

Universal Participatory Design: Achievements and Challenges

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Abstract— According to the principles of participatory design, a genuine democratic process requires effective participation of all affected people in the design process; this must include affected disabled users. However, user participation entails complex problems, which are aggravated by conditions of illiteracy and/or aging. This article presents the concept of Universal Participatory Design, a design philosophy and practice that aims to be inclusive during the design process, and which has a positive result for all. We first conducted a review of the literature to understand the limits of the relationships between participatory design and universal design. This paper then addresses some of the challenges to achieve Universal Participatory Design (UPD) by juxtaposing deficits observed in the literature with issues we experienced during two research projects. We discuss the key components of Participatory Design and its relationship to UPD, and establish a research agenda that aims to conceptualize and investigate participatory design with universal access. Our findings indicate the need for flexible design methods, adaptable artifacts, and positive designers' attitudes when encountering unexpected situations.

Keywords— *Universal Access · Participatory Design · Accessibility · Democracy in Design*

I. INTRODUCTION

Nowadays, everyone is a potential user of computer-based artifacts, including people with different backgrounds, skills, as well as disabilities [42]. On the Web, for instance, though the W3C argues that the Web's true potential is its universality, providing valuable guidelines regarding accessibility [48], disabled users hardly participate in design decisions regarding web systems or pages. Participatory Design (PD) can play a central role in promoting a genuinely democratic Web, but various challenges remain unsolved for promoting the effective participation of disabled users during design decisions.

Since its roots, PD presupposes democracy practices during the design process. A fully and ideal democratic space assumes that every human being should have the same opportunity to participate in decisions concerning his/her life [12]. Nevertheless, in reality, this right is always limited. According to the World Health Organization [49], more than 1 billion people have a disability (i.e., around 1 out of 7 has a disability).

The United Nations Convention on the Rights of Persons with Disabilities (CRPD) highlights the importance of the participation of People with Disabilities (PwD) in democratic processes. However, we still need to overcome several barriers to promote fully democratic participation, such as to provide access to public meetings, and to design proper voting booths. In addition, accessibility to information, which is vital for people to exercise an informed choice [49], requires deeper studies. The barriers for these people are aggravated by conditions of illiteracy and/or aging. The accessibility of information is also important for people with cognitive or learning disabilities.

Giving voice to PwD during democratic design processes also raises several research issues. This includes, for instance, strategies to conduct participatory activities that consider users with disabilities, and the ways in which to address vulnerable/excluded communities. The literature in the field of PD has increasingly given attention to PwD, the elderly, and socially excluded communities. For instance, the 2016 edition of the Participatory Design Conference (PDC) has a larger number of papers addressing these themes than the sum of the 2014, 2012, 2010, and 2008 conferences. Although the literature presents proposals for connecting PD to Universal Design (UD), the existing studies are still preliminary and do not resolve the lack of techniques, and underlying theoretical questions. These studies focus on a specific disability or disadvantaged situation, but still lack discussions regarding conceptual aspects and barriers to promote an inclusive democratic process.

Persson *et al.* [36] argue that there are various approaches that focus on increasing accessibility to the widest possible range of users. Nevertheless, there is little (or no) consensus regarding the definition and use of concepts such as Design for All (DfA), UD, and Inclusive Design. The initial goal of the DfA movements refers to the design of products that can be used by the widest possible range of people. The UD concept has its roots in Maces' (an influent American architect of the 20th century) definition of the process of designing products and environments for people's needs, regardless of their age, ability, or status. The Inclusive Design concept, which is mostly used in the United Kingdom, frequently encompasses

the idea of including as many people as reasonably “possible”, on a global basis. In this article, we use the term UD interchangeably with the term DfA [45].

The core idea behind the concepts of UD and DfA is that of an equalitarian society for all. For instance, the Americans with Disabilities Act (ADA) prohibits discrimination and ensures equal opportunity for persons with disabilities. Aware that there may not exist a solution that suits all people in all possible situations, the DfA can be considered a “design philosophy” that aims to design for human diversity, social inclusion, and equal opportunities. According to Marenko and Brassett [30], designing becomes a form of theoretical-practical research process, where designing asserts itself as a tool that questions and investigates core issues. These can include technologies, social responsibility, and citizen participation.

This article introduces the Universal Participatory Design (UPD) concept. We argue that UPD can be understood as a design philosophy and practice that targets an inclusive design process for all. The result must be positive for all, by respecting human diversity, social inclusion, and equality during a democratic design process. In UPD, we assume that there is an aspect that is “new” during every design event. According to this perspective, design is a task related to freedom, with equal opportunities for participation despite the participants’ physical, mental, or social conditions. Therefore, the UPD should be accessible during the period of the project’s design and use, despite the users’ diversity, and situations and events related to difference.

From a practical point of view, UPD raises various open research problems including, for instance: (1) how to remove barriers so as to promote the effective participation of disabled users; (2) how to include older adults in the design process; and (3) how to promote democracy and equality during the design process.

We aim to analyze the conditions for a participatory and democratic design process, giving voice to all users, including those with disabilities. In order to do so, we investigate recent literature on the relationships between PD and UD. In addition to the literature review, this research contributes to the field by presenting two case studies to illustrate the challenges in promoting the UPD. Our results are based on designers’ reports and discussion regarding two research projects employing PD and UD, which were analyzed to identify the difficulties researchers’ faced.

The first project addresses the design of an “inclusive social network” using PD with digitally illiterate people [3]. The second one tackles the use of PD to study barriers deaf users face on the Web [16]. In both cases, the designers conducted several participatory workshops, and faced problems to include users in the design process. In this paper, we present the results of our discussions with the designers, including our interaction during workshops, interviews, and meetings. The collected data was structured and analyzed with the “semiotics lens” by using the Semiotic Framework, an artifact from the Organization Semiotics (OS) discipline [25, 26, 44]. This framework allowed for us to elicit and categorize the solutions and challenges into six layers of signs: physical, empiric,

syntactic, semantic, pragmatic, and social. Our objective was not to produce a “framework” for UPD, but to underline the challenges, and ways of coping with them, aiming to bring to light relevant aspects of the UPD.

Based on our findings from the literature review, and the analysis of real case studies, this article raises open research questions regarding how to reach UPD. This includes reflections about theoretical issues, as well as about further investigations required regarding methods and design practices for promoting the participation “of all” in the design. Our key contribution is a theoretically informed analysis that clarifies and exemplifies the UPD via the case studies, pointing to solutions and open research issues regarding UPD in practice.

The remainder of the paper is organized as follows: Section 2 outlines recent literature on PD that addresses UD concepts, and recent literature on UD that adopts PD concepts; Section 3 describes and analyzes two case studies; Section 4 discusses the findings revealed by the literature analysis and by our empirical studies, organizing the demands for rethinking four key components necessary to transform PD into UPD. We argue that some steps are needed to obtain PD for (and with) universal access. Finally, Section 5 concludes the article.

II. UNDERSTANDING CONNECTIONS BETWEEN PARTICIPATORY DESIGN AND UNIVERSAL ACCESS

Several researchers in both fields of PD and UD advocate for user participation in design. Aiming to identify recent literature that studied UD issues in the PD community, we started our analysis (Section II.A) by systematically (one by one) reviewing the last 5 editions (10 years) of procedures from the Participatory Design Conference (PDC). Then, we analyzed (Section II.B) papers in the last 5 volumes/years of the International Journal of Universal Access in the Information Society (UAIS), a typical UD publication, looking for recent investigations studying or applying PD to promote UD. We then analyzed (Section II.C) papers in the last 5 volumes/years of the ACM Transactions on Computer-Human Interaction (TOCHI), looking for investigations that deal with typical UD issues. The review was limited to five editions due to the lower number of papers related to the studied topics in the older editions of the publication (considering an analysis based on titles). Section II.D summarizes and discusses the main findings of our literature review.

The objective of this section is not to present a comprehensive mapping of all PD and UD in all areas of the literature; we rather intend to analyze how PD and UD are addressed by typical publications in the PD, UD, and HCI research fields. Thus, we adopted an analysis procedure, which can be briefly summarized as follows:

- The full papers’ title, abstract, and keywords were read in pairs and selected for full text reading according to the following criteria: (a) we searched for references to UD in PDC papers; (b) we searched for PD in UAIS papers; and (c) we searched for UD and PD in TOCHI papers.
- After reading the full text of the selected papers, we wrote a brief report on the analyzed articles;

- The articles were selected in common agreement according to the following criteria:
 - a) *For PDC papers:* We selected studies present, as one of its main topics, a close relationship to UD. The articles that only mentioned UD issues or addressed secondary or indirect issues were not included in the analysis, *e.g.*, those focused on health care systems for disabled people, used and designed with healthcare professionals (not including patients in the design) ;
 - b) *For UAIS papers:* We selected studies that present, as one of its central topics, a close relationship to PD. The papers in which PD was secondary were excluded from our analysis, *e.g.*, those that cited the users' participation without presenting how it occurred, or those that reported on the users' participation in a very specific situation during the design process;
 - c) *For TOCHI papers:* We selected studies investigate, as their main topic, a close relationship to UD and/or PD. The articles that only mentioned UD issues, or addressed secondary or indirect issues, were not included in the analysis, *e.g.*, those that presented their design solutions as accessible without demonstrating the design process and evaluation in detail;
- We proceeded our analysis by organizing the papers into categories as follows: (a) PwD; (b) elderly people/older adults; and (c) excluded communities (or context-specific usability problems).

A. Analysis of the PDC Papers

We began our analysis of the publications focusing on PD; which provided us with a view of how UD is addressed within this community. PDC has existed for 30 years and has addressed a cohesive set of topics on PD. With the objective of identifying recent articles, we limited the review to the last 5 editions, *i.e.*, 10 years of publication on a biannual basis.

From the total of 79 full papers from the last 5 editions of PDC, we selected 8 papers that focused on UD issues. Fig. 1 presents the number of papers for each year (left side). As Fig. 1 shows, 6 of the papers were selected from the 2016 edition of PDC, which suggest the recent increase in interest in UD by the PD community. Considering the issues addressed in the selected papers (right side of Fig. 1), 1 paper emphasized elderly people/older adults; 2 papers reported on issues related to inclusive design of excluded communities; and, 5 papers focused on PwD, including 2 papers that highlight design with users with autism, 1 with dementia, 1 with mental disorders, and 1 with aphasia.

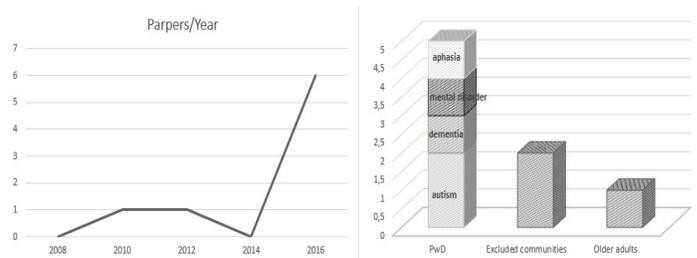


Fig. 1. PDC papers per year and issues addressed

Design concerning people with mental disorders is one of the challenges faced by PD studies. Kanstrup & Bertelsen [19], for instance, studied how to include people with mental disorders (*e.g.*, mild depression and anxiety) in situated PD, aiming to develop technologies that promote physical activities and identify locations for exercising. The paper proposed a set of participatory activities to engage users in design processes. It emphasized the importance of social aspects in inclusive participatory activities. According to the study, several participants had private concerns and bad experiences doing exercises in public. Similarly, Branco *et al.* [5] explored how PD can enable people with dementia, and their social circle, to co-design personalized strategies for communication. The authors emphasized the relevance of recognizing the uniqueness of each person with dementia. According to them, an individualized approach is required, “protecting the participants from anxiety and stressful situations, respecting their needs, and being aware of potential paternalistic attitudes”. The article also addressed the adoption of open artifacts in an open process (*i.e.*, left them open for personalization).

Makhaeva *et al.* [29] addressed the issue of design with autistic people. The authors aimed to create a creative conceptual space to enable the collaboration among participants and designers. The paper presents various difficulties and alternative solutions for creating conditions for autistic children to contribute in design. It emphasized the need to develop tailored processes with customized configuration in order to allow for meaningful participation and creativity. For instance, promoting flexibility when planning and conducting participatory work. The authors also highlighted the importance of a continuous balance between freedom and structure. Bossavit & Parsons [8] proposed a participatory design approach that involved teenagers on the autism disorder spectrum in the design of a serious game using natural user interfaces. The paper emphasized the importance of management and respect of the different types of expertise that each partner brings to the design team. The paper demonstrated the relevance of supporting students so that they can contribute in their own terms. The study also stressed the importance of being flexible and responsive during every stage of the design process.

Communication was pointed out as a key aspect in UPD. Leung *et al.* [24] examined the way communicative rationality and rational deliberation concepts are useful in designing game-like activities using design participation. The paper analyzed two inclusive design workshops to verify when and how designers should listen to the demands of those excluded

from design. They raised several aspects, such as the degree of autonomy in user's participation, and the designer's capacity to deal with the practitioners' requests. Galliers *et al.* [18] studied the inclusion of participants who lack language skills. The paper highlights that most of the PD techniques are not able to consider those who do not have language skills or use proxies (people playing the role of an aphasic participant). The study emphasized the importance of being flexible and responsive in the methods, recognizing that not everyone contributes in the same way.

Due to the fact that the population is aging, the inclusion of elderly people has appeared as a key aspect in PD. Leong & Robinsons [27] aimed to understand how ageing people decide to adopt and use particular technologies. The paper emphasized the need to consider elderly people's values in the design process. They proposed activities to support the emergence of values, and to understand how participants expressed and experienced their values concerning ageing. A key aspect was to not view this group as homogenous.

In addition, Agid [1] provided a reflexive analysis of design with a social justice organization. The paper proposed changes in designers' attitude in order to achieve more critical engagement. The paper further stressed the impossibility of the design being completely neutral during participatory relationships and actions.

The selected papers discussed several situations in which alternatives are needed to engage users during design, i.e., their objectives go beyond producing an accessible product. The papers addressed concerns regarding how to include the final users (with disability) in the design process. The studies highlighted the need for flexible methods, adequate artifacts, and adequate designers' attitudes.

B. Analysis of the UAIS Papers

The UAIS journal publishes studies concerning universal access and accessibility since 2001. Its issues have emphasized the design of inclusive interactions by including mobile accessibility, inclusive digital television, assistive environments, *etc.* In particular, we searched for articles that addressed PD topics. We limited our search of the literature to the last five years. Our analysis selected 6 articles on PD issues from a total of 190 full papers in 5 volumes of the UAIS journal.

Fig. 2 presents the number of papers for each year (left side). As seen, 1 paper was selected from the 2013 issues of UAIS, 3 papers from the 2014 issues, and 2 papers from 2015 ones. Considering the issues addressed in the papers (right side of Fig. 2), we selected: 1 paper that describes issues related to inclusive design in the context of country-specific issues; 2 papers that emphasize elderly people/older adults; and, 3 papers that focus on PwD, including 1 paper that deals with the issues of design with down syndrome users, 1 addressing users with dementia, and 1 addressing users with visual impairments.

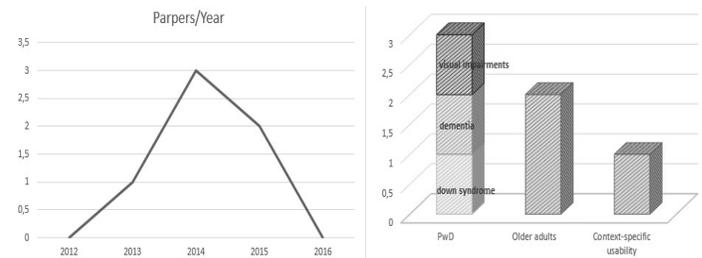


Fig. 2. UAIS papers per year and issues addressed

The design for users with visual impairments is a key aspect to be considered in universal and participatory design. Kim *et al.* [20] proposed a modified PD method for visually impaired people, which was applied in the development of haptic interfaces. Their study considered the user's involvement in the entire development process. They faced issues regarding how to reconsider visual-prototyping techniques for people with low vision during early design phases. The authors aimed to engage users with visual disability in the design of nonvisual interfaces to reflect user's needs. Design of haptic interfaces is only considered for users with visual disability.

Gonzalez *et al.* [22] investigated alternatives for improving an interactive digital whiteboard for Down Syndrome students. The study focused on alternatives that would aid the process of learning addition and subtraction operations. The authors discussed difficulties related to the use of PD techniques involving Down Syndrome students. They identified the design features necessary to guarantee accessibility for individuals with Down Syndrome via participatory approaches. Aryana *et al.* [2] focused on understanding the influence of country-specific characteristics on design. This study emphasized problems related to the smart phones' standard applications in Iran and Turkey. The objective was to address the issue of user participation in order to deliver design solutions for country-specific usability problems.

The design with older adults has also been addressed in UAIS papers. Doyle *et al.* [11], for instance, evaluated design solutions for independent living technologies to support ageing in place. They faced difficulties while applying PD with older adults, and to assess the impact and usability of technologies in the home environment. Rice & Carmichael [41] presented the collaboration of older adults in eliciting early stage requirements for television-based interactive solutions. They addressed how older adults' creativity can be used for designing digital television applications. They faced barriers related to inadequate drawing skills during the design process.

Some of the papers in UAIS have considered cultural issues in the design process. Mi *et al.* [31] used PD to define accessibility features, which were used to design accessible smartphones. The authors studied how PD techniques are useful to elicit requirements for the development of design guidelines to address the accessibility of smartphone applications.

The literature review of the UAIS papers indicates a low number of proposals with PD at the core of the design approach. Although the selected papers adopted and

experimented with PD techniques while addressing important concerns, they did not focus on defining novel PD approaches.

C. Analysis of the TOCHI Papers

TOCHI is a journal covering all aspects of Human-Computer Interaction for over 20 years. Our objective was to investigate how UD issues are addressed by recent studies published by CHI/HCI communities, as well as to analyze the ways in which the research adopts UD and PD principles.

From a total of 175 full papers from the last 5 volumes/years of TOCHI, we selected 12 articles with a focus on UD issues. Fig. 3 presents the number of papers for each year (left side). As seen, 1 paper was selected from the 2012 issues of TOCHI, 2 papers from the 2013 and 2015 issues, 3 papers from the 2014 issues, and 4 papers from the 2016 issues, which indicates the increasing interest in UD and/or PD by the CHI community. Considering the issues addressed in the papers (right side of Fig. 2), we selected: 5 papers focusing on people with disabilities, including 3 papers that emphasize visually impaired/blind users, 1 focusing on users with powered chairs, and 1 with a focus on users' communication needs; 4 papers were about elderly people/older adults; and, 3 papers reported on issues related to inclusive design for excluded communities.

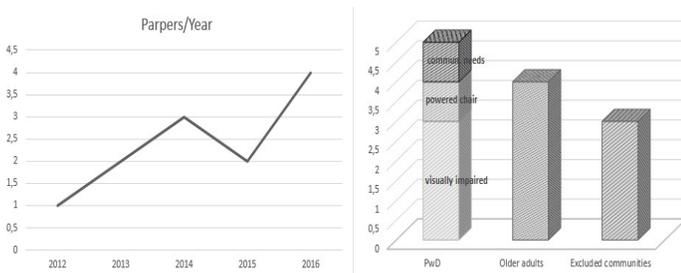


Fig. 3. TOCHI papers per year and issues addressed

Several TOCHI papers addressed the issues of design for people with visual impairments. Ferres et al. [13] described a case study regarding how to provide blind people with access to line graphs. The paper evaluated complex natural language interfaces for describing graphs that relied on a history of natural language description. The study presented recommendations for including graphs in textual articles. Quek & Oliveira [38] aimed to assist Blind or Severely Visually Impaired (IBSVI) individuals to access speech and gesture co-expressive communication. Results were discussed according to two themes: how the Haptic Deictic System (HDS) enables IBSVI to participate in embodied discourse in general, and how the HDS may support inclusive mathematics and science instruction. In this context, Vazquez & Steinfeld [46] proposed an assisted photography framework to help visually impaired users. They evaluated its implementation in the context of documenting accessibility to public transportation. The proposed framework can evaluate image quality based on a real-time image composition model. The results suggest possible system improvements and recommendations for future development.

TOCHI papers have addressed issues related to people with complex communication needs. Black *et al.* [6] developed a type of Augmentative and Alternative Communication (AAC) device. This device supports the generation and narration of an “oral personal narrative” for children who are developing language and who are not yet functionally literate. The design process included observations, interviews, and prototyping with stakeholders. Three children participated in the study: two were nonspeaking, and a third had intelligible dysarthric speech. The system was evaluated by the three children during two periods with the following objectives: (i) assessing the potential of the prototype to support interactive conversational narrative; and (ii) identifying areas for further development.

People with physical disabilities were addressed in Seaborn *et al.* [43]. This study produced a series of inclusive entertainment technologies and services for people who use powered chairs. The authors argue that HCI must pay attention to the rich diversity of real human populations. Framed by universal design and entertainment theories, the article proposed an initial set of theoretically and empirically informed guidelines.

Pearson *et al.* [35] addressed the issue of design for resource constrained communities, with the objective of providing information and various types of media access. Their approach was based on a combination of interactive voice response and printed media. It required no specialized hardware, literacy, or data connectivity. The article considered potential barriers to the system’s usage by those communities, e.g., difficulties to understand hierarchical menus, and difficulties to read texts. Wyche *et al.* [50] studied the impact of mobile phones, which serve to augment the marginalization of rural populations in Kenya, and proposed recommendations for mobile interfaces design. The results identify the difficulties and limitation faced by rural women using mobile systems, evidencing the mismatch between their capabilities and the systems’ design.

In line with this perspective, Briggs & Thomas [9] proposed a process that aims to promote an inclusive and value sensitive design. They described scenarios that capture new research in the field of identity, and use these as probes in an inclusive design process. Their approach started mapping the design space. Workshops were held with six marginalized community groups, separately: young people, older adults, refugees, women of an ethnic black minority, people with disabilities, and mental health service users.

TOCHI papers have addressed the inclusion of elderly people/older adults in the design process. Vines [47] *et al.* provided a critical analysis of 30 years of ageing research published across the ACM Special Interest Group in 644 ACM SIGCHI papers. The study proposed strategies for future research at the intersection of ageing and HCI. The

authors highlighted how an emphasis of these discourses might limit the understanding of the problem. The article defined a research agenda for HCI, drawing upon a multidisciplinary perspective.

A better understanding of how older adults judge the credibility of health information when compared to younger users was addressed by Liao and Fu [28]. The authors discussed the implications of this perspective on the design of online health information systems. Nansen *et al.* [32] explored the relationships between habits and interaction with technology by describing older people's experience with the Kinect to Xbox. The paper investigated the relationship between habits and natural user interface (NUI) with older adults and their family. The article presented insights for research and design regarding the role of habit in technology interaction. The authors discussed the relationship between aging and technology habituation as related to NUI, in addition to conjectures that lead researchers to rethinking the concept of habit in HCI.

Ogonowski *et al.* [34] used participative design and a persuasive health approach to allow for the seamless integration of an information and communication technology-based fall prevention system in older adults' everyday life. This paper argued that there is a need to give older adults an active role in the design of systems for fall prevention. The authors highlighted that few studies have described the processes of co-creation with older adults in detail. The results showed that the target population is more heterogeneous than commonly assumed. However, the study does not address the theoretical and methodological aspects of promoting universal access to PD practices.

The analysis of the TOCHI's papers revealed that the topics covered were more scattered than in PDC and UAIS. The addressed issues included how to define a good design process, how to understand and consider the users' needs, habits and values; and how to design accessible products based on extensive and rigorous studies and evaluations.

D. Findings in the Literature Review

The analyzed papers from PDC focused on (or at least considered as an important aspect) issues related to the "design of the design". This expression is related to the procedures for conducting the design process. This included difficulties and problems related to how to make a design with disabled people, with older adults, and to promote an inclusive design. As Halskov and Hansen [53] argue, the issue of methods remains an area that deserves considerable attention in PD research.

Various PDC papers proposed design alternatives that engage users in the design process, including new methods and artifacts. They also presented suggestions as to how to provide safe and welcoming environments and conditions, according to the participant's characteristics, social context, and emotional issues. Some PDC studies highlighted the importance of providing end users with an active role (avoiding proxies),

considering the degree of autonomy and stakeholders' participation. Flexibility in planning, and conducting participatory work is necessary to respect the users' individuality and the heterogeneities of a given group. PD should be able to accommodate specific circumstances and individualities (*e.g.*, some participants may demand predictable practices, whereas others may prefer unstructured ones). In this sense, some studies emphasized the need for flexibility regarding the ways in which users can contribute (considering their physical and/or cognitive disabilities), and the type of contributions participants might give to the design.

However, most of the PDC papers focused on a specific disability or group of users, not aiming to create a design process for all (*i.e.*, for a heterogeneous group). They did not emphasize heterogeneous groups, targeting a design process for all.

The UAIS papers, unlike the PDC ones, focused on the design of universal accessible products rather than on providing an inclusive design process. PD is frequently applied as a tool for developing universal products, and is not the object of study itself. The analyzed UAIS papers often addressed how to guarantee that the participants' suggestions lead to the design of universal products. They included a concern regarding the importance of considering individual and collective needs, as well as local (*e.g.*, country-specific) and global problems. In addition, the studies emphasized the importance of identifying difficulties, and exploring alternatives, while using (or adapting) PD methods to elicit requirements for UD. According to the analyzed papers, the involvement of disabled people at the start of the design phases contributes to the design of universally accessible products.

We did not find articles published in UAIS that focused specifically on the design of methods to promote accessible user participation during design activities that promote UD. Most of the investigations dealt with specific disabilities or groups of people.

Most of the TOCHI papers (with some exceptions) adopted long-term studies and/or controlled user evaluation methods that focused on the efficacy of the proposed solutions (in terms of accessibility). These studies were used to produce evidences of the importance of understanding the users' accessibility needs. The analyzed papers emphasized the need for long-term evaluative (or participatory) studies in order to understand accessibility issues prior and after design. This included reflections on the role of technology not only as a tool for inclusion, but the possibility of technology being a factor of exclusion (if not properly designed). Awareness of human diversity in a given population, local culture, excluded communities' habits and their values, were recurrent themes addressed by the studies published at TOCHI.

Except for one article, the UD term was only occasionally mentioned in the TOCHI papers. Discussions regarding the "design of design" (*i.e.*, discussion on how design activities are planned and executed) were also less frequent than in PDC papers. There was limited discussion of PD methods, techniques, and artifacts, as well as PD principles, such as democracy and extensive/inclusive user participation.

III. CASE STUDIES

This paper considered two projects that emphasized the promotion of PD and UD. The objective was to analyze the difficulties and challenges faced in the projects. Section 3.1 presents the research method used to collect and understand data from the projects. Section 3.2 presents a description of the projects, one aimed at including digitally illiterate users, and the other addressing the inclusion of deaf users in participatory design. It is out of the scope of the paper to discuss the specific methods adopted in the projects. Section 3.3 describes the findings from our analysis of the case studies.

A. Research Method

We aim to provide an overview of the problems faced, and adopted solutions, in the case studies investigated that promote UPD. From this main objective, we pursued the following goals: (1) provide the designers' view of accessibility problems faced during the projects' executions; (2) elicit their adopted solutions; and (3) organize the problems from physical to the social levels. In this analysis, we do not intend to produce a framework or a method that serves as a recipe for UPD. It is out of our scope to analyze the effectiveness of the design methodology adopted, or to compare the two projects' outcomes.

Aiming to provide a structured view of the identified difficulties and solutions, we based our analysis on the Stamper's Semiotic Framework [44, 25, 26]. This artifact addresses aspects related to the structure, meanings, and usage of signs, respectively. In addition to the traditional syntactic, semantics, and pragmatics organization, Stamper introduced a physics layer to tackle physical aspects of the sign (e.g., signals and marks), an empirics layer to address the statistical properties of signs, and a social world layer to treat the effects of the use of signs in human affairs. In information and communication systems [44, 25, 26], the six levels are organized in two groups: the first group includes the physic, empiric, and syntactic levels related to the information technology platform, and the second group includes the semantic, pragmatic, and social world levels that are related to human information functions.

The Semiotic Framework has been used with several purposes, including requirements elicitation, as well as practices with users (e.g., [7]). Each level of the Semiotic Framework involves elements described as follows:

- *Physical*: signals, traces, physical distinctions, hardware, component density, speed, economics, ...
- *Empiric*: pattern, variety, noise, entropy, channel capacity, redundancy, efficiency, codes, ...
- *Syntactic*: formal structure, language, logic, data, records deduction, software, files, ...
- *Semantic*: meanings, propositions, validity, truth, signification, denotations, ...
- *Pragmatic*: intentions, communications, conversations, negotiations, ...

- *Social*: beliefs, expectations, functions, commitments, contracts, law, culture, ...

In this paper, we used the Semiotic Framework to organize the problems and solutions found in the projects. The issues that are addressed in each level of the framework, in our case, are related to the design process (*i.e.*, not to the finished product).

The analysis of both projects was conducted according to the following steps:

- *Step 1* – Analysis of the projects' documentation (e.g., project reports, papers, thesis) to identify documented difficulties/challenges faced in the six levels of the Semiotic Framework;
- *Step 2* – We collected and analyzed transcripts of discussions that occurred during the design (within the workshops), of interviews, and of meetings with the designers (after design). The designers expressed the difficulties they encountered at each level of the framework;
- *Step 3* – The results from the previous steps were organized and collaboratively discussed among the involved researchers;
- *Step 4* – Synthesis and tabulation of the results were done using the Semiotic Framework.

B. Projects' Descriptions

We first present a brief description of the e-Cidadania Project, to then describe the deaf users' web accessibility project. The projects presented in this study were approved by the Committee on Research Ethics at University of Campinas (C omite de  tica em Pesquisa da UNICAMP Campus Campinas) under the number 039.0.146.000-08, and by the UNIFACCAMP Board (20131107). All the participants signed consent forms for each activity and workshop they participated in.

The e-Cidadania Project

In a diverse scenario, *e-Cidadania* [3] conducted several participatory workshops in a community Telecenter, located at *Vila Uni o*, a neighborhood in Campinas city, Brazil. It aimed to elicit people's requirements for the conception of an Inclusive Social Network (ISN) system named *VilanaRede* [33]. Such system had the objective of being accessible to the widest variety of users, including those less familiar with technology, and those with low literacy levels. The *VilanaRede* refers to an interactive web system created from the joint efforts of stakeholders, including those with disadvantaged access to knowledge and the digital culture.

The Brazilian context is characterized by vast socio-economic, cultural, and geographical differences, as well as unequal access to technology and knowledge. Social indicators during the time in which the Project was conducted indicated that almost one third of the Brazilian population, between the ages of 15 and 64 years old, were considered functionally illiterate [23]. This indicator increases significantly with the

age of the population. Brazil was thus a relevant scenario for the development of inclusive solutions.

The ISN represents an opportunity for interaction, access to information, and knowledge through the Web. Such system aimed, primarily, to allow for people to share their interests and activities, constituting communities. The *e-Cidadania* project had the intention of transforming an ISN into an engine for digital inclusion and citizenship. The ISN had to be accessible to people unfamiliar with information and communication technologies.

The system design was elaborated with the participation of representatives from several groups that were already constituted, such as members of the neighborhood associations, youth representatives, and service providers in the region. The project included 24 participants with different social profiles, such as housewives, cooks, handicraftsmen, hairdressers, seamstresses, retirees, teachers, students, and others. Regarding age, 8% were over 60 years old, 50% of the participants were between 51 and 60 years old; 17% between 41 and 50 years old; 17% between 31 and 40 years old; and 8% between 21 and 30 years old.

In addition, the rationale was to reproduce a heterogeneous population in terms of educational achievement. Thus, 25% of the participants held university degrees (8% uncompleted); 25% had high school degrees, while 8% had not completed high school; 17% completed an elementary school education, and 17% had not completed elementary school.

Furthermore, the heterogeneity considered experience with the use of computers. About 50% of the participants had a computer at home with Internet connection (including dial-up connections), and 25% had a computer at home without connection to the Internet. This does not mean that they had a high frequency of computer and Internet usage, and much less that they had experience with the Internet. Around 60% of the participants declared that they did not use the computer frequently. Most of the participants who used the computer more frequently (40%) declared that younger family members assisted them (usually their sons or daughters). Around 17% of the participants did not have a computer at home, and 8%, did not provide this information. In this sense, the project was comprised of users who did not use computers, who had low contact with computers, who owned computers but were not frequent users, those who owned a computer and used it frequently while assisted by others, and users who used computers frequently without assistance.

The participants were involved in participatory workshops conducted throughout the project. In addition to community members, researchers and software developers took part of the workshops, which consisting of a group ranging from 25 to 30 people. By always relaying on a participatory approach, the workshops explored several OS artifacts to clarify the meanings prospective users created for ISNs, understand and elucidate interaction requirements and features, and to evaluate the system. The use of OS artifacts played a key role in facilitating communication between communities, government, users, designers, and others. The artifacts allowed for further understanding of real situations, and for an analysis of requirements, in addition to grouping the stakeholders into

categories and pointing out the problems related to each category. The use of artifacts in a participatory practice enabled discussions on detected problems, possible solutions, and new ideas. The workshops' dynamics included a brief introduction, with an explanation of the objectives of the workshop, followed by participatory practices. The group was invited to complete the artifacts collaboratively through the mediation of researchers. Participants were invited to share their ideas, answer questionnaires, *etc.*

Over a period of 3 years, 11 workshops were carried out. Each workshop addressed specific goals in the project, and had a specific dynamic to address the goals. The first workshops aimed to detect the basic features that the system should provide, including a system architecture proposal, an agile software development proposal, and key aspects of accessibility and usability to be considered. The second period included workshops that aimed to run the initial beta versions of the system, and practices to understand the system's utilization, taking into consideration difficulties and users' interests. During the third period, workshops had a specific focus on distinct features, including, for instance, investigations to clarify the way in which the participants make sense of search engines. The last workshops were dedicated to a comprehensive evaluation of the system with the stakeholders' participation, and included formal inspections of interaction design and system code.

Deaf Users' Web Accessibility Project

This project analyzed the way in which deaf users make use of the Web. We identified the barriers they encounter in order to propose design solutions for such barriers. The project lasted for 4 years and 2 designers participated in the study. One frequently interacted with users during participatory sessions, and the other interacted with users during specific situations. However, both worked together in the elaboration of the artifacts and methods used in the sessions.

The project took place at the Deaf Service Center in the city of Macapá in Brazil - CAS (*Centro de Atendimento ao Surdo*), and the Deaf Mission (in Libras) of the Baptist Church of Macapá-Brazil. Macapá is the capital of the State of Amapá, near the Amazon River estuary, with few connections by land to other parts of Brazil, and low Internet connections, which were mostly based on radio technologies.

Twenty-five users, born with hearing loss or who have high levels of hearing impairment since they were very young, participated in the activities during different stages of the project. In addition, three normal hearing users and three interpreters participated in the activities. All deaf users were fluent in Libras (Brazilian Sign Language) and 19 (76%) had lip-reading skills. However, they had different skill levels in the Portuguese language. Considering their educational levels, 14 participants held university degrees, 7 held high school degrees, and 4 were elementary school students. Their ages ranged from 12 to 44 years old. All of the deaf participants declared that they use the Internet frequently (more than once a week). Nevertheless, most of them declared that they have serious difficulties using it. The deaf participants had educational levels higher than the average Brazilian population. They also had a high proficiency in sign language.

All hearing users held university degrees and were not proficient in Libras (beginner level students in Libras). Their ages ranged from 25 to 29 years old, and all had good computer skills.

Despite the advances in educational techniques for the teaching of deaf literacy, deaf people frequently face difficulties reading complex terms and with the use of written language to express themselves. Many researchers have considered the written language as a second language for the deaf [37], as people with hearing impairments most commonly use sign language to express themselves more naturally.

The project clarified situations, and proposed design solutions, for the inclusion of deaf people in the Web by using various methods such as interviews, storytelling, workshops, and user's participation, relying on semiotic-based artifacts (including problem articulation artifacts, ontology charts, and norm description as proposed in [4]). The project promoted online sessions that aimed to evaluate the use of Internet tools by deaf users, and to carry out participatory practices at a distance. Overall, 32 sessions with the users were conducted during the 4 years of the project.

Instead of proposing means for deaf users to communicate with each other, or means to translate the written language to sign language, the project aimed to use the existing technologies (e.g., avatars) as resources to stimulate the learning of the written language and the user's autonomy in an inclusive and universal view of the Web. Results from the project included: (1) a study of the barriers for people with hearing loss making use of the web [14]; (2) the elicitation of accessibility requirements for people with hearing loss [15]; (3) the use of computational resources for bilingual deaf literacy [16]; and, (4) a set of design recommendations that encourage the learning of the written language by deaf users using Web resources [17].

Despite the promising results in terms of design solutions and the mutual learning enabled by participation in the project, we highlight difficulties and identify challenges that demand further research, considering an UPD perspective.

C. Findings from the Analyzed Projects

Designers involved in the *e-Cidadania* project agreed that their major difficulty concerned how to tackle users with low literacy levels, who had no idea of the possibilities that an ISN system could create. Participants were unfamiliar with information and communication technologies. The design process always had to take this aspect into consideration. This context resulted in the need for extensive planning meetings between designers and researchers aiming to design the workshops activities, meetings which included concerns about participation models, the methods, artifacts, and how to set up the environment that promoted the inclusion of the users in the design.

Both designers in the deaf users' project agreed that communication issues were very frequent, especially when the activity demanded interventions from interpreters. The designer who was most involved in the participatory sessions reported: "*Due to my rudimentary skills on sign language, I*

think that the greatest difficulty, when I was carrying out activities with deaf users, was to establish productive and effective communication. I often noticed, through the users' reaction, that the interpreters translated the information in their own way. This resulted in misunderstandings during the execution of the practices, and required further explanation and revisions".

Direct participation of users without proxies (e.g., someone who interprets their statements and communicates with the designers) is also advocated by other PDs studies (e.g., [18]). In addition to the democratic principles of equal opportunities for participation, the direct participation of users (without proxies) provides for richer design, user interactions, and mutual learning. The designers agreed that even in situations when the participation of interpreters is possible, extra methods and artifacts are needed for deaf users to express their views clearly and directly. With adequate methods and artifacts, the interpreter's role changed from being exclusively directed at communication, to a supporting role, with the objective of facilitating communication in contextualized practices. The upcoming paragraphs present a synthesis of the major challenges and difficulties faced in order to promote inclusion in both projects, according to the six levels of the Semiotic Framework.

Physics. At this level, the key difficulty is associated to the physical artifacts used to support the design process. In both projects, the participants had difficulties writing and reading, which limited the use of artifacts based exclusively on writing. To enable direct and dynamic user participation, without having proxies, additional planning and resources were needed. However, these resources were not always available. In fact, participatory sessions that demanded extra devices and physical representations as a substitute for the written language were sometimes a non-viable alternative. A designer described difficulties he faced with written-based tools for deaf participants (e.g., post-its and flip charts): "*I faced difficulties when using writing in Portuguese in the application of the tools during the sessions. Consequently, there was a need to repeat the same activity several times, and search for visual alternatives and adaptations*". For instance, it was necessary to record contributions in sign language using video equipment. It was also necessary to use transcription software in this context. In summary, the difficulties experienced at the physical level were mostly related to providing a flexible physical environment with the necessary equipment and artifacts, considering the projects' contextual limitations.

Empirics. We identified the challenge of defining an adequate group size for the workshops. Since UPD must consider a heterogeneous group, the complexity of this group increases as it grows. This aspect creates difficulties in the design process related to managing people. During activities involving online-based tasks, designers experienced limitations in Internet connections and equipment viability. Video was an alternative tool for communication with deaf users, but also a limitation when considering the participation of people in isolated and disadvantaged regions. In some situations, the designers used text-based chat tools, but experienced difficulties. For instance: "*It was difficult to develop activities that would be conducted at a distance, for example, when*

asked to show how we could improve an application's accessibility using new technological resources". In addition, the groups' size during face-to-face sessions, and the limited number of interpreters were challenges experienced throughout the projects. To this end, some methods and artifacts, which demanded the interpreter, had to be revised, and alternative and flexible solutions had to be considered (e.g., using visual resources).

Syntactics. At this level, designers faced challenges regarding the planning and structuring of the workshops and their sequence to consider and give voice to all the participants. Throughout the project's extensive duration, the design activities had to be carefully planned into a sequence of activities relevant to the participants (they understood and learned from the activities' results), and for the research's output. In addition, designers needed to propose artifacts and techniques that allowed all members of the group to participate without segregation. Considering a group with difficulties in written communication, reading, visual impairments, etc, the interpretation of the used diagrams in order to elicit interaction requirements demanded specific support. The challenge was to provide the means for participation of individuals who have difficulties comprehending the structure of the artifacts. Designers reported on their concerns regarding how to prepare artifacts that can be understood by the participants. Language syntax is an essential aspect of the workshop's mediation. Designers experienced difficulties, for they were frequently required to use alternative languages and expressions. It was essential to consider, for example, how to represent requirements so that all stakeholders could interpret them. The phrasal structure of written language was a recurring problem during communication with deaf users throughout design sessions. Aiming to avoid the interpreter's intervention, some activities that intended to evaluate communication on the web (e.g., using chats) were initially specified in a written form. However, the majority of the participants had serious problems using rules of the written language, as they rarely used articles or connectors, and they did not respect syntactic conventions. A designer reported: *"I had difficulty understanding unstructured text written by the deaf users, and they faced difficulties understanding texts. Sometimes, even when translated into sign language, the question had to be rephrased several times due to the distance between the grammar in the written and sign languages"*. The experienced difficulties, related to the syntactic level, include the challenge of enabling meaningful communication that takes into consideration the limited use of grammar rules by deaf users, and the differences between grammar in written and sign languages.

Semantics. This level concerns aspects of meaning. In both projects, designers faced difficulties communicating with low literacy users. Initially, they had distinct understandings of the elements proposed for the interface and aspects of design activities. Alternative practices were required to assure that participants reached a mutual understanding of the problems and solution proposed. This is further related to the question of how to promote and conciliate discussions. In the UPD, several activities require that the group reach a consolidated drawing of the interface. This activity demands mutual understanding by designers and participants, during a process of co-design.

Therefore, the key challenge remained how to conduct a critical assessment of design results in an interpretable way for all participants. The way in which most deaf participants read and wrote was based on the association of words in the written language with sign language concepts. This resulted in misunderstandings between deaf users and designers or non-deaf participants. There were frequent situations in which there was a different meanings for a word used by the designer and by deaf users. In other situations, deaf participants used words in a context that was not understood by non-deaf users and designers. For instance, a designer reported: *"I had difficulty understanding the meaning of words used in the interview responses"*. The non-deaf participants' difficulty communicating in sign language was also presented: *"I had difficulties using sign language, as I know the meaning of few words in this language. I regularly had to request the support of the interpreter to maintain the dialogue"*. Therefore, designers should be aware of, and avoid, the use of abstract terms, unusual words, onomatopoeia, and particularly Internet slangs. Semantic issues were exacerbated by aspects such as regionalism and individualities. Although many participants had similar educational levels (in terms of years of schooling), they had different levels of practice with the written language. The designers had to be flexible and prepared to "rephrase" when talking with deaf users, considering the singularity of each participant. The use of long texts in explanations about methods and artifacts was avoided, and visual explanations were needed. Videos in sign language were constantly reviewed to support the users so that they could understand the practices.

Pragmatics. This level stands for aspects related to expression, interpretation, and negotiation of intentions during the design process. The users presented different motivations for participating in the design and use of the Web. Motivation was essential during the practices with the users, and a way of taking them into account when planning the design of the methods and artifacts. Individually, many users were interested in the web as a source of information, news, and for communicating with friends. Others saw it as an opportunity to enhance computer skills, and viewed this practice as a source of employment and social insertion. First, the designers noticed that verbal communication was insufficient to enable participants to clearly express their intentions during the design activities. This required further investigations and definition of techniques, in addition to artifacts, to allow for clearer communication of intentions during the design proposals. Also related to intentions, designers in the *e-Cidadania* project reported complications, and identified the relevance, of allowing for clear negotiations amongst heterogeneous groups of users. In the other project, most of the deaf users considered access to the web as an alternative to expand their communication network, by overcoming their communication barriers, as well as an opportunity to improve their written language skills. The designers reported on the challenges of understanding the users' motivations. They also identified the difficulties deaf users had to understand the designer's intentions during a proposed practice: *"Sometimes, I had difficulties communicating the purpose of a practice; deaf participants executed it incorrectly, and it was necessary to change and repeat the explanations"*. The difficulties

experienced include aspects, such as: (1) How to capture the deaf users' motivation, and (2) How to express design intentions in the proposed practices when communication is limited in terms of language skills and perception.

Social World. The highest level in the Semiotic Framework stands for aspects related to social values, culture, privacy, and engagement. Due to their different background and profile, in the *e-Cidadania* project, participants had different social values and cultures. This level also addresses privacy issues, since the stakeholders' system of values influence their sense of privacy in an information system. In an UPD, design techniques must explicitly consider and formalize these issues so as to assure adequate design results. Designers involved in the *e-Cidadania* project reported on their difficulties clarifying and making social-related issues explicit to all participants. They also expressed the challenge of evaluating how each participant makes sense of the benefits of participating in the design process. This issue is related to how to define interaction scenarios that motivate each member of a heterogeneous group to participate of the design. Deaf user's everyday communication habits is also a relevant aspect for consideration. This aspect is perceived not only in the construction of the design artifacts, but throughout the design process. For instance, the designers learned rules, based on cultural aspects, that must be considered for polite communication with deaf users: *"for good communication, it was essential maintain eye contact, because when two people talk in sign language it is considered rude to look away; and it is also preferable to give a light touch on the shoulder or arm than to call someone by name"*. Considering Web access, deaf people develop groups in social networks that have their own social and communication rules and purposes. A designer reported on her difficulty, and on the importance of, understanding social aspects as follows: *"They [the deaf] had different social rules and concerns, and usually trust participants who knew sign language; some of them became very dependent on that person during the tasks. Some participants demonstrated the desire to create friendship bonds with other participants who knew sign language. These facts demonstrated lack of friendships with people who do not speak the same language. This can be explained by the fact that most of the deaf participants' families have no (or limited) knowledge of sign language"*. The designers identified the challenge of considering cultural aspects and social rules, taking into account the individual context of each participant in the design.

IV. DISCUSSION

This discussion section relies on the results from the literature review (*cf.* Section 2) and experiences reported by designers in our case studies (*cf.* Section 3). The literature review considered the last five editions of three important publication venues in areas related to the UPD concept, including PDC (Participatory Design), UAIS (Universal Design), and TOCHI (HCI/CHI). The analyzed case studies considered documentation and reports on the experiences of designers in two research projects using PD. First, we discuss major findings from these sources. We then discuss demands for rethinking four key components of PD: (1) a change in

designers' attitudes; (2) the use of flexible mediating artifacts; (3) the adoption of open participatory methods; and (4) a commitment to the universality of the design product. Our discussion indicates the need for further research in the area of UPD. Table I summarizes key aspects from the literature review, case studies, and PD components, which are discussed in the following paragraphs.

Various issues highlighted in our literature review of the PDC papers were also present in the projects analyzed in Section 3. The *e-Cidadania* project, for instance, dealt with the participation of people with multiple levels of digital literacy, demanding flexible methods, artifacts, and attitudes during participatory sessions. Similarly, the project regarding deaf users revealed the importance of considering cultural aspects during the design and execution of PD activities. We emphasized the main issues faced in these projects, such as: (1) dealing with resource constraints during design, considering heterogeneous participants and unexpected situations; and (2) planning universal participation in a way that ensures that the results lead to a universal product.

As the objective of the projects was to produce software systems according the UD principles, various concerns from the papers published in the UAIS were also observed in the analyzed projects. In the *e-Cidadania* project, for instance, the design of an inclusive search mechanism [39] took into account the local language and opinions of people with low digital literacy. The analysis of the local language informed the product design so that it would be suitable for digitally included users as well. Users' participations were a tool for understanding UD requirements.

Instead of designing deaf-oriented tools (*e.g.*, a web chat based on sign language), which may segregate this population from other users, the project involving deaf people guaranteed user participation in the construction of mechanisms for including deaf users in existing Web tools. Thus, we highlighted (in addition to the presented issues) the relevance of rethinking the design of PD methods so as to motivate participants (not only the designers) to think of "the others", aiming to produce universal solutions with UD principles. This is especially relevant when we consider the impossibility of guaranteeing that everyone is represented in a PD group.

Several TOCHI papers focused on long-term studies, like the case of the *e-Cidadania* project. In this project, we conducted 11 workshops over 3 years. We found that the major challenges faced were related to pragmatic and social levels of the Semiotic Framework. They were only clarified (at least in parts) after some workshops, and required long-term evaluation. The designers must be aware that some issues, such as the understanding of participants' habits and values, cannot be addressed in a few participatory sessions. Likewise, the design of methods that considers practical limitations (*e.g.*, time, resources, and skills) remains particularly challenging.

TABLE I. KEY ASPECTS FROM THE LITERATURE REVIEW, CASE STUDIES, AND CHALLENGES

Literature Review	Case Studies	PD components
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Literature Review	Case Studies	PD components
<p>PDC (Participatory Design):</p> <ul style="list-style-type: none"> - Need for flexibility regarding the way in which users can contribute; - provides safe and welcoming environments; - provides an active role (avoiding users' proxies); - flexibility in planning and while conducting the activity; - focused on a specific disability or group of users; - Did not emphasize heterogeneous groups, targeting a design process for all. 	<ul style="list-style-type: none"> - Participation of people with multiple levels of digital literacy; - flexible methods, artifacts, and attitudes in participatory sessions; - cultural aspects in PD activities; - addresses resource constraints; - addresses how to plan universal participation. 	<ul style="list-style-type: none"> Change in designers' attitudes Use of flexible mediating artifacts Adoption of open participatory methods
<p>UAIS (Universal Design):</p> <ul style="list-style-type: none"> - PD as a tool for achieving universal products; - participants' suggestions create products for universal design - individual and collective needs, local (e.g., country-specific) and global problems - dealt with specific disabilities or group of people; - does not focus on methods to promote accessible user participation. 	<ul style="list-style-type: none"> - Took into account the local language and opinions of people with low digital literacy; - the local language informed product design; - users' participations were used as a tool for UD ; - proposed inclusive tools "for all", instead of deaf-oriented tools; - deaf people participated in construction; - motivated the participants (not only the designers) to think of "the others". 	<ul style="list-style-type: none"> Change in designers' attitudes Commitment to the universality of the design product
<p>TOCHI (HCI/CHI):</p> <ul style="list-style-type: none"> - Long-term studies and/or controlled user evaluation methods focused on the efficacy of accessible solutions; - empirical evidences for understanding the users' accessibility; - UD term was only occasionally mentioned; - discussions regarding how the design activities were planned and executed was less frequent. 	<ul style="list-style-type: none"> - present long term evaluations; - UD challenges at pragmatic and social levels were clarified after some workshops, though there is the need for long-term evaluation; - both projects' results are based on empirical evidences; - understanding of participants' habits and values required long term evaluation; - design of methods considering practical limitations remains a challenge. 	<ul style="list-style-type: none"> Commitment to the universality of the designed product

Based on the studies from the three publication areas and the analysis of our projects, we organized demands for rethinking four key components of the PD in order to reach UPD, which are presented in the upcoming paragraphs.

Change in designers' attitudes. The designer must assume a positive attitude in face of unexpected reactions (positive and negative), unexpected situations, individualities, social concerns, and resource limitations. (S)he must be prepared to change the methods and plans initially proposed according to in loco circumstances. Dealing with a heterogeneous group of participants remains a challenge from an attitudinal perspective, especially when one considers pragmatic and social aspects (e.g., habits, culture, and values). The designers' capacity to deal with the practitioners has to be considered, and the designers must be aware of their limitations.

Use of flexible mediating artifacts. The set of artifacts must be elaborated in a flexible way in order to cope with unforeseen situations. The artifacts should consider, for instance, the physical limitations, cognitive limitations, habits, values, and cultural factors of groups with different backgrounds and skills. In addition to social aspects, the individual characteristics of each participant must become evident, because each participant needs to understand his/her contribution to the design. Creating such flexible artifacts is challenging and may require in-depth studies of methods for designing artifacts using interactive design processes. For example, some digital/virtual artifacts are particularly interesting for various groups of users, but impractical in other contexts. Multimodality may be a key factor to consider in the construction of those artifacts. The use of more performative (and flexible) design artifacts must be explored to increase the users' participation during design, and after design, activities [51].

Adoption of open participatory methods. Whereas some studies in the literature identify groups of users who need (or prefer) more rigid and predictable methods to systematize effective participation, other studies describe users who need (or prefer) open methods (using open artifacts) that accommodate for various levels and means of participation. This points to the need for the further investigation of methods that are able to be flexible and deal with unforeseen situations, assuring that PD principles such as democracy and opportunity of participation in all situations. The adequate balance between rigid methods that allow for better evaluation of results and possibility of replication, and methods that promote creativity and free participation, requires further investigations. How to promote user empowerment during use remains another aspect to be considered from a universal access perspective [52].

Commitment to the universality of the product's design. UDP not only concerns the full participation of users during the design process, it also requires an understanding of the production of (universally) accessible outcomes. The relationship between "universal" and "democratic" participation during the design process, and the universal result produced, requires further investigation. This implies in the need to include, during the planning and execution of the design process, concerns regarding universal aspects of the product under design, for example, leading participants to think of "the others".

Based on these components, there are attitudinal, methodological, and communication issues that must be faced by UPD. Various aspects related to these issues have been

addressed by the literature in related areas for decades. However, there is a lack of methodological tools, as well as an integrated approach, that takes into consideration PD components towards in order to reach UPD. As Table I shows, unlike the case studies, the existing literature (when we consider the fields of study individually) does not focus on UD aspects and the four key components of PD simultaneously. Thus, this article contributes to the elaboration of an integrated vision of accessibility and participation, through the analysis of existing literature, as well as the problems and solutions adopted in case studies.

In summary, this research found that the unpredictable nature of possible events and unique situations (perhaps “impossible” to generalize) that may occur during a design process, which aims to promote democratic opportunities for the participation of heterogeneous stakeholders, is the greatest challenge we should cope with in order to conceive of UPD.

V. CONCLUSION

PD has promoted user participation in design decisions that affect their life. However, one person out of seven in the world’s population has at least one type of disability. These people, in addition to disadvantaged communities, older adults, and people with low digital literacy (to cite a few), experience various barriers to perform effective and egalitarian participation during design processes. In this article, we introduced the concept of Universal Participatory Design (UPD) as a philosophy of design and practice that intends for the inclusion of participants during the design process, despite their physical, cognitive, educational, or social conditions. We assumed that a real inclusive design process could improve the quality of the product designed according to UD principles. As UPD addresses an intersection of issues addressed by PD, UD, and CHI/IHC communities, our study analyzed how these issues are addressed in some of the most prestigious publication vehicles over recent years. We then analyzed two research projects, which involved the process of design through the inclusion of people with low literacy and deaf people. We identified challenges faced in these projects related to the UPD concept. Based on the literature review and our findings from the analyzed projects, we contributed by clarifying the UPD concept in terms of its principles, and by identifying practical considerations. We clarified issues related to promoting the UPD, and defined long-term research challenges, including demands for a research agenda that strives for a genuine and universal democratic design process.

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