accessibility [23].

4.3 Training Activities on Accessibility Issues in Sweden

Courses on Design for All are widespread at Swedish design/architecture schools, for example, the courses started at Lund University at the Department of Design Science in 2003, and at Luleå University in 2007. Mid Sweden University in Sundsvall established the first international Master's Programme in Design for All in 2010 [21].

4.4 Mid Sweden University

Mid Sweden University is located in the middle of Sweden and consist of two campuses: Sundsvall and Östersund. The university provides equal opportunities and inclusive educational environment in accordance with the institutional document *Work for Equal Opportunities*:

> The equality of all human beings is an obvious and basic value in all activities at Mid Sweden University. Both students and employees should be treated and met with respect and dignity and differences should be respected in order to make the most of the individual's opportunities in terms of studies and work [29].

The campus in Sundsvall is fully accessible, including the historic buildings that were adapted to provide equal access to all students and employees of Mid Sweden University.

Mid Sweden University offers support to students with disabilities, for example: help with taking notes, adjusted course literature (e.g. talking books and books in Braille), mentor support, rooms with special equipment and resources, technical/pedagogic help equipment, sign language interpreter/note taker [30].

The university provides also educational and research activities focused on inclusive design – Design for All. The Design Research Lab at Mid Sweden University in Sundsvall is a member of the European Institute for Design and Disability (EIDD) –

Design for All Europe. The Lab is located in the Department of Industrial Design and consists of two parts: (1) user stage, and (2) control room with several measurement tools. The aim of the Lab is to conduct research on how different design solutions can affect various users, including people with disabilities [31].

The international Master's Programme in Design for All, at Mid Sweden University in Sundsvall, started in 2010. This programme focuses on the development of humanistic and sustainable design solutions by the methods, which consider human diversity throughout the design process [32].

5 Case Study of Inclusive Higher Education in Slovakia

5.1 National Legislative Framework in Slovakia

In Slovakia, the issue of accessibility to HE for students with disabilities began to develop significantly in the 90s of the 20th century. The Antidiscrimination Act (No. 365/2004) is important legislation document on equal treatment in some areas and prohibits any kind of discrimination on the grounds of disability principle. The Antidiscrimination Act stipulates an obligation to maintenance of equal treatment in education.

The basic documents defining the roles and measures to ensure the rights of persons with disabilities in Slovakia are UNCRPD (ratified in 2010) and "*National Program for the Development of Living Conditions for Persons with Disabilities 2014–2020*". This program defines also tasks related to the accessibility of the environment and education for people with disabilities.

Accessibility of Physical Environment. The basic requirements for an accessible built environment were incorporated into modifications and amendments of the Building Act (No. 50/1976). The first decree on accessibility to the built environment was passed in Slovakia in 1994. The current legislation related to the accessible built environment is stipulated by Decree No. 532/2002, which specifies also general technical requirements for buildings used by persons with limited mobility or orientation.

Accessibility of Higher Education. The major development of inclusive HE started in 2013, supported by the Ministry of Education, Science, Research and Sport. A new legislation amendment was passed, and a barrier identifications and removals were supported with the help of state subsidies.

The Higher Education Act (No. 131/2002, revised in 2013) stipulates an obligation of HEIs to create generally accessible academic environment also by creating suitable conditions for students with specific needs without decreasing requirements for their education output. This act also defines a range of students with specific needs, who are entitled to the support services and individual educational procedures. In order to provide adequate support for these students, there are coordinators or support centres at universities. Decree No. 458/2012 stipulates the details on minimum requirements for a student with specific needs.

The Council of the Minister to Support Students with Specific Needs, established in 2013, has the main role to deliver systematic solutions for students with specific needs and to establish a platform for cooperation among Ministry, universities and non-profit organisations.

Accessibility of ICT and Study Materials. Decree No. 458/2012 on minimum requirements for student with specific needs stipulates the basic requirements for access to information and education resources (including study materials) for students with specific needs, especially for students with sensory impairments.

5.2 Methods and Tools for Monitoring Accessibility in Slovakia

There are no guidelines on the accessibility monitoring in Slovak legislation. However, the accessibility monitoring systems created by the experts are used in practice, as following:

- Monitoring of physical/architectural accessibility has been carried out by the Center for Design for All (CEDA), Faculty of Architecture, Slovak University of Technology (FA STU) in Bratislava. CEDA team published two publications on accessibility of HE (in Slovak language), which serve as a manual.
- Monitoring on information accessibility has been carried out by the Support Centre for Students with Special Needs, Comenius University in Bratislava. The Centre elaborated Web-site accessibility guidelines (in Slovak language), which are posted on their web-site.

5.3 Training Activities on Accessibility Issues in Slovakia

According to the Higher Education Act, two national support centres are set up in Slovakia to fulfil the role of methodological, training and coordination centres: (1) Support Centre at Comenius University in Bratislava, and (2) Barrier-free Centre at Technical University in Kosice. These centres have been carrying out training and consultation activities for coordinators for students with specific needs since 2013.

Since 2008, CEDA provides the national training activities on accessibility of the built environment. CEDA team consists of the university teachers, who are involved in teaching compulsory subject on Universal Design since 1995.

5.4 Slovak University of Technology

Slovak University of Technology (STU) in Bratislava is the largest technical university in Slovakia. STU offers technical education and engages students in research in informatics, civil engineering, architecture, and chemical, mechanical, electrical engineering and material technology.

CEDA at FA STU provides educational and research activities focused on implementation of inclusive methods, mainly in urban planning, architecture and education. CEDA is a member of the international organization EIDD - Design for All Europe. CEDA coordinated two development projects at STU, co-funded by the Ministry of Education, Science, Research and Sports:

- *"Creating the study conditions for students with specific needs at STU"* (2013) – with aim to identify architectural barriers in all university buildings and student dormitories, and then to provide recommendations for accessibility improvements and adaptations;
- *"Elimination of architectural, way-finding and information barriers at STU"* (2015–2017) – with the goal to remove existing barriers and provide accessible solutions at six university buildings and one student dormitory, as well as to create the Support and Counselling Centre, mainly for students with specific needs.

The Support and Counselling Centre is located in FA STU building, which belongs to the protected buildings, therefore the accessibility adaptations were realised in accordance with requirements of heritage preservation.

The premises of the Centre are located near the study department on the ground floor and consist of two specialized classrooms, consulting-technical room, storage for assistive devices, and accessible toilet. Specialized classrooms are equipped with a sound amplification system (built-in induction loop) and flexible furniture. Students can choose chairs with or without armrests, and chairs with folding small table; regular and height-adjustable tables are available. Various furniture elements respect individual student demands and allow for greater flexibility of spatial layout depending on the type of event. The technical room is equipped with the devices for embossed graphics and Braille signs.

FA STU implemented the compulsory subject on Universal Design (originally Barrier-Free Design) in curricula since 1995. The initiator was Maria Samova, who gained valuable experience at research fellowships in Finland (1985) and in the USA (1994). One of the priorities of teaching Universal Design is to form positive attitudes of students towards social inclusion and active aging. As a part of the teaching, there are various sensitization exercises and discussions with various groups of users, including people with disabilities.

6 Conclusions

Nordic countries (e.g. Norway, Sweden) present one of the best example how the inclusive methods can be implemented in national policy and legislation, as well as how to create inclusive educational environment for all students. The principle is based on equal opportunities without any creation and separation of the specific group of students. Universities in Norway and Sweden provide support services that are integrated within the services to all students, and the educational environment is inclusive for all.

The situation in Slovakia is different, because Slovak legislation has not yet welcomed the issue of universal accessibility and has not created a comprehensive document, which would specify requirements for a wide spectrum of users. The understanding of the inclusive education is still focused on specific groups of students, not the whole heterogeneous group of students with diverse needs. Therefore, it is essential to urge implementation of the inclusive methods into national documents and legislation in Slovakia.

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Inclusive Design of Wearable Smart Objects for Older Users: Design Principles for Combining Technical Constraints and Human Factors

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Abstract. The purpose of this article is to propose an evaluation of integration principles between constraints resulting from the choice of technologies to be used on devices, and human needs deriving from the needs analysis of the elderly, in the field of wearable smart objects design for self-sufficient and non-self-sufficient users. The authors will describe this process according to the state of progress of HABITAT project.

Keywords: Inclusive Design · Wearable devices · Wearable technologies
Smart object · Design for elderly people · Healthy aging · Internet of Things

1 Introduction

The continuous growth of average age of the world population, and the consequent increase of the percentage of elderly in our society, created an enlargement of the demand for goods and services related to healthcare and safety issues[1].

The continuous increase of costs related to chronic diseases and the pressure to which public budgets are subjected, are just some of the challenges that welfare systems will have to face all over the world in the next years. In this scenario, digital technology can put itself at the service of health issues by supporting it both in the

[1] World Health Organization, *World report on aging and health*, 2015.

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progress of knowledge and by making possible paradigms of support for medical care H24 anywhere-anytime, especially for the most fragile and in need of support categories, just like the elderly [1]. In the debate on the Internet of Things, the scientific community starts to question what effects and positive impacts can have on people who need assistance and daily help [2]; some researches are nowadays focusing on Health Iot, a network of devices connected to each other to collect, record, analyze and share health data [3].

Wearable devices stand out in this sector, which incorporate advanced technologies and can provide solutions of effectiveness and efficiency concerning certain challenges that health systems have to face.

Wearable devices conceived around the last twenty years aimed to help on solving that problems related to safety, but with huge limitations: the first products were substantially “wearable buttons” to ask for help, they were unaesthetic and above all stigmatizing for people wearing them, causing them embarrassment to wear it in public; secondly, they weren’t predictive and didn’t have the same accuracy as the current available detection systems that are able to anticipate emergencies before they happen; thirdly, they didn’t have the ability to communicate “autonomously” a danger.

2 Case Study

In this paper the authors will describe some aspects of a research project they are working on, that is focused on Inclusive Design for the elderly; the project is named HABITAT, it is funded under the program POR-FESR 2014–2020 of Regione Emilia Romagna, Italy, and it aims to design and test a platform based on Internet of Things for the realization of environments that are assistive, flexible and adaptive for the care of the elderly in their home environment.

Among the various smart objects designed, there are in particular two wearable devices conceived to detect the elder’s habits interpreting data collected throughout the day, that will be combined to allow a reading of behaviors protracted over time, so as to make a further long-term evaluation possible on both motor (i.e. The elder performs the same paths but at a lower speed and with more difficulty in the movements) and cognitive decline (i.e. the elder often does the same route without having a goal).

3 Supported Thesis

The aim of the paper is to demonstrate that the chosen design methodology allows to combine the available technologies with the design requirements expressed by the users.

3.1 Wearable 1

The first wearable device deals with indoor localization of users in their living environment, with the aim of monitoring the elder’s behavior: the amount of ground covered and the relative time it takes to walk it, in order to evaluate any possible decline in motor skills; the actual position, in case the individual needs to be located; the user's immobility, to hypothesize danger and set an alarm; etc.

For the indoor localization of elderly, disabled people, or persons with any form of senile dementia (i.e. Alzheimer's Disease), a reader able to control in real-time multiple active tags has been designed, developed, and tested.

The technology that has been exploited to achieve this goal is the Radio-Frequency IDentification (RFID), widely spread in the last decades, but still in development nowadays; it exploits the communication via the propagation of electromagnetic waves at radio-frequency between two different entities: a tag, that can be active or passive depending on whether or not it is supplied by batteries, and a reader, that remotely queries the tags for the purpose of identification, automatic memorization…

In the framework of the HABITAT Project, a compact and hand-held RFID reader, named RID (the acronym of Remotely Identify and Detect) [4] has been used for this aim: the operating frequency of this prototype is 2.45 GHz, belonging to the ISM (Industrial, Scientific and Medical) Radio Band covering from 2.4 GHz to 2.4835 GHz, and its main working principles are based on the Monopulse radar and beam-steering techniques; this last technology, in particular, allows to perform an horizontal, or azimuth, scanning that enables to obtain an accurate estimation of the angular position of the tagged entity (Fig. 1).

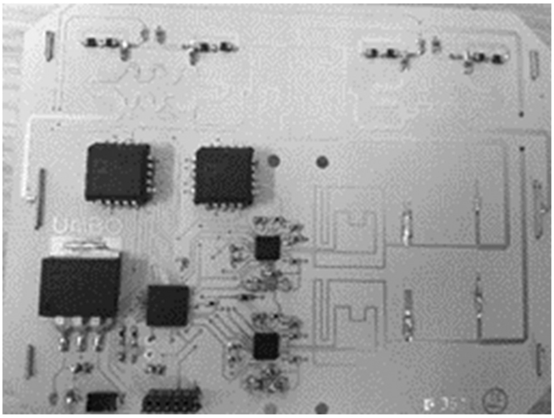

Fig. 1. Layout of the reader circuitry.

The radar is based on an array of two flag-type dipole antennas [5], able to create, through proper feeding, two different radiation patterns (known as Sum Σ, in-phase feeding, and Difference Δ, out-of-phase feeding), whose a-posteriori combination is able to guarantee an appropriate figure of merit (MPR – Maximum Power Ratio) at each angle, revealing the precise angular position of the tag at a certain time [4].

As explained before, this smart object allows the angular detection of the tags; the distance, that would obviously provide a further essential information to process the data and to correctly localize a person in a room, is estimated making use of the maximum RSSI (Received Signal Strength Indicator, i.e. the power values received at the reader from each tag) at the Σ Channel: the usage of a simple formula taking into account both the value of a reference RSSI (at 1 m) and a path-loss model to simply characterize the involved radio channel, allows an almost real-time recover of the information. The room under evaluation has been also divided into three calibration zones: the different radiation patterns of Sum and Difference at the borders and the different radio conditions have been considered for all of them [6].

Fig. 2. Segmentation of the office scenario under test in three zones of calibration.

The wearable RFID active tags use a patch antenna at the frequency of 2.45 GHz: this choice is based on the fact that, due to the presence of the ground plane in the antenna layout itself, it intrinsically isolates the antenna performance from the body and thus can be easily worn without being influenced by the human body, and vice versa. Both the reader and the tags are equipped with Texas Instruments (TI) MSP430 microcontroller and a TI CC2500 transceiver (two for the reader, one for each channel); the circuitry used for the tags derives directly from the TI eZ430-RF2500 Development Tool. The substrate of the antenna (dimensions: 50 × 50 mm, with a thickness of about 0.65 mm) is made of typical RF materials: several choices can be made such as Taconic RF 60-A, Rogers 4360G2, or FR4 (Fig. 3).

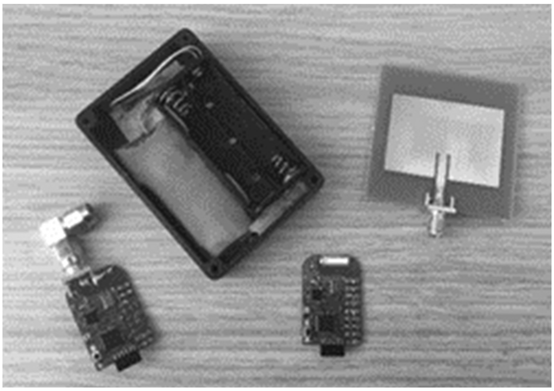

Fig. 3. Active tags, circuitries, and FR4 patch antenna used in the tests for wearable RFID tags.

3.2 Wearable 2

The second wearable designed within HABITAT, is a device capable of quantitative and qualitative analysis of the elderly indoor and outdoor movement, thanks to an inertial platform (IMU) which is inserted in the object itself. Also this device will provide useful information for the assessment of the health and activity status of the person.

Wearable systems for activity monitoring comprise various types of sensors, transmission modules and processing capabilities and they promise to change the future of personal care. Personal wearable systems need to satisfy a great diversity of criteria and constraints. These include small weight and size, privacy and security of personal data, unobtrusiveness, ease of use, low cost, reliability and low power consumption. Designing such a system can be a challenging task since there are often conflicting requirements that have to be considered from the designers. In addition, although there are already many different solutions on the market for activity monitoring, few of them are designed having elderly users in mind.

It is not always necessary to design a new piece of hardware; today's smartphone not only serves as computing and communication device, but it also embed a rich set of sensors, such as an accelerometer, a magnetometer, a gyroscope, a GPS, a microphone, and a camera. The high computing power, together with multiple connectivity and sensing options is enabling new applications across a wide variety of domains, such as healthcare[2], social networks, safety, environmental monitoring[3], and transportation[4]. Therefore an activity monitor could just be designed as a smartphone or smartwatch app.

The most widespread and utilised sensor for designing an activity monitor is the accelerometer. Uni- and multi-axial accelerometers: actigraphs[5] are commonly used in sleep medicine and clinical research to assess patients' motor behavior. Actigraphs are small watch-like devices worn on the wrist to log limb movements but can also be attached on the ankle or waist; they basically record the presence or absence of motor activity and its intensity. Pedometers, attached to the patients' ankle or waist, are also based on an accelerometer and on a step/peak detection algorithm.[6] The application of inertial sensors fixed on the patient's lower back allows the analysis of individual

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mobility patterns as an indication of the patients' motor behavior[7,8]. Advanced signal processing and feature extraction methods can be applied when the sensing unit is fixed on the lower back in order to assess specific characteristics of balance, gait, postural transfers, and turns. Depending on the specific motor tasks of interest, activity classification algorithms can benefit from the readings of a gyroscope and/or a magnetometer in terms of reliability and information content; the combination of an accelerometer, a gyroscope, and a magnetometer is called Inertial Measurement Unit (IMU).

4 Methodological Process

The entire Habitat project has followed a User Centered approach [7] to design smart objects and the system that governs them, so users have played a fundamental role both during the definition phase of the requirements [8] and during the experimentation phase of the various design solutions hypothesized.

The applied methodology was aimed at optimizing the combination between constrains deriving from the technological choices and requirements derived from the analysis of the needs carried out with users. The phases of the design process applied for the definition of the wearable smart objects project, were the following:

4.1 Definition of Primary Users, Secondary Users and Stakeholders, and Analysis of the Relative Needs Concerning the Design of the Two Wearable Devices Within the Project HABITAT

The needs analysis has been carried out in different steps [9]: at the beginning were collected many contributes using surveys, direct interviews, focus groups… than information were elaborated in order to obtain brief statements that could express the requirements desumed by the different categories of users involved in the project. These statements were classified depending on the user that expressed them, on the field they were related to and on the relevance they had for the design of wearable smart objects.

4.2 Definition of Constrains Deriving from the Technologies Developed by the Partners of the Habitat Project, and Individuation of the Features of Smart Wearables to Be Designed

Wearable1: Regarding the RFID reader, the steering of the electronic beam is able to detect and localize tagged users in a scanning zone going from −45° to 45° (Fig. 2) with respect to the direction orthogonal to the reader plane. Several measurement campaigns in different indoor environments have been carried out and it has been

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[7] Zijlstra, W. and Aminian, K. (2007). *Mobility assessment in older people: new possibilities and challenges*. European Journal of Ageing, 4, 3–12.

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demonstrated that the major localization errors belong to border regions (up to 30% of percentage error on the absolute position). For these reasons, it would be preferable to install the reader in a corner of a room, in order to ensure that almost every part of the room will be covered.

Obviously, a setup of the room adopting two or more cooperating readers would be desirable, to enhance the indoor localization accuracy, as the reader-tag distance increase. Moreover, in this way, a possible hiding of the tag's antenna from one reader's view (i.e. caused by human blockage) should be balanced by the presence of the other one.

With regard to the vertical placement of the RID, for typical indoor localization of human beings, it's recommended to locate it between 160 and 180 cm of height: this could prevent or minimize the effects of humane blockage or other unwanted interferences.

However, as regards the wearable tag's constraints, the fact that the antenna has a shielding plane is of great importance for the aim of wearability and coexistence with nearby human bodies: for that reason, the choice for the tag's antenna has fallen upon a planar patch.

After several trials, also some feasible positions of the active tags have been selected: on chest as a pendant, on the shoulders, or in a cap on the head.

Wearable 2: Information collected by the Habitat infrastructure are locally processed and displayed on the wall-mounted touchscreen in a summary report.

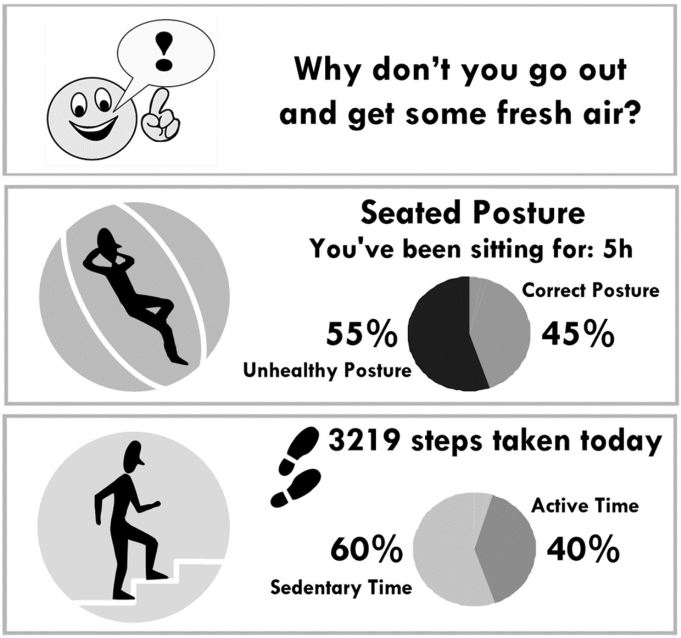

Fig. 4. Summary report of the Habitat system. The report includes statistics about room occupancy, physical activity, and sedentary behavior. It also provide personalized tips and suggestions for the user.

Information about physical activity consists of the number of steps, the sedentary time, and the active time. Although this information could be derived with very simple wrist or waist worn actigraphs, the wearable sensor is placed on the lower back by means of an elastic case waist belt. This placement allows the estimate of a rich set of features for the assessment of the quality and quantity of postural transitions and gait bouts. The algorithms embedded into the wearable sensor automatically identify lying, sedentary, active, and walking bouts along with the movement intensity [10]. For each waking bout the algorithm automatically detects turns while walking and segments each walking interval into straight-path walking episodes and turns [11]. A set of advanced gaits and turning features is extracted such as step duration and variability, gait coordination [12], gait regularity, gait symmetry [13], gait smoothness [14, 15], turning peak velocity, turning mean velocity, turning angle, turning smoothness [16], and number of steps for turning (Fig. 4).

Those advanced features are of clinical interest and can be used to monitor both the physical capacity and the physical performance of the user and hence predict functional decline. Even though advanced features are not shown to the user they are used by the system for personalizing feedbacks, messages, and the user experience in general.

4.3 Application of the Quality Function Deployment, for the Definition of Project Priorities and Hierarchy of Most Important Needs to Be Met, and Interpretation of Its Results

The QFD [17] is a tool that helps to design products and services starting from a hierarchy of users' and customers' needs. It helps to decide the performance due to items or services to be designed and allows having feedback on the consistency of project proposals and starting objectives. The inputs of the QFD are the "Needs," that are defined to reflect users' necessities and the "Features", that are measurable performances of the object to be designed. Both needs and features are put in correlation through a matrix chart, which helps designers to evaluate the degree of relationship. Starting from hierarchy resulting from expressed evaluations, it will be than decided how to design products or services. In this project QFD helped to combine issues related to quality (emotions and necessities of selected categories of users), with issues related to quantity (measurable features of the smart objects to be designed regarding both design and technologies), designers had the role of applying these results to the design of wearable devices.

4.4 Design and Construction of the First Rough Prototypes

Designers hypothesized different solutions for both wearable devices, then they chose the ones considered more appropriate for the achievement of the objectives established in the preceding phases.

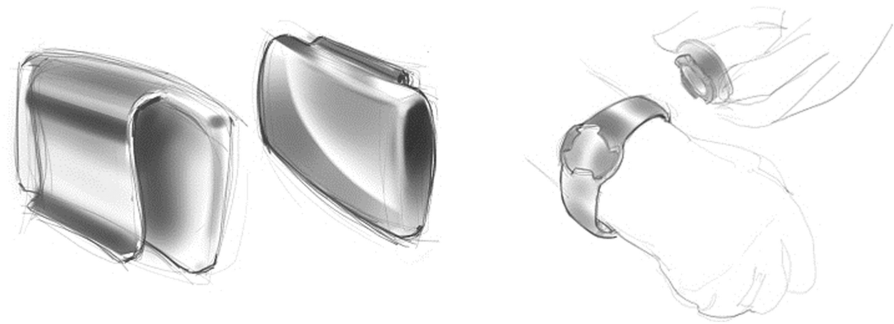

Fig. 5. Sketches of Wearable1

Fig. 6. Sketches of Wearable2

The first prototypes had the function to make possible an evaluation of usability by older people, so wearables have been realized with poor and cheap materials, just to make possible a simulation of usage and to evaluate dimensions, shapes, colors and psychological impact for the user (Fig. 5 and 6).

4.5 Testing of Prototypes with the Same Users that Were Involved in the Initial Analysis and Development of Test Results for the Improvement of Wearables' Design

The rough prototypes have been tested by primary users, both self-sufficient and not self-sufficient elderly, to collect feedback aimed at evaluating the usability of the smart objects. A meeting was organized between designers and users in a day center usually visited by the elderly; the testing phase concerned both the use of devices and the interface connected to them. Users have been subjected to the various developed solutions, instructions related to the usage were minimized just to assess how the use could be intuitive and not related to previous knowledge. At the end of the test phase, information gathered through observation, direct questions and shots of the elderly in action was elaborated to understand which strategies were most effective for the implementation of natural and physical interfaces. The results of the test phase were then translated into the design of precisely objects and interfaces that were an evolution of the previous project, which would allow an increase in the level of usability without compromising the technical choices derived from the use of the technologies described above.

5 Results

The iterative process typical of User Centered Design [7] allowed designers to improve the design of the two wearables by having a feedback of users for the different hypothesized versions, and to optimize the functioning of technological components used in the project. The design process passed through several stages, each of them more complex and efficient compared to the previous ones, each stage corresponded to an evolution of the design of the two wearable devices.

6 Conclusions

The QFD, a tool created to encourage listening to the user's voice, and collaboration between designers of different disciplines within the Japanese industries, proved to be an effective tool for the user centered management of multidisciplinary research design projects. In the project described in the paper, the technological constraints identified by the team of engineers, were assumed as invariants in the definition of the concept, based on the needs analysis developed by the designer team. All the data collected in the various phases and in the co-design workshops were used to identify the configurable features, and to define their importance in relation to the needs, producing shared project specification, enriched by the different skills of the team.

User Centered Design allows not only to direct project results to a humanly significant outcome, but also to harmonize multidisciplinary skills in an effective synergistic design research development process.

The wearable devices project illustrated in the article reached the final phase. The definitive prototypes are under construction and will soon be officially presented and tested for the verification of obtaining a TRL 5 level.

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Internet of Things and Elderly: Quantitative and Qualitative Benchmarking of Smart Objects

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Abstract. Population aging and related healthcare costs already are a problem to face and will increasingly become an even more serious issue. This phenomenon triggers important social changes, highlighting the urgency of finding new dynamics and services also for the Home Care and Healthcare field. The spreading of smart objects and the Internet of Things it is possible to improve the quality of services and device performance for monitoring qualitative and quantitative parameters of elderly people with the ultimate goal of improving their quality of life. The paper therefore proposes to perform a competitive benchmarking between the selected products and the needs identified in the Habitat project, in order to determine its effectiveness; moreover, the correspondence to the needs will be evaluated from a qualitative and quantitative point of view. This work, in addition to provide a lucid and specific market analysis of the studied products, will help to identify the critical points and strengths of the smart objects. Its ultimate goal is to develop a comprehensive needs framework which provides a solid foundation in making new smart object prototypes for old people.

Keywords: Internet of Things · Inclusive design · Smart object Elderly · Healthy aging

1 Introduction

In order to encourage healthy and active aging [1] and prevent forced hospitalization which is not psychologically accepted by an elderly user, different instruments for monitoring physical parameters have been available on the commercial market for quite some time. These devices have proved to have several critical points, focusing more on mechanical and engineering aspects, while underestimating the empathic, functional and aesthetic aspects. For this reason, many of these products have not achieved their desired success. With the development of smart objects [2] and the Internet of Things [3], you are now capable of processing objects interconnected with the network and many of the critical issues that have emerged can be resolved. However, designers who are willing to apply these new technologies will inevitably have to think about new

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language styles, new rules and communication paradigms. In any case, this change in social dynamics between people/objects/environment should increase quality of life without decreasing its humanity, and it is becoming a typical Design challenge. We are looking for solutions that use new technologies according to people's needs and allow to develop products that can empower people [4, 5].

The studies and research on cognitive ergonomics [6] carried out in recent years are confirming that the study of human/machine interaction is becoming increasingly important. In addition, we are assisting to the progressive transfer of healthcare and assistance from medical centers to homes, and this is going to have relevant repercussions on the way we design homes and furniture and home devices for the elderly. Many Home Care products are in the uncomfortable position of possessing a high technological complexity, but at the same time they must be operated and understood by a user who is certainly lacking specific knowledge and, in many cases, has physical, cognitive or sensory disabilities. It is therefore necessary to take into consideration many aspects of the ergonomic, social, cognitive and functional nature in order to try and design products and interfaces that are accessible and inclusive for the users involved. There are three aspects that must necessarily be examined in an inclusive approach: the product itself and its technology, the people involved and the environment in which it is to be used [7]. Each of these these three factors has a great complexity and heterogeneity within it.

2 Methodology

This paper will therefore identify a number of services and smart objects for Home Care that will be analyzed and benchmarked through a qualitative approach, verifying their potential to satisfy a list of needs related to elderly people home life [8]. This list of needs is the result of a long and extensive work of field user research which has been elaborated by the authors within a research project, called Habitat, financed under the POR FESR 2014-2020 of the Emilia Romagna Region in Italy [9]. The Habitat project aims to develop and test a platform based on the Internet of Things that make it possible to create assistive and reconfigurable environments by implementing, improving or redesigning some everyday objects. This research is at its conclusion stage.

The objective of the benchmark analysis presented in this paper is to evaluate some design solutions already available in the market and to verify how they fit the requirements that have been identified in the Habitat project. We expect to outline a design approach that could be helpful in conceiving smart object able to increase elderly people's autonomy [10].

2.1 Analysis of Needs

The list that is going to be used in the benchmark analysis has been elaborated thanks to a scrupulous and meticulous user research that has seen the involvement of about 900 men and women, obtaining almost 500 total needs [11]. These needs were met thanks to direct interviews, the elaboration of dedicated focus groups and also thanks to the involvement of experts during a period of almost 6 months. The objective of the survey was to focus on the reasons for the satisfaction and/or frustration of the respondents with regard to certain actions of daily life. In this paper, the needs that specifically concern the relationship between user and technology to increase living comfort, self-esteem and independence of the person will be extracted. For this reason, next to the unique code that distinguishes the user who has expressed the need, there will be a numeric code which specifically identifies them.

The main users typologies identified within the Habitat project are:

– Uas: the self-sufficient elderly person that typically lives in their own home, often living alone, either with their spouse or even with a very elderly dependent parent, which they must care take care of.
– Una: the elderly person who is non-self-sufficient and resides either in his/her home and is usually assisted by a relative or caregiver. Non-self-sufficiency can be of different nature: physiological as well as pathological but the most significant aspect is the involvement of the motor sphere rather than the cognitive one. This category of users includes very uneven profiles, but they all share the need for continuous and professional assistance in their daily lives.
– Ope: operator (OSS, nurse, physiotherapist, animator…). The peculiarities that unite these figures are the professional training usually linked to the world of healthcare or social care.
– Pan: the relative of the elderly person who is non-self-sufficient is usually the son or spouse of the elderly person, who acts as a caregiver in the case they live together in the private home. In this research, it was decided to consider the relative as a figure too given the profound emotional implications of their role with respect to that of an outsider not emotionally involved with the elderly person.
– Cgn: caregiver of the non-self-sufficient elderly person. They are the ones who helps him/her in the care of the person and in the fundamental activities of daily life.
– Dec: decision makers (administrative managers, mayors…) are the people considered as the project stakeholders; in particular, a focus group was held with decision makers such as mayors or managers of the healthcare company who are the people who will actually choose the devices and services offered by the healthcare company to the facilities and individuals who need it.

The selection of the most pertinent and relevant needs regarding the analysis to be carried out on some smart objects and Home devices on the market are presented below:

– Uas. 015 - I want to feel close to my children even if they live many kilometers away from me
– Uas. 021 - I want to receive help for daily household tasks
– Uas. 026 - I don't want to be forced to change my home in perspective of my old age.
– Uas. 039 - I want to feel fulfilled in following the daily routines that give me security
– Uas. 042 - I want to get help in the daily intake of medicines that I have been prescribed

- Una. 012 - I just want devices that you can easily understand easily how to use them
- Una. 007 - I want to stay and live in my house as long as I'm conscious
- Ope.cd.033 - I don't want the responsibility of more people than I can control
- Una. 016 - I don't want to feel checked or spied on by other people
- Pan. 017 - I want to keep him busy by recurring less on television
- Pan. 082 - I want you to never forget to have your lunch,
- Pan. 084 - I want to have some advice on an easier way to organize the house
- Ope. 070 - I want to have a history of the user's monitored values
- Ope. 125 - I want to enable users to perform psycho-motor activities
- Ope. 032 - I want the safety standards to be adjusted according to the autonomy of the subject.
- Ope. 022 - I want the alert system to respect the privacy of users
- Ope. 031 - I would like the security not to be at the expense of privacy
- Dec. 006 - I want to give the relative a tool to know if everything is really going well as he says on the phone
- Dec. 013 - I want the elderly person to be more aware of the technological solutions they have around
- Dec. 021 - I want a device conceived to make it easy to train people that will have to use it.
- Dec. 023 - I want to introduce systems with a view of cutting down on expenses and increase savings in the long-term.

2.2 Smart Objects for Home Care

In order to carry out the benchmarking, we made a selection of devices and smart objects that have been presented in the last 5 years. Every selected device has a potential to improve the quality of life of elderly people through the application of some of the following technologies and solutions:

- Artificial Intelligence
- Sensors (location, thermal, presence, etc.)
- Wireless connection
- Interfaces and outputs for humans
- IOT

These improvements can be dictated by a better and personalized spatial localization that produces a consequent higher security and independence for an elderly user or tools and services that facilitate their daily routine, helping people in taking medicines or in remembering specific appointments. Below is the list of products and services extrapolated, with a subsequent brief technical description; these devices will be evaluated and compared thanks to the features listed in the datasheets available on institutional websites.

ONDO THERMOBAND (Young W. Lee, United States, 2016). It's a device designed for elders. It automatically sets the thermostat according to the user's body temperature. The device is a sort of bracelet, on the band there are some sensors continuously detecting the user's body temperature of the older who lives alone.

The data is then sent to the linked thermostat through built-in Wi-Fi to instantly set the ideal room temperature. https://www.youngwleedesign.com/2-1.

ELLI Q (Fuseproject-Intuition Robotics, United States, 2017). ElliQ is a robot designed to en-courage an active and engaged lifestyle by suggesting activities and making it simple to connect with loved ones. ElliQ is conceived to remind users of events in their diary, or when it's time to take medication, while also suggesting activities like exercises or podcasts to listen to. https://elliq.com/.

SENIOR LIFESTYLE SYSTEM (Qorvo-Sensara, United States, 2016). Qorvo's Senior Lifestyle System in few weeks learns the routine day-to-day activities of the senior resident, provides intelligent status updates in a dashboard app, and sends alerts to designated caregivers if something unexpected happens. The system learns seniors' everyday behavior patterns using unobtrusive wireless sensors located around the home, and detects changes in behavior that may cause concern. It then alerts family members and/or caregivers via messages. http://www.qorvo.com/design-hub/blog/smart-homes-for-seniors-how-iot-helps-aging-parents/.

JON (MedMinder, Mexico). It's a digital pill dispenser. A caregiver fills the medicine tray that goes into the device. The adult child logs onto the Web, remotely programs the schedule and can see if the user has complied. The dispenser flashes (if locked, it unlocks) when it's pill time, then beeps if the medicine's not taken. A pre-recorded voice reminds to take them. If the user doesn't, he gets a call, and a family member receives an email, text or call. https://www.medminder.com/.

GOSAFE2 (Philips Lifeline, United States, 2016). Philips Lifeline is a personal help button for home use that is worn around the neck or wrist and can detect if you've fallen. It dispatch a neighbor, family mem-ber or emergency services based on each unique situation. Users can ask for help with the press of a button. https://www.lifeline.philips.com/.

GRAND CARE SYSTEMS (Grand Care, United States). GrandCare is a system that tracks daily activity, has medical moni-toring (glucose, oxygen, blood pressure, weight). An interactive touch screen lets you watch videos, photos, listen to music, play games and provide activity and health monitoring, medication tips and easy communication. https://www.grandcare.com/.

MOBILEHELP DUO (MobileHelp, United States, 2014). This is a mobile device with GPS satellite location tracking with an in-home base station. If the user is unable to press the button to call for help it automatically send an alarm in case of fall. https://www.mobilehelp.com/.

TEMPO (Care Predict, California, 2017). Tempo is a wearable that houses a array of sensors able to detect an individual's activities of daily living (ADLs) and location. Tempo senses ADLs like eating, drinking, bathing, sitting, sleeping and more. Tempo also manages to locate the person. If the user calls the alert, the message is sent to the caregiver. https://www.carepredict.com/how-it-works/.

SILVER MOTHER (Sen.se, France, 2017). This device is a smart hub made by multi-purpose tracking sensors that can analyze hundreds of individual's activities of daily living. System can monitor pill boxes, drinking habits, sleeping, specific events at home and living habits. Personal data are collected on a web server and visible on a personal dashboard either directly on internet or on a specific mobile app. The hub can send regular notifications based on selected programs and instant alerts when a cause of concern is detected. Weekly summaries can be sent by email to doctors and other family members. Every small sensor requires internet connection, it has a thermometer, 3-axis accelerometer built in and it could be reached up to 100ft indoor by radio frequency signals. https://sen.se/store/silvermother/.

SILVER FOX (Andreas Schuster, Berlin, Germany, 2017). Silverfox comprises a wearable device for the senior and a caregiver app. The device automatically senses an emergency through motion detection, a call for help or the press of button. Through the device's microphone, seniors can talk directly to their care circle – wherever they are. Instead of an anonymous call center, seniors would often rather turn to the people they know and trust first. This could be family, friends, neighbors, or private nurses. Since every user is different, the service is customizable to individual safety and privacy needs through the caregiver app. The assistant can raise awareness of potentially dangerous patterns, like activity loss or wandering. It can also support in daily life through medication reminders or voice notifications. http://silberfuchs.io/.

3 Benchmarking

This chapter presents the final matrix of correlation between selected needs and devices. To facilitate reading, it is specified that in the first column of the matrix the needs selected as most relevant to the object to be designed are collected; these are given a vote on the importance with respect to the user who has stated them (AIN - absolute importance of the needs) that can be declined with the following values: 5 = indispensable; 4 = very important; 3 = Important; 2 = preferable; 1 = negligible [12].

The matrix allows to attribute a vote to the correlation between needs and the level of satisfaction of that need provided by the products selected for Home Care, by entering the following values: 9 = strong satisfaction; 3 = medium satisfaction; 1 = weak satisfaction; 0 = no satisfaction. The votes entered generate the last lines of the matrix showing the votes for the products selected. Below table of correlation between the selected devices and needs. The final results were obtained thanks to the development of a calculation algorithm. The percentage is derived from the sum of the product between the Absolute Importance attributed to the needs and the Correlation between Needs and devices. The benchmarking table is divided into two parts to allow greater legibility (Figs. 1 and 2).

		Absolute Importance of Needs	Relevance of needs	ONDO THERMOBAND	ELLI Q	SENIOR LIFESTYLE SYSTEM	JON	GOSAFE2
Uas.015	I want to feel close to my children even if they live many kilometres away from me	4	5%	0	9	0	0	0
Uas.021	I want to receive help for daily household tasks	4	5%	0	3	0	0	0
Uas.026	I don't want to be forced to change my home in perspective of my old age	5	6%	0	3	3	0	1
Uas.039	I want to feel fulfilled in following the daily routines that give me security	5	6%	0	3	0	1	0
Uas.042	I want to get help in the daily intake of medicines that I have been prescribed	3	4%	0	3	0	9	0
Una.012	I just want devices that you can easily understand easily how to use them	4	5%	9	3	3	3	3
Una.007	I want to stay and live in my house as long as I'm conscious	5	6%	0	3	3	1	1
Ope.cd.033	I don't want the responsibility of more people than I can control	2	3%	0	1	1	1	1
Una.016	I don't want to feel checked or spied on by other people	3	4%	3	3	3	3	3
Pan.017	I want to keep my self him busy by recurring less on television	3	4%	0	9	0	0	0
Pan.082	I want you to never forget to have even only your lunch	2	3%	0	1	0	0	0
Pan.084	I want to have some advice on an easier way to organize the house	3	4%	0	1	3	0	0
Ope.070	I want to have a history of the user's monitored values	5	6%	1	1	3	3	0
Ope.125	I want to enable users to perform psycho-motor activities	4	5%	0	9	0	0	0
Ope.032	I want the safety standards to be adjusted according to the autonomy of the subject	5	6%	1	3	3	1	1
Ope.022	I want the alert system to respect the privacy of users	4	5%	1	3	3	1	1
Ope.031	I would like the security not to be at the expense of privacy	4	5%	0	1	9	9	3
Dec.006	I want to give the relative a tool to know if everything is really going well as he says on the phone	4	5%	0	3	3	1	1
Dec.013	I want the elderly person to be more aware of the technological solutions they have around	3	4%	1	9	9	3	1
Dec.021	I want a device conceived to make it easy to train people that will have to use it	5	6%	3	3	3	3	1
Dec.023	I want to introduce systems with a view of cutting down on expenses and increase savings in the long-term	3	4%	1	3	3	1	3
		80	100%					

	ONDO THERMOBAND	ELLI Q	SENIOR LIFESTYLE SYSTEM	JON	GOSAFE2	
Absolute importance of the product	80	292	203	151	75	1530
Relevance of the product	5%	19%	13%	10%	5%	100%

Fig. 1. Correlation matrix between selected needs and analyzed devices. Table 1.

		Absolute Importance of Needs	Relevance of needs	GRAND CARE SYSTEMS	MOBILEHELP DUO	TEMPO	SILVER MOTHER	SILVER FOX	
Uas.015	I want to feel close to my children even if they live many kilometres away from me	4	5%	3	1	0	0	3	
Uas.021	I want to receive help for daily household tasks	4	5%	3	0	3	0	0	
Uas.026	I don't want to be forced to change my home in perspective of my old age	5	6%	3	1	3	3	1	
Uas.039	I want to feel fulfilled in following the daily routines that give me security	5	6%	3	0	1	0	1	
Uas.042	I want to get help in the daily intake of medicines that I have been prescribed	3	4%	3	0	1	1	3	
Una.012	I just want devices that you can easily understand easily how to use them	4	5%	1	3	3	3	1	
Una.007	I want to stay and live in my house as long as I'm conscious	5	6%	3	1	3	3	1	
Ope.cd.033	I don't want the responsibility of more people than I can control	2	3%	1	0	1	0	1	
Una.016	I don't want to feel checked or spied on by other people	3	4%	1	3	3	3	1	
Pan.017	I want to keep my self him busy by recurring less on television	3	4%	9	0	1	0	1	
Pan.082	I want you to never forget to have even only your lunch	2	3%	1	0	0	1	1	
Pan.084	I want to have some advice on an easier way to organize the house	3	4%	3	0	3	3	1	
Ope.070	I want to have a history of the user's monitored values	5	6%	3	0	3	3	1	
Ope.125	I want to enable users to perform psycho-motor activities	4	5%	3	0	1	1	0	
Ope.032	I want the safety standards to be adjusted according to the autonomy of the subject	5	6%	1	1	3	1	1	
Ope.022	I want the alert system to respect the privacy of users	4	5%	1	1	3	1	1	
Ope.031	I would like the security not to be at the expense of privacy	4	5%	3	1	3	3	1	
Dec.006	I want to give the relative a tool to know if everything is really going well as he says on the phone	4	5%	3	1	3	3	1	
Dec.013	I want the elderly person to be more aware of the technological solutions they have around	3	4%	9	1	3	3	3	
Dec.021	Il want a device conceived to make it easy to train people that will have to use it	5	6%	1	3	3	3	1	
Dec.023	I want to introduce systems with a view of cutting down on expenses and increase savings in the long-term	3	4%	3	3	3	3	1	
		80	100%						
			Absolute importance of the product	226	79	188	144	92	1530
			Relevance of the product	15%	5%	12%	9%	6%	100%

Fig. 2. Correlation matrix between selected needs and analyzed devices. Table 2.

4 Results

From the critical reading of the elaborated benchmarking, it can be seen that: the products that best meet the needs listed are Elli Q, Senior Lifestyle System, Grand Care System, Tempo and Silver Mother, as they are made up of an ecosystem of products interconnected with each other thanks to wireless technology to a digital online service that manages their activities, through machine learning techniques to identify the behavioral patterns of users and to adapt to the different situations that arise in domestic or community environments. Among these products, Elli Q is highlighted as an object that best meets most of the needs of the different target groups, thanks to its ability to use artificial intelligence to manage the complexity of the system for which it was designed and to interact empathically and in an engaging way with the elderly. It was noted that Elli Q and Grand Care System in particular are the only ones that completely satisfy the needs of the "self-sufficient elderly" category, which, in the table shows a weak correlation, if not zero, with almost all the projects examined, but which, in the analysis of needs, together with the "Operator" has the highest percentage of importance. In this case, the five needs of the "self-sufficient elderly person" indicate the presence of products that focus more on technical functions such as reminder, rather than focusing on the quality of a person's daily life and making it less solitary and more engaging, while respecting their habits. As far as the "Operator" type is concerned, what emerges is above all the lack of products and services that follow and help operators in their primary care activities for their patients. Above all, the need for simultaneous management of many users, which is often difficult and poorly organized, is not satisfied at all. Therefore, this fact causes disorder among the different assistants who are due to supervise more people than they are able to handle. While there is a very weak correlation in the customization of security systems according to the different needs of their patients and their privacy when it is necessary to transmit personal alerts.

All devices (except Elli Q) also fail to meet the needs of elderly people who want to carry out motor activities useful for their personal well-being. Another category not very closely related to the comparative products can be found in the figure of the "relative". It is important in the system of relationships that are created in the domestic habit because very often it is the relative who takes on the role of caregiver and he is the one who takes charge of all the activities related to his elderly parents, thus weighing on his daily life. In particular, the least taken into account problem is "Pan. 082 - I want you to never forget to have even only your lunch", which is underestimated in everyday life but is important for the physical health of the elderly. The most frequent correlations can be found in the "Decision Maker" type, which highlights that the home devices market is trying to respond to the problems posed by the gradual aging of the population. Instead, the projects that have weak or no correlations at all are Jon, GoSafe2, Silver Fox, MobileHelp Duo and Ondo ThermoBand, as they are objects that perform specific functions to solve specific problems, often emergencies and situations after the events has occurred, without actively assisting users in their daily activities and preventing problems. Finally, since all products are linked to a senior target group, the most correlated need is related to the simplicity of the interface.

5 Conclusion

The obtained results cannot be considered definitive and universally applicable. However, they are based on a selection of needs obtained through a meticulous and in-depth work of user research.

The autonomy and health care of the elderly at home are design topics representing the point of convergence of needs coming from different users and stakeholders, so that design solutions that focus on a single reference run the risk of neglecting factors and performance necessary for success.

The products that seem to be capable of satisfying a wider range of needs, also expressed by different users, are those which are conceived as an integration of several customizable solutions and which are equipped with interaction devices that can be modulated according to the user who is interacting with them at that moment.

In particular, the products that are able to modulate the complexity of their interfaces depending on the nature of the task to be performed and on the capacity and availability of the user, seem to be more successful.

If we were to find guidelines for the design of smart objects for home applications for older users, desumed from the analysis produced in this article, we could summarize them as follows:

- Base the project on the needs of a complex user, composed at least by:
  - Elderly users
  - Caregivers
  - Relatives
  - Professional operators
- Privilege system design solutions.
- Conceive the smart objects as interoperable elements that speak a common and understandable language.
- Privilege customizable solutions.
- Privilege natural and flexible interfaces.
- Privilege emotionally significant solutions for interaction rather than simply efficient ones.

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Social Footprint. An Exploratory Analysis of Existing Evidence and Opportunities

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Abstract. The design of products, systems, and services not often is driven to be socially innovative. One of the reasons could be that especially in the private sector, the impact of a Design for All approach it is not easy to assess. Nevertheless, many companies produce goods and services whose outcome goes beyond the mere consumption or experience level. Specifically, there is evidence that in different sectors (from design to food, from fashion to wellness) the level of consumer engagement is changing. In particular, it is expected that final users will experience an improvement in the quality of their lives in a more sustainable and nature-friendly way. This has often be referred to as social footprint or social impact. However, while a clear-cut measure of the environmental effects exists, that is the carbon footprint, the same cannot be said for the social footprint. Researchers and private organizations are discussing possible ways to measure it, and some have been implemented, but a general agreement on a unique definition has not been reached yet. When available, it is also unclear what it is the extent of its applications. The goal of this paper is to offer a detailed review and analysis of what it is known so far and to be able to propose a different point of view which moves from CSR and CSM to the possibility of evaluating the economical growth and success of enterprises developed from Design Driven Social Innovation. We intend to use the study to design a set of questions to be able to then interview some key experts in the area (mainly social entrepreneurs) to understand if there is a shared interpretation of the concept of the social footprint and how Design for All is being implemented, why and with which results. We also want to understand which are the key categories that could be transformed into measurable information. The study should be seen as a basis for the next steps, which are, respectively, the building of a social footprint indicator for businesses which have integrated society into strategy and its applications.

Keywords: Design driven social innovation · Social footprint
Design for all · Social impact · Business impact · Ethical business

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1 Social Footprint: From CSR to Shared Value

1.1 Defining Social Impact Through Externalities, Processes and Philanthropy

From a corporate business point of view, the concept of social footprint most of the times indicates the impact of a company's externalities on the wellbeing of people, society, and communities that belong to its ecosystem. The term "social footprint" is also interchangeably used with Corporate Social Responsibility (CSR) or, also, Corporate Management Responsibility (CMR) [1]. Given the broadness of the term "social," some authors suggest using an umbrella term that encompasses all the different categories of footprints. In particular, the "Footprint Family" is an integrated indicator that includes the ecological, carbon, and water footprint generated by the economic activities of a company [2]. From a strict economic perspective, CSR can be seen as the capacity to address, and hopefully to reduce, the negative externalities in the society and the environment, and to strengthen the positive outcomes. However, CSR is a concept with several applications and practices, which differ from country to country.[1] Besides the general definitions, a full understanding of CSR requires a bottom-up approach. It starts by observing companies' actual behavior, and it follows up by identifying common features from which to infer guiding principles at a more general level. For example, in 2016 Google launched Google Green, an initiative with the scope of making the giant company environmentally sustainable. Their annual environmental report states that their data center uses 50% less energy than the average centers around the world, 36% of their servers were made of recycled electronics, and so on [3]. Another example of CSR practices is the Community Involvement Program of Xerox. Employees occasionally participate to grassroots and volunteer initiatives in their community. Xerox scientists may thus teach to elementary kids in less fortunate areas, or Xerox lawyers may be involved in pro-bono legal causes.[2] Another common strategy largely used by both corporations and medium-size companies, is to set up private foundations that usually fund project and programs for charitable purposes. Just to name a few big players, this practice includes the Bill and Melinda Gates Foundation, the Walmart Foundation, or ExxonMobil Foundation. When looking at the actual examples, it seems that companies can choose to practice CSR within the company itself, thus proposing a "good example" for its customers and employees, or an external approach, devolving some of the revenues to other social projects in different fields (medical, education, infrastructures, etc.). The latter approach is rooted in philanthropic charity, and it contributes to build a positive image of the company. If we want to go more in-depth, it is worth mentioning the work of Dahlsrud [4] who offered a classification based on five dimensions. In particular, he distinguishes between CSR activities that involve:

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[1] Definition of corporate social responsibility, Financial Times Lexicon, available at http://lexicon.ft.com/Term?term=corporate-social-responsibility–(CSR).

[2] Source: https://www.xerox.com/corporate-citizenship/2014/communityinvolvement/volunteer-programs/enus.html.

The environmental dimension (the natural environment and the idea of investing in a cleaner and more sustainable way)
The social dimension (the relationship between business and society – improve and contribute to a better society)
The economic dimension (that includes the socio-economic or financial aspects, including the description of the CSR in terms of a business operation)
The stakeholder dimension (that involves stakeholders and shareholders)
The voluntariness dimension (that includes external volunteering activities)

Different companies can choose to use one or more dimensions in their CSR strategy.

Although many companies adopt CSM practices, there is still a lack of standards in defining a universal method to measure it. If it is hard to propose a unique *definition* in both the corporate and the academic world, *measuring* it, it is even more complicated. In an extremely simplified way, according to its measured value, the impact of the social footprint can be positive or negative. It goes without saying that the effect is positive when the society or the environment is better off, and negative when the society or the environment worsen their condition. Many companies present annual reports of their CSR actions together with a detailed list of figures and tables where they describe their green initiatives, but a standard indicator is not usually reported. A detailed review of the methods currently used and proposed in the literature can be found here [5].

Although nor related to the current study, another popular use of social footprint is related to the online or digital footprint. It indicates all the information left behind on the Internet, including for examples comments on social media, online purchases, and website registration [5].

1.2 Towards Social Impact as a Core Business

There is also a lack of consensus regarding whether social responsibility has a beneficial effect on the company's financial performance [6]. One perspective, for example, sustains that firms face a trade-off between profit and social outcomes, seeing social responsibility as a cost for businesses instead of as a benefit [7]. On the opposite, other authors believe that the costs of CSR are minimal, and can be easily overcame by the effects on the morale and the productivity of the employees [8]. During the financial crisis of 2008–2009, financial stocks of companies with a high social footprint were four to seven percentage points higher than companies with a low social footprint, suggesting that CSR can have a protective role during times of economic depression [9].

Recent business practices with a more decisive approach towards social business models are also emerging, for example, there is a new class of businessmen called "*Changemakers*" whose goal is to put the social good at the core of their for-profit company [10]. The interest towards a profitable ethical business is such that some consulting groups – such as the Global Impact Investigating Network – have the principal goal to make their impact profitable in terms of revenues [11]. The possibility to merge profit and a positive social impact has also been recognized a few years ago in the United States as a legal entity under the name of "Benefit Corporation". A benefit corporation – as the name suggests – is a profitable business that produces outputs beneficial for the society and the environment. A detailed description of the legal framework can be found here [12]. Just to name a few examples, among benefit corporations we find "Kickstarter", "Laureate Education", or "Plum Organics".

Another aspect that is worth mentioning is that the way companies can incorporate and measure their impact on the society and the environment is very dynamic. In the last five years, new definitions and new paradigms are in fact emerging. Last year, for example, the Center for Social Impact Learning (CSIL) has released the "Pulse of Impact Management Report" [13] "*The report includes a snapshot of current practices at the impact due diligence, monitoring and reporting stages among impact investors based on a scan of 257 publications, interviews with 17 firms in the impact investing arena, and SVT Group's empirical experience in the field over the past 15 years*". The overall goal is to create valuable information for newcomers, and help them navigate among the several opportunities to measure social impact.

Looking at the demand side, new opportunities for companies which care about their social impact might also come from new consumer segments who are now willing to spend more time to look for company's information and production standards, as well as quality cues and features in new products. These consumers are eager to spend their money on intangible values of products, which should be green, ethic, healthy, socially responsible, and so on [10].

Another important aspect is the demand for products that seek to be, at the same time, inclusive of the human diversity, and innovative in their design. At the centre of these products' development, there is the human business capacity to answer creatively to human abilities, necessities and aspirations (ANAs).

The capacity of a company to produce respecting these two aspects generate a critical additional value that should integrate the traditional view of a company's social footprint. To the authors' knowledge, however, there is no study or research on it.

2 Human Diversity for a Sustainable and Innovative Social Impact

Human Diversity plays a pivotal role in social strategies, as several studies and researches have underlined exploring the relation between H.D. and design, design thinking and design implementation in markets, approaches like Design for All, Holistic Ergonomics, Co-design Research, Human Factors Design, Human Diversity, Participatory Design, Inclusive Design, Human Centered Design being some of the methodologies applied. Within this framework, H.D. has been considered and analysed from different perspectives and through different tools for the purpose of designing systems, products, communication and business models (BandiniButi, Brown, Donald, Ehn, Hall, Latour, Norman, Taleb, Verganti, Yaneva and others).

The almost unlimited vastness of human diversity can be partially contextualized for the purposes of design, markets and stakeholders, within a defined value chain, through A.N.A.s (Abilities, Necessities and Aspirations) (Accolla). Each individual is different from others because of many factors, such as: culture (family and collective), background (personal and work related), habits, time of the day, biological age, generation, sensorial-biological-cognitive-motor abilities, and others. Each individual also expresses differently his/her factors in "diverse selves" in relation to the specific role she/he plays in the value chain is participating in. Each person changes his/her abilities, necessities and aspirations according to what he/she is doing, why, how, when, where and for which purpose.

Through A.N.A.s, each person changes the way he/she experiences systems, relations with others, services, purchases, products, etc. actively affecting social and business environments. Within a Holistic Ergonomics framework, A.N.A.s help designers and decision makers to empower H.D. through its own richness meeting the challenges of complexity and avoiding undesired classifications and stigmatizations which represent a failure for both business success and social integration. The role of Aspirations is pivotal in this approach for its role in general and specifically in mature markets [19].

3 Designing for Human Diversity as a Competitive Advantage and Winning Business Factor

In last year's markets and societies are witnessing different approaches to sustainable development which are creating interesting patterns and setting new precedents.

Understanding the complexity and richness of Human Diversity is a business resource and an opportunity for innovation when it is driven by design. Abandoning the outdated concept of H.D. as a constraint or an obstacle to overcome, gives endless possibilities to management and design to build new profits with social value. H.D. is a key to business innovation and growth.

The authors have selected two examples of Design Driven Social Innovation in diverse business areas, where sustainability is cool and profitable.

3.1 Self-image Business: The Development of the Fashion Industry's Perfect Package

Art, fashion, beauty and economy cultures, throughout centuries, have identified and followed different specific types (mostly female) defining historical trends. Within each trend, features to be considered as beautiful and agreeable were set: culture, ethnicity, age, body type, weight, facial features, behaviour, hobbies/activities, occupation, etc. represented the perfect package. Human diversity was not in the list, therefore self-image has been something to standardized, external and perfect to aspire to and to change oneself for in the process to achieve it. Throughout the XX century "the perfect package" and its implications have been variously evaluated thus changing societies' perceptions and opinions about it.

In recent years Fashion has taken a huge leap on body type, weight, ethnicity and other, both through product's innovation and promotion campaigns: the fashion industries, small and big, have spotted the great business potential in embracing human diversity and designing for it.

For women of all generations is therefore becoming increasingly easier to feel satisfied with their own selves also through the offer of an industry which is answering to and respecting the vast diversity of their clients' necessities, abilities and aspirations.

The authors have chosen among the many, some examples where the core activity is about product innovation for human diversity, more then solely H.D. portrayed in promotion and adv (Disegual, Gucci, Diesel, etc.).

Starting through its Italian Issue directed by Franca Sozzani (1988–2016), the influential and iconic magazine Vogue has actively embrace human diversity as a core, varying from ethnicity to body type and weight. Vogue Italia launched: in July 2008 Vogue Black, an issue featuring all black models; in February 2010 its spin off Vogue Curvy Label *VCurvy by Vogue,* fashion for women with shapely bodies, curvy models and the news from plus-size icons, according to Sozzani statement, "a channel where you may find out that a size 16 makes you happier than a size 0, and where having curves equals to being sexy and self-confident,"; in June 2011 Vogue Italia cover featured three plus-size models; 2013 the Grammy Curvy; in January 2013 Beautiful Curvy Calendar. Starting from 2014 also Vogue America and UK embrace curvy fashion through different actions. Both the social and business impact of Vogue is well known and documented.

The online retailer for women's Swimsuit for All llc., it's a body-positive swimwear brand specializing in sizes 8 and up. It sells boldly designed swimsuits for a wide range of body types, ages and ethnicities. *Swimsuit for All* have pushed boundaries of body diversity's perception through slogans as: "Confident curves. Rock your bikini body at any age or size." and tags as #swimsexy, inspire women to feel confident in their own body. Its products have been featured in Sports Illustrated Swimsuit issue getting also a cover, their models being the first curvy and the oldest to ever appear in it. *Swimsuit for All* has been founded in 2005 by current CEO and President Moshe Laniado, acquired in October 2014 by New York-based plus size fashion company, Fullbeauty Brands.

3.2 Design for All: When Excellence in Design for H.D. Transforms a Feature for Disability in Performance and Trend for All

The vast majority of aids for impairment used to have little design qualities, suffered from a distorted 'medical approach', narrow minded features' strategies, and so on, ending up in non-scalable and undesirable solutions responsible for social stigmatization and little market success.

In recent years the spreading of Design for All culture changed the strategic design and business approach in various functional areas.

Eone represents an excellent example of this new trend. Watches for visually impaired people are usually unappealing and uncomfortable for people who are not specifically trained. In 2012 on Kickstarter, Eone launches a campaign with a very noticeable design watch, original, designed for everyone, including the blind. The concept was an immediate success. 3800 contributors supported the project, representing an investment over 594 thousand dollars. After months of collaboration with blinds, Eone clearly identified the sake of discretion and the desire to not draw the attention on their disability. The talking watches did absolutely not respond to this issue. Eone decided to create Braille watches. With two balls, easily detectable with a simple touch, the new watches allow a clear, fast and discreet reading. The first line of watches pays tribute to Brad Snyder with the Bradley collection.[3]

In 2015, the Eone Bradley watches won the coveted awards from Red Dot Design Award and the Design Basis 77. In 2014, Eone was nominated for the Design Museum's Design of the Year Award and was awarded the Da Vinci price. Bradley watches are permanently exhibited at the British Museum.

As many other companies, Eone commits in CSR and CMR; specifically it donates a portion of its sales to the guide dog association "The Seeing Eye", makes significant contributions in order to improve Blind living, pursues sustainable practices and products.

Not so commonly, Eone Timepieces, which declares to "create a world that is more beautiful, equitable, and sustainable for everyone", it is a for profit that has been created on a product conceived for social impact and sustainable development.

4 Designing the Next Step: Data and Methods

A goal of our research is to conduct an exploratory analysis on the perceptions towards the added value determined by the capacity of a company of being at the same time, inclusive and innovative in its design. By interviewing experts in the area (mainly CEO and managers from companies with a design-driven social innovation capacity), we expect to individuate key measurable outcomes to successively build an indicator. This indicator will signal a company's ability to design for human diversity, strive for social innovation and make a positive social impact. We also expect that this indicator will be used independently, or just added to other measurement methods.

From the understanding of the existing social footprint definitions and the business cases presented, we designed a set of questions to explore with the target the possibilities to meet social needs using profitable business models. We built an online questionnaire with Survey Monkey. We expect our respondents to be businesspersons or individuals with diverse business experience. Sample units will be selected according to the following criteria: (i) the company they work for includes principles of diversity in its production system; (ii) the company invests in design driven innovation focusing of social sustainable development and economical growth (iii) the company already respects some principles or ethical standards. This last criterion has, however, to be intended in a loose way, it is a necessary but not sufficient for inclusion in the sample.

The questionnaire includes 22 questions, most of which were open. A detailed list of the content is reported in Table 1.

The first batch of questions asked respondents what they intended with social innovation, sustainable development, and ethical business. The goal of this part is to identify common keywords and spontaneous opinions towards the key elements of this research.

The second group of questions ask respondents their insights about current changes in social innovation and inclusion of human diversity in the design phase.

[3] Brad, former lieutenant, lost his sight in Afghanistan. Determined to pursue an active life, Brad won two gold medals in swimming at the Paralympic Games in London in 2012, only one year after the terrible accident: an inspiration for visually impaired people.

The third group of questions finally focus more on the economic opportunity that results from a business model that encompasses human diversity, social innovation in the design and principles of ethical business. This last group of questions also asks about perceived challenges. The questionnaire is available at https://www.surveymonkey.com/r/social_footprint.

All respondents will be asked to give their personal consent before completing the survey (Question 1).

Table 1. Questionnaire

Questions
Your answers will be kept confidential and will be used only in an aggregated form for academic research. Do you agree to participate?
In your opinion, what is "social innovation"? (Feel free to answer in English or Italian)
In your opinion, what is "sustainable development"?
And "ethical business"?
Do you believe that the meaning of social innovation is changing nowadays? In particular, in light of new consumer needs or technological progress
What type of social innovation do you think has the most significant impact on sustainable development?
Do you consider human diversity in your business choices? For example, if you have a restaurant, human diversity means that your menu includes kosher foods of choices for people suffering from celiac disease
Do you believe there is an economic opportunity in following principles of ethical business?
Do you believe there is an economic opportunity coming from the integration of human diversity in the design of your products or services?
Do you believe there is an economic opportunity in investing in innovation?
What are the main challenges coming from the adoption of ethical business and sustainable development?
What are the main challenges coming from the integration of human diversity in the design of your products or services?
What are the main challenges coming from investing in innovation?
How likely do you think that producing ethically gives you an advantage over your main competitors?
How likely do you think that taking into consideration the human diversity in the design of your products and servcies gives you an advantage over your main competitors?
How likely do you think that investing in innovation gives you an advantage over your main competitors?
Nowadays, how difficult/easy is to create new products with an added value?
How was your business originated?
Can you please tell us a little about your business idea? In particular, where did the original idea come from? For example, if you have a restaurant, did some clients with special needs ask you for more variety? Or did you just wanted to target new customers?

5 Conclusions

The authors believe that DfA has demonstrably a great business potentiality, building competitive advantages and defining suitable blue ocean strategies: an indicator of its impact in businesses and society could help a broader awareness and implementation of DfA, thus catering for a positive sustainable development.

Michal Porter, defining the next evolution in capitalism, introduces the concept of CSV (creating shared value) as one which should supersede CSR. He identifies three key ways that companies can create shared value opportunities: by reconceiving products and markets, by redefining productivity in the value chain and by enabling local cluster development.

“The concept of shared value can be defined as policies and operating practices that enhance the competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates. […] expanding the connections between societal and economic progress. The concept rests on the premise that both economic and social progress must be addressed using value principles. Value is defined as benefits relative to costs, not just benefits alone. Value creation is an idea that has long been recognized in business, where profit is revenues earned from customers minus the costs incurred. However, businesses have rarely approached societal issues from a value perspective but have treated them as peripheral matters. This has obscured the connections between economic and social concerns. In the social sector, thinking in value terms is even less common. Social organizations and government entities often see success solely in terms of the benefits achieved or the money expended. As governments and NGOs begin to think more in value terms, their interest in collaborating with business will inevitably grow” [14].

The authors belief is that there lie great opportunities for positive growth and development in companies which use design driven social innovation to create profit through core businesses and strategies (product and services) which aim is social impact. From this perspective, the understanding of Human Diversity and the aware exploitation of its richness are key factors for success. This can be achieved in both newly created businesses (like Eone) and established ones who can start some activities in the area (as Google, IBM, Intel, Johnson & Johnson).

Real social entrepreneurship should be measured by its ability to create shared value, not just social benefit [14].

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Graphic Design of Interactive Tools for People with Autistic Spectrum Disorders

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Abstract. Recent statistics from Disease Control and Prevention (CDC) stats that about 1 in 68 or 1.5% of 8-year-old children were identified with Autism Spectrum Disorder (ASD) in the United States. Initiatives with innovative and inclusive perspectives contribute to a better understanding of the disorder, in this perspective this work presents the proposal of an ergonomic and inclusive study for the creation of a graphical environment for an educational interactive application for children with ASD, in order to help them in the identification of facial expressions and the feeling that surrounds them, aiming the improvement in their social interaction with human being.

Keywords: Autism Spectrum Disorder · Social inclusion
Graphic environment · Universal design

1 Introduction

People experience difficulties in interacting with the world, and even essential core activities can become an obstacle due to the absence of an action that includes them as participants in society. In a survey conducted by the US Center of Disease Control and Prevention in 2016, autism can be in 1.5% of 8-year-old children. Autism spectrum disorder is a developmental disability that occurs in early childhood and persists with the person in the course of their life. It was observed the need of the development of tools that allow better understanding of students equally. Inclusive design gained strength when society saw itself with the need to implement inclusive practices. In this context, the elaboration of tools that allow better access or improvement of certain activities, becomes of the utmost importance for an inclusive education.

This paper presents the development of a graphic environment for an educational interactive application aimed at children with Autism Spectrum Disorder (ASD), in order to contribute to the expansion of possibilities in the teaching learning process, regarding the recognition of facial expressions that represent emotions and feelings. The work will contribute to the creation of a digital interactive application with the objective of favoring and stimulating the child's attention to the meaning of facial expressions and their relation to feelings, in order to facilitate inclusion through interaction with the people that surround them, from an application that is a tool that arouses interest and maintains the user's attention.

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2 Objective

The overall objective of this project is to develop the graphical environment to an educational application designed for people with ASD in order to contribute to the expansion of possibilities in teaching learning process. With the study of the main principles of difficulties people with ASD and disorders presented by them and the study of the critical aspects involving the development of digital tools.

3 Methodology

The methodology is a systematic analysis with the application of questionnaires with parents of children with ASD. For the construction of the animations, graphic environment and the characters, we considered the difficulties of understanding pointed out and the suggestions of parents and guardians of the children. This information was associated with concepts of visual communication, game design and cognitive ergonomics. This process allowed the ergonomic evaluation of each element of the graphic environment from a study of the critical aspects that involve the development of digital tools.

4 Results

4.1 Characters

On the physical characteristics of the four characters developed, it was considered the miscegenation of the Brazilian people, besides providing a greater aesthetic diversity. The great variation of colors meets the intention to make the game more attractive visually and the intuitive character aims to maintain the concentration of the players. All characters wear the blue shirt because it is the color symbol of Autism Spectrum Disorder (Fig. 1).

Fig. 1. Characters developed.

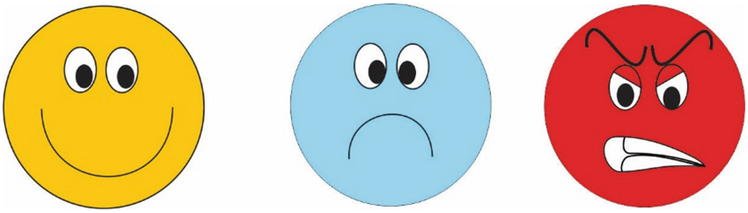

Fig. 2. Facials expressions.

4.2 Initial Interface

The initial interface of the game (Fig. 2) has an interactive and instinctive character. It uses several symbols and characteristic elements of Autism Spectrum Disorder, the puzzle and the colors. The target audience is expected to target children with the disorder, assisted by parents and guardians (Fig. 3).

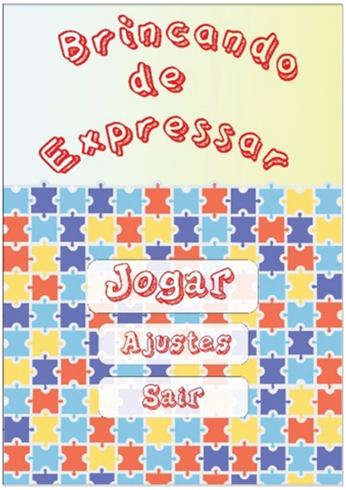

Fig. 3. Initial interface.

4.3 The Game - Association

The game tends to contribute in the recognition of the facial expressions that represent emotions and feelings. In the first phase, the player is presented with faces expressing four emotions: joy, sadness, fear and anger. The objective of the player is to bring the face with the facial expression to the corresponding box. By saving in the right box, you get stars. When placing in the wrong box, the face will return to the top of the screen, restarting the process. In this step the color association is also explored (Fig. 4).

4.4 The Game - Creation of Facial Expressions

In the second phase, the child is invited to assemble a face according to feeling, in this instance of example, happy. The face is assembled by choosing the parts of the face, that is, the color, the eyebrow, the eyes and the mouth. Making the child associate the elements of the face with the feelings present in the day-day (Figs. 5 and 6).

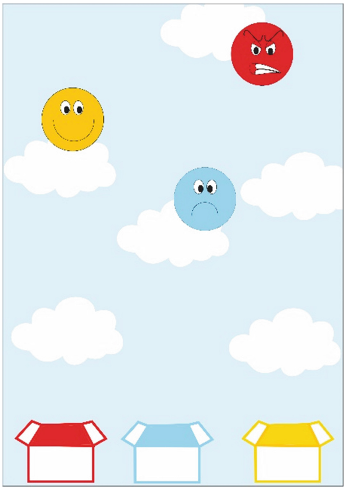

Fig. 4. Association of expressions.

Fig. 5. Creation of facial expression.

5 Discussion

In the process of realizing the project it was noted the importance of using the graphic environment and the game, we need even more tools that enable full learning. According to Silva et al. (2017), there are variations in the intensity of manifestation of

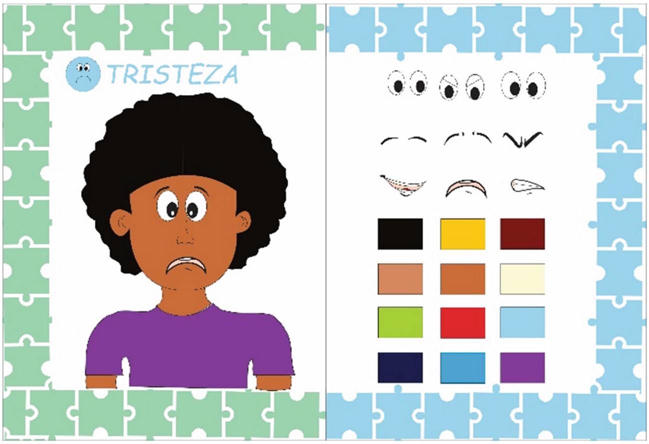

Fig. 6. Facial expression: sad.

symptoms, which means that some people may present behavioral excesses and others, deficits or even absence of behavioral repertoire.

The diagnosis, still imprecise, is not able to accurately state the incidence of the syndrome. Thus, because the causes of autism can not yet be genetically asserted, a diagnosis based on the patient's observation (which usually presents symptoms such as communication difficulties and repetitive behaviour) is used. Thus, the detection of symptoms is not easy, since they vary from person to person, which makes it difficult to target the tool to a specific group, since the comprehension and reception of the information are related to the age, the degree of the disorder and to the individual repertoire. Then research related to the area is of admissible and proficient character. Given that an accessible environment is one that makes it possible to welcome everyone by generating an inclusive society, it fosters social integration and promotes knowledge inside and outside of their daily lives.

6 Conclusion

The scientific merit of this project is the creation of means that contribute to the well-being of people with Autism Spectrum Disorder. In this context, universal design is of utmost importance in making changes in the physical and social structure to enable the independence of the person.

The use of digital tools contributes effectively using attractive models, concepts and technologies. In addition, the activities carried out with the use of applications favour the provision of visual cues, in contrast to the activities developed with the use of paper and pencil, a tool widely explored in the education of people with ASD. Visual cues are considered fundamental strategies for learning in this context.

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Use of the Functional State Simulator of the Elderly Adult to Identify Requirements for the Design of Food Containers

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Abstract. The mass consumption products such as food packaging are designed for people without physical and cognitive limitations, becoming barriers for the elderly who present functional conditions associated with the aging process. The main problems are: (i) the decrease in force that hinders the opening of the containers, (ii) the visual limitations that prevent the reading information on the labels, (iii) the loss of fine motor skills that impossible an optimal grip, (iv) the lack of memory that generates bad brand recall, among other difficulties. Taking into account the little information that there is on the subject from the design, and the gap between what is found in the literature and the student's experience, in terms of language complexity, approaches, analysis methodologies, etc.; was proposed since 2016 within the line of research in Ergonomics of the Industrial Design at Universidad Pontificia Bolivariana (UPB) in Medellin, the design of a simulator that replicates the functional states of the older adult (sight, hearing, fine motor, posture and walking), allowing the user to understand the built environment by students from project areas who are interested in product development destined to this market. Given the above, the objective of this article is to identify the requirements and design specifications of food packaging aimed at the elderly, implementing the set of functional state simulators, to generate designs with formal, functional, chromatic, communicative and productive adaptive characteristics to the needs of this user.

Keywords: Food containers · Design · Requirements · Simulator
Functional states · Older adult · Food packaging

1 Introduction

Some of the methodologies used to characterize the user are based on traditional learning strategies. This traditional conception of learning is known for sharing parallel knowledge about real life, in this case, about the aging processes and their relation to object and spaces.

In the world, the population of adults older than 65 years old is increasing at an accelerated rate, estimating 650 million people on average. According to the National Institute of Aging [1], it is estimated that this figure will triple by the year 2050,

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reaching 2000 million people more than 60 years old, that is 24% of the overall population.

Associated to the aging process, illnesses that limit the basic functions when to work on daily life tasks arise; diseases as Parkinson, arthritis, cognitive deterioration and visual decline, are common in people that belong to this population and all of them affect the capacity to interact with specific everyday objects [2].

Nowadays it is evident in some products – especially those of mass consumption, everyday use and urban-architectonic places – the lack of adaptation they have to the needs of older people – between 65 and 90 years old. This, being a serious problem from usability, for they become non-efficient activities, causing disabling environments that could become harmful for them. Despite all this, designers have not taken enough of this market niche into account, isolating themselves from this issue that affects the community, not only nationally but also, internationally. This occurs due to the same misconception of a design that is applied under optimal terms of use, framed in a user without severe physical limitations, thus creating a more commercial instead of social design.

From this perspective, there is a need to make progress in research around the elderly as users/consumers and to incorporate concepts such as accessibility, universal design and usability in packaging design, so they are friendly, not only for older people but also for the diversely functional individuals, but for the overall population in equal conditions [3]. Even though old age has different perspectives from the biological, psychic, social and phenomenological aspects, it is a process that is difficult to perceive if one is not in the place of the older adult. That is why, through the use of a corporal simulation experience, the quality of the student's learning process is accelerated and improved while being integrated, in a systematic and organized way, into each teacher's pedagogical models [4].

From the previous premise and taking into account the lack of information on this topic, and the gap between what is found in the literature review and the student's experience in terms of language complexity, focus, analysis methodologies, etc., a project was proposed in 2015 at Universidad Pontificia Bolivariana (UPB) in Medellin, within the ERGO research centre of the Faculty of Industrial Design. Said project was called "Simulated bodies of functional states of the elderly".

For the previously mentioned project, the following research question was suggested: How should the designer know and understand the needs of the elderly? To answer this, it was inferred that it was necessary to try walking in their shoes, that is to SIMULATE said human activity, defining this term as "The process of designing a real system model and make experiments with it so be able to understand its behavior" [5].

In this sense, using wearable technology to simulate the body experience of the elderly –specifically fine motor skills–, the student is located in a context that reproduces any aspect of reality and establishes, in that environment, situations, activities and/or issues similar to the real conditions. The aim is to compile the necessary design requirements to develop accessible and usable packaging specifically for the elderly, taking into account the functional and operative factor that are needed for the inclusive products development.

2 Background

During the interaction between the elderly and a container, usability problems arise due to the lack of adaptation the product has towards the abilities and functional limitations of the user. Studies conducted in Great Britain, reported that, in 2003, approximately 49.000 elderly people had accidents while handling any type of mass consumption packaging, and 35% of them had to undergo some kind of hospital treatment models [6]. In the United States, several problems associated with the use of containers were registered in various investigations, but one of the most notorious was Doyle, who reported widespread complains about the low performance and the difficulty in the use of the containers, thus, identifying the need to integrate design criteria that will facilitate the container's use (before and after being opened) [7].

In Latin America, countries such as Argentina and Brazil are conducting research about the same subject, framing the study carried out by Universidad de Buenos Aires [8] which detected the presence of a stronger effort in the upper limbs (hand-arm) when opening very tight lids. In addition, the low visual communication that the user has with the product, due to the legibility of the labels, is considered a key factor by understanding this population has visual limitations. In the same way, studies are conducted in Brazil, where the evidence shows a great difference in the container's opening process, forcing the user to use auxiliary means, such as cloths and sharp objects (knives, drills, etc.), which results in high possibilities of risks to the user [9].

It can be concluded that there is a strong relation between the functional limitations and the problems regarding the opening of the containers. The formal, functional, chromatic, informational and material characteristics experiment tension with those physical and cognitive aspects, which results in having the container design becoming an obstacle in getting the purpose of use, i.e., the access to content.

3 Methodology

The elderly belonging to the third and fourth age, face different difficulties while performing daily activities, mainly, when they get in contact with the objects used in these tasks. This triggers the use of alternate methods that can be dangerous and counter-productive if we take into account how some users suffer from diseases that modify their fine and gross motor skills.

This project focuses on the elderly's hand, considering that it is the body part that is linked to the process of manipulation, grip, opening and closing of a container. Additionally, associated diseases such as arthritis, loss of muscle tone, bone and nerve deterioration, among others will be considered. From this information, we propose the design of a simulator that allows the designer to experiment some of the gross and fine motor skills limitations related to the aging process, with the aim of designing accessible and usable containers while being in the user's position. To accomplish this, it was necessary to identify the anatomy and bio mechanism of said body segment finding different movements that are measured by permissible degrees or ranks, which position the wrist (clamp, fist) to grasp and hold different elements (extension, abduction and flexion) [10].

3.1 Fine Motor Skills Simulator Design

The objective of the fine motor skills simulator was to replicate rheumatoid arthritis at the highest possible level of affection, as long as it does not affect the joints and bio mechanics of the user who will interact with the system. According to experts, arthritis is an autoimmune disease and causes the inflammation of the joints caused by and alteration of the synovial membrane, which is the layer that covers the whole joint and allows movement to be made thanks to the synovial fluid.

Other diseases, such as arthritis, osteoporosis and tendinitis, will be simulated through movement impairment from the hands and the sudden system deterioration in the joints. Diseases linked to the loss of fine motor skills make it difficult for older adults to interact with products such as food or medicine containers.

The simulator has a glove-like structure, made from a non-elastic fabric, sewn with elastic thread. The glove has layers of fabric covered in foam, located in such a way that the forces go where they are needed, to generate a better simulation. The purpose is to seek a better adaptability from the glove, the hand, and the forces that generate from its movement.

This system uses elastic properties and the vector force of the fabric to produce counter-forces to the user's movement, reducing the force and precision of the movements, simulating loss of muscle mass. This glove also restricts the joints by applying compression force on them and limiting their movement range to simulate the usual discomfort of arthritis. The glove's shape is very consistent to the hand shape, thus avoiding the ridge that usually remains at the fingertips and expanding wrist support using Velcro and a double union that better adjusts to the hand, making it more comfortable and adaptable (See Fig. 1).

Fig. 1. Fine motor skills simulator model (Research process result. UPB students, 2017)

3.2 Simulator Reliability Tests

To get more accurate results, guides –ribbon forming a straight line and a dot– were used from the camera and background, used as reference point to position the knuckles. The following are the findings that suggest system liability: While performing the thumb abduction movement, the glove reduced its mobility in 31°, which represents 50% less mobility overall (See Fig. 2). Regarding the extension of the thumb, the glove reduced its mobility in 8°, which represents 36% less mobility overall, while the index and ring fingers had a bigger decrease in movement (24% and 42% respectively).

Concerning the index finger's flexion, there was also a noticeable decrease in mobility of 21°, corresponding to 33%. At the same time, the heart finger's mobility went down to 3° (6%). The ring finger had a bigger mobility loss, 14%.

4 Results

4.1 Containers Testing: Elderly People

When selecting the type of cover to be used, the screw cap was chosen from over the lid with aluminum foil in it, for the results of the research suggested that this particular kind of lid brings more problems to the table when it is time to be used by the elderly. In addition, it was possible to make much more interesting and verifiable morphological interventions (see Fig. 2).

At the same time, the tetrabrik square 1 L box from Alquería was chosen, for this product belongs to the basic family shopping needs being a mass consumption element. This way it was possible to create a project that would be more useful for the public, especially the elderly.

Fig. 2. Selection container

The functional analysis is related with the contain the liquid product, the transfer the liquid product during the different stages of storage transport and use, the information to product and the protection from light and heat. The package body is shaped as a rectangle with a square base and has a structural component that help with rigidity and lightness in weight in the body. It has a "sandwich" of polyethylene, cardboard and aluminium which give the package structure and isolation.

TEST 1. Fingerprint Mapping and Percentage of Contact with the Surface
The aim is to determine the issues that arise when handling the screw-type lids in the TETRA BRIK containers. It is important to understand users as adults belonging to the

elderly community, in order to also create an evaluation of positive aspects present in other elements of the same segment, which could eventually foster the development of a new product or a significant improvement of the existing one.

The test sought to identify the effort perception in the manipulation of the different lids of different kinds of packages of products in the basic family shopping needs. This to define positive and negative aspects to enrich the lid´s re-design process, and also the test sought to identify the fingertip map left by placing the fingers on the lid when manipulating it (see Fig. 3).

Fig. 3. Perception and grip test/fingertip mapping test (Research Project – ERGO 2017)

The aim is to measure the following quantitative and qualitative variables to: (i) determine whether the participant's grip is very good, good, fair, bad or very bad in terms of function, (ii) regulate if the user experienced any pain or fatigue while manipulating the lid, giving it a score from 1 to 5 (1 being no pain or fatigue and 5 being strong pain or fatigue), (iii) analyse the degree of effort and difficulty experienced by the participant when manipulating the lid, (iv) define the measurement of the fingertip mapping in cm, also identifying width and length, (v) decide the contact zone percentage between the lid and the user's fingertips, (vi) regulate the fingers distribution on the lid's Surface, in terms of measurements, centimetres and angles, and (vii) the following chart shows the measurements related to height and width in the fingertip maps, as a result of the tests, where participants had to grab the lids of the specific containers. It is possible to determine the thumb and the index finger's measurements. Last, the weighted measurements of the 4 participants and the 8 containers are shown, along with the contact zone figures (see Tables 1 and 2).

TEST 2. Usability

With the diameter, height, ripples, relation lid-user, effort perception was identified during the opening of the container and the comfort of the grip. Overall, 8 different kinds of containers that are studied, only two of them are shown in the following chart for comparison purposes (see Fig. 4, Tables 3 and 4). It is worth mentioning that the final results do take the 8 cases into account (See Fig. 5).

Table 1. Thumb fingerprints chart (measurements in cm)

Container number	Variable	Participant 1	Participant 2	Participant 3	Participant 4	Weighted measurement	Fingerprint area
1	Width	4,3	2,9	2,2	3,5	3,22	3.22 cm2
D 2,5	Height	1	1	1	1	1	
2	Width	3	3,5	2,1	3,9	3,12	3,28 cm2
D 3,1	Height	1,05	1,05	1,05	1,05	1,05	
3	Width	5,2	3,5	2.4	4,1	3,8	3.8 cm2
D 2,8	Height	1	1	1	1	1	
4	Width	3,8	2,8	2,3	2,7	2,9	2.32 cm2
D 2,4	Height	0,8	0,8	0,8	0,8	0,8	
5	Width	6,6	3,8	2,6	2,5	3,87	4,6 cm2
D 3,4	Height	1,2	1,2	1,2	1,2	1,2	
6	Width	4	3,5	3,1	2,5	3,27	4,9 cm2
D 3,3	Height	1,5	1,5	1,5	1,5	1,5	
7	Width	6,2	4	2,7	2,8	3,92	4,3 cm2
D3,9	Height	1,1	1,1	1,1	1,1	1,1	
8	Width	3,7	4,1	2.6	2,5	3,22	3,22cm2
D 3	Height	1	1	1	1	1	

Red Smaller contact area, and Blue: Bigger contact area (Research Project result - UPB)

Table 2. Thumb and index fingers weighted areas comparative chart

Container number	Thumb area	Index area	Total area	Side container area	Percentage of lid contact
1	3.22 cm2	2.27 cm2	5,49 cm2	9,81 cm2	55.96%
2	3,28 cm2	2,73 cm2	6,01 cm2	15,08 cm2	39.85%
3	3.8 cm2	2,72 cm2	6.52 cm2	12.31 cm2	52.96%
4	2.32 cm2	2,06 cm2	4.38 cm2	7.24 cm2	60.48%
5	4,6 cm2	3.84 cm2	8.44 cm2	21.78 cm2	39.84%
6	4,9 cm2	5,32 cm2	10.22 cm2	22.75 cm2	44.92%
7	4,3 cm2	3,79 cm2	8.09 cm2	26.28 cm2	30.78%
8	3,22cm2	3.72 cm2	6,94 cm2	14.13 cm2	49.11%

Red Smaller contact area, and Blue: Bigger contact area (Research Project result - UPB)

a) b)

Fig. 4. Some containers studied a) Tetra Brik Alquería b) Luki juice (Research Project -UPB)

Table 3. Analysis Tetra Brik Alquería

Tetra Brik Alquería		
Aspect	Effort perception	Grip comfort
Diameter	It was observed how a greater effort was required because of the reduced diameter, which translates into less of a contact area	Some problems regarding the firmness of the grip were shown, but the side grip was kept. Here, the base and thumb made contact in the base of the thumb and the side of the index finger
Height	Reduced height was evidenced in relation to the fingers' surface that was in contact. In one of the cases the finger slipped because of the applied force	The height allowed for the configuration of the grip, even if by its reduced measure, its firmness and intensity was engaged during the opening process. The thumb's base and the side index finger surface were in contact
Ripples	It was observed how the lid's pattern did not help much to maximize the opening force, for it triggered the grip to slip and difficulty to manipulate in one of the cases	There was a low degree of friction in relation to the lid's surface. That is why in one of the cases, the grip slipped, even though it wasn't problematic
Lid's diameter-body diameter relation	It was possible to identify how the lid's diameter and the body's diameter was not as good, for the lid's diameter is much smaller than the body's diameter, thus registering greater effort when manipulating it	It was found that both grips are guaranteed because of the measurements and the square geometry of the body provides a better mooring and a stronger grip when opening the lid

Research Project - UPB

TEST 3. Required Force to Open the Container

To determine the issues that arise when handing the screw-type lids in the Tetra Brik containers. It is important to understand users as adults belonging to the elderly community. In order to also create an evaluation of positive aspects present in other elements of the same segment, which could eventually foster the development of a new product or a significant improvement of the existing one.

Table 4. Analysis Luki Juice

Luki Juice container		
Aspect	Effort perception	Grip comfort
Diameter	It was observed how less effort was required because of the bigger diameter, which translates into more of a contact area	Because of the contact diameter, it was possible to guarantee better firmness in the grip, resulting in an easier manipulation. The base of the thumb and the side index finger Surface were in contact
Height	Great height was evidenced in relation to the other lids, which is why the contact zone was bigger and allowed the effort perception to be less. Even if it was not a completely flat Surface, the height was very appropriate	The height allowed the grip to be set and firmly kept it during the opening of the lid, for there was a bigger contact area. The base of the thumb and the side index finger surface were in contact
Ripples	It was observed how the lid's pattern, located on each side of the pentagon, was very good, for it is very well marked making for a better mooring	It was observed how the ripples pattern and the hexagonal lid shape, made for a good configuration
Lid's diameter-body diameter relation	With this particular lid, some issues were found, for the body was not completely firm and its manipulation was difficult, thus translating into a greater effort when opening the lid	It was observed how, from its hexagonal morphology, the fingers fit perfectly, identifying 3 sides that were in contact with the thumb and the index. Regarding the body's grip, as it was not firm itself, there was a difficult relation, where the pliers grip in top of the body made it difficult to get the lid when trying to open it

Research Project - UPB

Four Tetra Brik Alquería packages were tested to determine the necessary force to break the lid's seals and be able to open the package. For this test, we used a metallic device that goes around the lid to be able to use a dynamometer to qualitatively measure the maximum force needed to break the security seals (Table 5).

4.2 Detail Design

The relation between the lid's diameter and the body's diameter is very important when rating the effort needed to open the container. As we could see, the lids that had a diameter which was more similar to the body, facilitated a better grip and optimized the effort making it easier to pen the containers. Also, the biggest diameters allowed for a more optimal grip maximizing the effort.

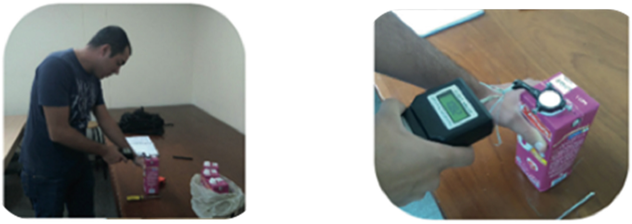

Fig. 5. Required force to open the container

Table 5. Design specifications of food packaging

Needs	Requirements	Measurement	Demand/Desire	Aesthetic communicative	Functional operative	Morpho-productive
Adaptable to fingers width	Appropriate height to manipulate	15 mm height	Demand		x	
Optimization of manipulation at the moment of the grip	Appropriate diameter for grip	39 mm diameter	Demand		x	
Material that guarantees light weight and productive viability	The lid must be made by the same kind of polymer used in other lids of the tetra pack brand	High density polyethylene	Demand			x
Side elements to favor friction	The lid must have ripples on the side to favor friction when manipulating it	1 mm wide × 0.4 mm Deep ripples, with a separation of 2.5 mm from each other	Demand		x	
Risk-free for the user	Curved edges		Desire		x	
Visually noticeable and pleasant	Matt and smooth Surface with a good finishing		Desire	x		
Use facilitating morphology	Morphology that maximizes the effort put into its manipulation	Hexagonal morphology	Demand		x	
Internal diameter to adapt to the original lids for Tetra Brik	Same diameter as original tetra brik lids	Internal diameter of 24 mm	Demand			x

Research Project - UPB

Height plays an important role, for the smallest lids (as the one from Alquería or Colanta) do not allow for a firm grip, causing the force to not be concentrated on the lid.

The body's geometry is another important aspect when analysing the ability to open the lid and how firm the grip would be. As we could see, the bodies with square geometrical shape allow for a firmer grip and better moorings and support, so when opening the lid, there is a greater force in this area. Even though the grip tends to be good, cylindrical elements have the risk of making the hand slip and reduce the applied force to the lid (see Figs. 6 and 7).

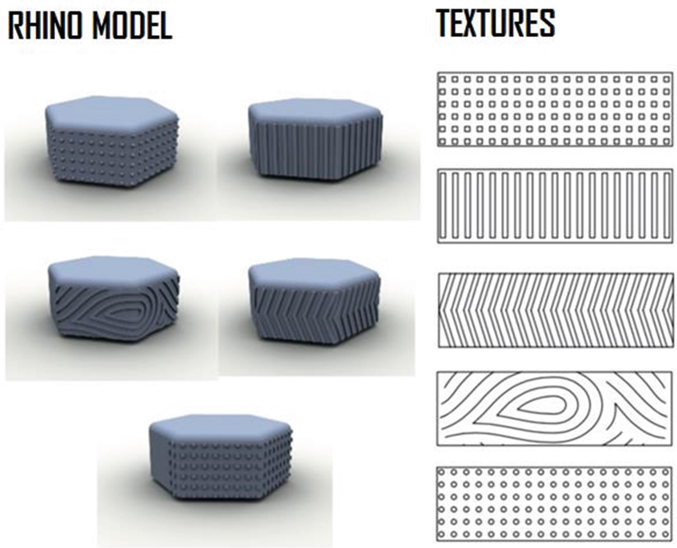

Fig. 6. Rhino model and textures (Research Project - UPB)

Fig. 7. Prototype (Research Project - UPB)

5 Conclusions

When simulating and feeling the user's body experience on first hand, the student gets to better internalize knowledge. The theoretical information lays foundation and complements the design process in a good way, but the practical and experimental component holds elements that slip away from literature. A good product demonstrates that it knows the user well when, in its composition and operation, satisfies their needs, is efficient and exceeds the expectations of the user experience. It is a complementary tool that help fill gaps in a project's approach; also, because the empathic work creates meaningful learning. As stated by Fingerman, about simulation, "It is a technique that produces a great degree of motivation and active participation form the student. It develops skills and abilities, stimulates the critical energy, allows for a visualization of the consequences of their actions, and applies practically the theoretical knowledge" [11].

Therefore, this Project sees to finish the simulators system for the elderly and, through its use, progress on the inclusion of the elderly in the design requirements of a product. It seeks to widen the concept of simulation to other different status of men, such as reduced mobility, pregnancy and other pathologies that affect people whose environment must address their abilities and limitations.

The simulators become part of the support material for the ergonomics lab in the faculty, to which students will have Access to complete their design processes. In addition to the prototypes, a guide for the elderly and a user's manual will be created to complement the usability of the designed devices.

Regarding the containers design, specifically in the opening, it is concluded that: The ripples configuration is decisive. As we could see in Jugos HIT, the fact that they are deeper and have a greater distance from one another, facilitated the opening of the container and allows for a better grip. From the lid's morphology, we could see how LUKI's hexagonal shape was much better suited to the grip, for its sides were in contact with the fingers in an optimal way, making for a perfect traction. Despite the problem being the container's body, it was possible to see the relation between the lid and the grip, making the best relation compared to the other lids in the study.

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