Achieving Universal Design: One if by Product, Two if by Process, Three if by Panacea

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Abstract. Since its beginnings almost 3 decades ago, universal design has been called many things, from another term for accessible design to a process for designing to a panacea encompassing all design. Clearly, it is all of things, yet at the same time it is none. As a product it has form and function, yet it is not specialized, accessible design. As a process it is a way of designing, yet it is no different than the typical design process. As a panacea, it is about making all things usable and inclusive, yet that has been a utopian illusion – at least in the design of physical objects and spaces, from which universal design emerged. However, as digital technologies continue to emerge and evolve, the universal design appears poised to fulfill its potential and promise.

Keywords: Universal design · Usability · Utopia

1 Universal Design as a Product

Whereas universal design is not a specific "thing" or artifact, things, be they architectural spaces, manufactured goods or digital interfaces can, and arguably should be, universal, that is, usable to the greatest extent possible [5]. Importantly, as an artifact, any universal design "thing" has both form and function.

1.1 Form

Form (n) is the outward appearance, proportions, shape and structure of something as distinguished from its substance (American Heritage Dictionary 1985). Physical form can be two or three dimensional, thus encompassing design at all scales from interfaces, products, and spaces to digital and graphical information. Form is distinguished by its features and their attributes.

Features (n) are any identifiable parts of the artifact. In general, features are categorical. They represent the identifiable parts (i.e., they have a name), such as buttons, links and screens of an artifact. Features, in and of themselves are not measurable; but rather are present or not. However, that does not mean that all features are identical. On the contrary, what differentiates among features are their design attributes.

Attributes (adj.) are characteristics, such as height, length, width, color, texture, and condition that define the proportions, appearance and other qualities (e.g., acoustic) of a

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feature. As such, attributes are measurable (i.e., quantifiable or describable) (see also Sanford and Bruce [11], Sanford and Jones [12], Stark and Sanford [13]).

1.2 Function

Unlike specialized designs (e.g., assistive technologies) that function solely to permit everyday artifacts to be usable by people with disabilities by overcoming barriers inherent in the form of those artifacts, universal design is everyday design that functions as a facilitators by being usable by all individuals to the greatest extent possible. As a result, the extent to which any artifact is universal is dependent on the degree to which it, itself (without any additional specialized design) facilitates usability for the widest array of users [10].

Conceptually, universal designs are based on an understanding that disability is not a single point requiring specialized intervention, but a continuum of ability that would benefit from more usable design. As such, it accommodates the widest possible range of body shapes, dimensions and movements [4] through contextually-appropriate solutions. Because every context represents a unique set of needs and opportunities, a universal design approach allows for contextual problem solving. As a result, universal designs, by their very nature, represent distinctive situationally-derived alternatives in which function and functionality are built into everyday form.

1.3 Is It Universal?

The only real way to determine if an artifact is actually universal design is to see if it is usable by everyone. However, due to the impracticality of this strategy, a common alternative is to evaluate an artifact using the performance guidelines that are included in the Principles of Universal Design (e.g., Connell et al. [1], Finkel and Gold [2], Sanford [10]). The guidelines enable artifact usability to be based on both form (e.g., appealing for all) and function, as a defined set of usability outcomes (i.e., flexibility, simple and intuitive, perceptibility, ease, limiting error, and sufficient space) (Table 1).

This can be done prospectively during the design process to assess how well different attributes will act as potential facilitators for different types of abilities of usability or retrospectively, after the design is completed to usability by actual users. Prospective assessments evaluate how usable a proposed design would be based on predefined assumptions of usability guidelines across the range of human abilities, including vision, hearing, stature, balance, upper body strength and mobility, lower body strength and mobility, cognition, dexterity, communication and speech, and life span. Retrospective assessments, on the other hand, can be used to measure usability under conditions of actual use based on interactions between design and individuals with measureable abilities.

Table 1. Principles of universal design [1].

Principle 1: Equitable Use: The design is useful and marketable to people with diverse abilities
1a. Provide the same means of use for all users: identical whenever possible; equivalent when not
1b. Avoid segregating or stigmatizing any users
1c. Provisions for privacy, security, and safety should be equally available to all users
1d. Make the design appealing to all users
Principle 2: Flexibility in Use: The design accommodates a wide range of individual preferences and abilities
2a. Provide choice in methods of use
2b. Accommodate right- or left-handed access and use
2c. Facilitate the user's accuracy and precision
2d. Provide adaptability to the user's pace
Principle 3: Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level
3a. Eliminate unnecessary complexity
3b. Be consistent with user expectations and intuition
3c. Accommodate a wide range of literacy and language skills
3d. Arrange information consistent with its importance
3e. Provide effective prompting and feedback during and after task completion
Principle 4: Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information
4b. Provide adequate contrast between essential information and its surroundings
4c. Maximize "legibility" of essential information
4d. Differentiate elements in ways that can be described
4e. Provide compatibility with a variety of techniques or devices used by people with sensory limitations
Principle 5: Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions
5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded
5b. Provide warnings of hazards and errors
5c. Provide fail-safe features
5d. Discourage unconscious action in tasks that require vigilance
Principle 6: Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue
6a. Allow user to maintain a neutral body position
6b. Use reasonable operating forces
6c. Minimize repetitive actions
6d. Minimize sustained physical effort
Principle 7: Size and Space for Approach and Use: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility
7a. Provide a clear line of sight to important elements for any seated or standing user
7b. Make reach to all components comfortable for any seated or standing user
7c. Accommodate variations in hand and grip size
7d. Provide adequate space for the use of assistive devices or personal assistance

2 Universal Design as a Process

As a product, the term universal design is used as a noun – "that artifact is a universal design" – or an adjective – "that universal design artifact," it is, first and foremost, a process. In most common definition – "the design of all products and environments to be usable by all people" [5] - universal design is used as verb, which implies that it is a process, rather than a product. Steinfeld [14] frequently refers to universal design as a process, suggested a new consensus definition of universal design as: "a process that increases usability, safety, health and social participation through design and services that respond to the diversity of people and abilities. He further suggests using the term universal designing, a verb rather than a noun, because the verb form puts the emphasis on going there, rather than having gotten there [15].

The application of the universal design principles further differentiates between the process of universal design and the product of universal design. Whereas the UD Principles can be applied to a product, either proactively or retrospectively, to determine the extent to which it is universal design, as a process, they are applied as specific design criteria to guide the design. Therefore, other than the explicit inclusion of the UD Principles as design criteria at the beginning of the design process, the universal design process is identical to the typical design process.

3 Universal Design as a Panacea

As technologies become more complicated and novel and as people with ever increasing range of abilities need and want to use those technologies, there is a real and growing need for more usable interfaces. Simply, put, we need universal design solutions.

In Greek mythology, Panacea was a goddess of universal remedy. So too, universal design is championed as the solution for all usability problems. And perhaps, it could be. But, to be the usability cure-all, universal design has to have widespread adoption and implementation. To date, this has not happened due to a variety of barriers including misperceptions about what it is, and what it is not.

First, the most pervasive barrier is perhaps the perception that universal design, is an idealist utopian concept, has an absolute idealist agenda, an exclusionary structure and unrealistic goals [15]. While it is true that universal design as design for all is a utopian concept. if not for all, then for whom? On the one hand, virtually every design falls short of its target criteria and goals (think, versions 2.0, 3.0…). Therefore, if we don't set our goals unrealistically high, we are likely to fall a lot further from the ideal than we could have. More importantly, this will require even more iterations to reach the ideal (think versions 1.2, 1.3, 1.4…). On the other hand, if we set our goals unrealistically high then we might just come a lot closer in a much shorter time than anyone expected (think versions 2, period).

Again, the definition states that universal design is the design of all products and environments to be usable by all people to the greatest extent possible. Here, let's focus on the phrase *usable by all people*. Usable by all people does not explicitly state that any design has to be the ideal best fit for every person on the planet. It merely states that it has to be useable, that is, able to be used or capable of being used. This suggests, that a universal design could be the ideal best fit for one individual and be difficult, yet still usable by another. Although the utopian goal would remain a perfect fit for all individuals, this understanding of universal design allows the designer to make reasonable tradeoffs to ensure usability for all.

3.1 Universal Design Ballots

Voting accessibility for individuals with disabilities has generally been accomplished through specialized designs, providing the addition of alternative inputs (e.g., headphones with tactile keypad for audio output, sip-and- puff) and outputs (e.g., audio output) to existing hardware and/or software architecture. However, voters with vision, cognition and dexterity limitations experience different types of usability problems with accessible voting machines. For example, blind and visually-impaired voters take significantly longer to vote compared to sighted voters [7] and navigating a ballot often leads to confusion [3, 9]. For voters with cognitive limitations who can be confused and overwhelmed by the amount of information and visual complexity of a full-face or the lack of overall orientation in page-by-page ballots, there is a need to incorporate more cognitive supports [6]. To provide access to voters with dexterity limitations, a variety of assistive technology inputs (e.g., sip-and-puff, jelly switch devices) have been added to voting machines. In addition to creating set up problems for poll workers who are unfamiliar with these input devices [8], they can negatively affect the voting experience. In contrast, simple touch screen and gestural input could ease physical effort.

To address the different needs of people with the widest range of functional abilities, a universal design approach was used to design two new experimental universal ballot interfaces, EZ Ballot and QUICK Ballot, as part of one voting system on a Windows Surface tablet. Although both ballots were based on design criteria that included the universal design guidelines with the intent of comprising one integrated voting system for all voters (i.e., one piece of hardware with 2 alternative interfaces), each ballot had a unique selection and navigation process (linear EZ ballot and random QUICK Ballot) designed to facilitate access and participation in voting. EZ Ballot was designed with a linear, binary yes/no input system for all selections that fundamentally re- conceptualizes ballot design to provide the same simple and intuitive voting experience for all voters, regardless of ability or I/O interface used. The second interface, QUICK Ballot was designed to provide random access selection that minimized voting effort.

Both ballots use the same ballot contents with the same size of text, the same size of touch buttons, the same means of tactile cover with indicators, and the same quality of voice. More importantly, both ballots aim to provide equal access to voters with a range of abilities, skills, and experiences. However, whereas EZ ballot provides a step-by-step directed guide that allows users to follow a particular sequence of steps, QUICK Ballot provides a familiar typical ballot format that allows users to directly choose a certain candidate on the touch screen. In addition, both ballots provide the linear navigation methods across contests, but differently. They allow starting from the first contest and moving through to the last contest linearly by touching "No" button or swipe gesture (EZ Ballot) and "Back" and "Next" buttons (QUICK Ballot).

The primary difference between EZ Ballot and QUICK Ballot was the use of a linear versus a random selection method within contests. Within contests, EZ Ballot provided a linear selection method that allows starting from the first candidate and moving through to the last candidate by touching "No" and selecting the candidate by touching "Yes" button. In contrast, QUICK Ballot provided a random selection method that allowed one to directly select the candidate by touching the name of the candidate.

For visually-impaired users, QUICK Ballot provided one-finger scan and lift finger interaction for directly selecting a candidate (Figs. 1 and 2).

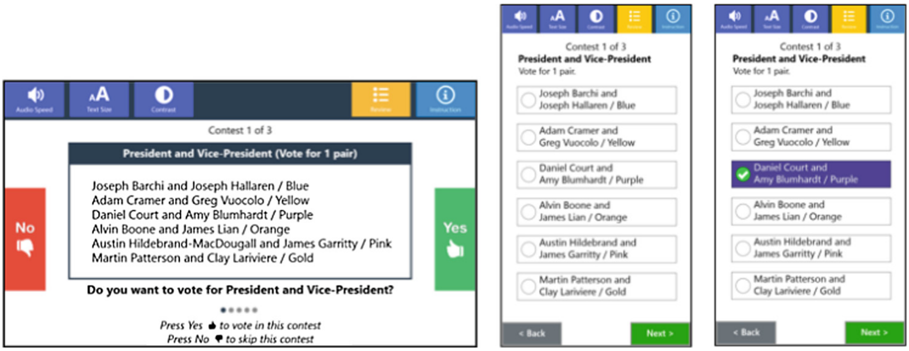

Fig. 1. EZ Ballot (left) and QUICK Ballot (right) interfaces.

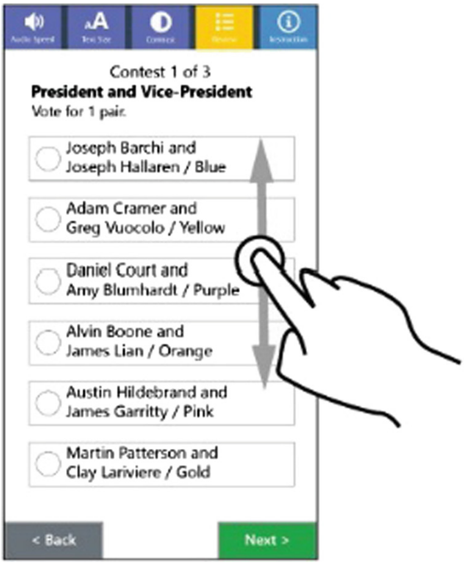

Fig. 2. Screenshot of unselected (left) and selected candidate using drag-lift of QUICK Ballot (right).

To examine the effectiveness of the two UD ballots in facilitating voting performance of people who would be most impacted by the design of the ballot, a study was undertaken with individuals who had a range of visual abilities including those with and without blindness or vision loss. Findings from the study indicated that participants with and without vision loss were able to use both ballots independently. However, users with vision loss made fewer errors and preferred EZ Ballot; while users without vision loss made fewer errors and preferred QUICK Ballot. Clearly, these findings begin to suggest that while UD, by definition, is design to be usable by all people by the greatest extent possible, this does not mean that design is equally usable by all people. Rather, by applying different "doses" of the Principles of Universal Design and their respective guidelines as design criteria, designs, whether physical, digital or a combination of both, may not only be differentially usable based on ability, but they may also be differentially desirable based on preference. Most importantly, this suggests that universal design does not dictate a one-size-fits-all approach. Whereas, this "one-size-fits-all" approach is useful to prove the efficacy of universal design, it assumes that if usability is achieved, that the universal design artifact will be desirable and effective for all users. This approach fails to consider that the 7 UD principles and their respective guidelines are not black and white, but shades of grey that may require trade-offs in design that favor one principle over another. As a result, both ballots were usable, although the degree of usability varied according to a user's abilities and preferences. Despite this understanding, the Principles of Universal Design have failed to and will likely never become, a panacea in the design of physical artifacts.

4 Post-mortem

Although the Principles of Universal Design were developed by a group of experts representing a range of physical design professions (e.g., architecture, graphics, product design, landscape design), before wireless technologies became ubiquitous, the voting ballot project suggests that they are equally applicable and relevant to the design of mobile applications and other digital interfaces.

The voting project also makes a strong case for a broader, more flexible understanding of universal design that focuses on usability, rather than perfection. More importantly these two points clearly indicate that digital interfaces will act as the medium through which universal design will become a usability panacea. Whereas the design of physical artifacts and their interfaces is fixed, with limited flexibility to achieve a level of usability for all individuals, digital interfaces are dynamic and easily adapted for use in a single piece of hardware. Therefore, while the physical design of hardware might have limited flexibility to accommodate a range of abilities, digital technologies offer the possibility of seamless integration of multiple or customizable software interfaces that are differentially usable by different individuals into a physical artifact that is usable by all individuals.

In the end, the design of digital technologies is future of universal design, while at the same time, universal design is the future of digital technologies.

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