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Inclusive Design Advisor: Understanding the Design Practice Before Developing Inclusivity Tools

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Abstract

This paper describes an exploratory study investigating ways to accommodate inclusive design techniques and tools within industrial design practices. The approach of our research is that by making only small changes in design features, designers end up with more inclusive products.

Our research group examined how to enable designers to make design decisions toward more accessible products by observing and interviewing 20 experienced industrial designers. We also designed an inclusive design advisor tool that provided suggestions that designers could use to make more inclusively designed products. We asked the designers about their opinions of available inclusive design techniques and tools and their tendency to use those techniques and tools. We then presented our designers with the interactive design advisor tool built in Google SketchUp. Although the tool was in the very early stages of development, it exemplified an interactive way to supply designers with information about inclusivity. Through using the tool, designers were encouraged to talk about pros and cons of the tool. We also asked the designers to provide more detailed information about their current practices. The results confirm that tools, such as guidelines, user testing, and physical simulations, all have limitations that restrict their adoption by designers. Also, inclusive design advisors, such as the tool developed in Google SketchUp, could be accepted by the design community if the tool is tailored for each design domain and the tools that they use. Additionally, the designers highlighted that they would consider inclusivity if it is part of the design requirements. Moreover, they underlined the need for supplying inclusivity information to clients—who commission the project and who own the final product.

Keywords

inclusive design, industry, design process, designers, clients, accessibility, design domain, end-users, inclusivity, new product development

Introduction

This paper forms part of an ongoing research project that has studied ways in which inclusive design could be accommodated into design processes in industrial contexts. Past research indicates that one way of addressing accessibility problems is by supplying designers with tools and methods (Beecher & Paquet, 2005; Maguire, 2001; Vanderheiden & Tobias, 2000). This would enable designers to evaluate the physical interactions that occur between users and new concept designs, as well as to understand their impact on users with limitations.

The next two sections analyze some of the accessibility evaluation tools and techniques that are currently available, and could be used by designers, and reviews common industrial design practices as they relates to these tools and techniques.

Accessibility Evaluation Techniques and Tools

The need to enable product design teams to understand end-user requirements has driven experts, for many years now, to develop an extensive range of techniques and tools. These techniques and tools vary in format and scope and include guidelines, user participation, and physical or digital simulation tools.

Guidelines

There is a range of checklists, standards, and guidelines suggested by many experts as a way to guide designers to address the needs of end-users (Nicolle & Abascal, 2001). For instance, the World Wide Web Consortium (W3C) has developed standards and guidelines for designing accessible websites (http://www.w3.org/TR/WCAG20/). Some guidelines are presented as lists of general user requirements that designers should cover in their new concept, whereas other guidelines are more specific in providing information about dimensions of a product or product features. For instance, the *Access to ATM - UK Design Guidelines* explores user's anthropometric data and their relationship to product dimensions (guidelines are available at http://www.cae.org.uk/publications_list.html).

In some cases, guidelines are used very early in the design process to define the general user requirements that designers should consider when designing a new concept. In other cases, where the guidelines are more specific, designers can use guidelines as a checklist to evaluate their new design concepts. In the latter, the guidelines can provide information about physical characteristics that the new concept should include for users. For example, guidelines could include preferred user requirements for certain products or users, such as dimensions, materials, color, density, maximum noise produced, maximum force required, etc. The scope of guidelines varies from general requirements to specific information depending on the type of product under development. The guidelines' data are normally presented in descriptive texts and tables.

User participation

User participation is included in usability tests, user observation, user co-designing, and, more recently, user theater. The impact of the results is directly related to the method used, the recruited sample of users, and the stage of the project where it is applied. If usability tests are applied during the design process and include some participants with disabilities, many issues that relate to inclusivity would be radically reduced, thus enabling more users to enjoy the benefits of inclusively designed products.

Direct user participation in the design process is a well known way to enable designers to understand users' needs and desires (Allsop, Holt, Gallagher, Levesley, & Bhakta, 2010; Green & Jordan, 1999; Norman, 2002). This helps designers fulfil the needs of a broader range of the population, including elderly and disabled people. Users can participate in different phases of the design process:

- Before the generation of conceptual designs by letting users interact with products similar to the product that will be developed (Eisma et al., 2004; Newell, Carmichael, Morgan, & Dickinson, 2006)
- During the conceptual phase by enabling users to co-design a product (Rode, Toye, & Blackwell, 2004; Sanders, 2000)

- Later in the conceptual phase by involving users in the design iteration evaluations and testing of prototypes (De Couvreur & Goossens, 2011; Stappers, van Rijn, Kistemaker, Hennink, & Sleeswijk Visser, 2009)

Physical simulation tools

To help young, able-bodied people understand the limitations of physical impairments, designers developed an apparatus (approximately three decades ago) to simulate the loss of physical capability. These types of apparatus, or tools, have been used in lectures, workshops, and training sessions (Hitchcock & Taylor, 2003; Moore, 1985). Some recent versions of this tool include Third-Age Suit, Age Explorer, and Simulation Toolkit [1]. All of these tools have braces, pads, and other physical restrainers sewn into the suit. They also have fogged or yellow spectacles to limit the vision and, in some cases, earmuffs to decrease the wearer's hearing capability. The Simulation Toolkit was created with adjustable features to enable the wearer to simulate gradual difficulties from different levels of impairments, a characteristic that is not present in the Age Explorer and the Third-Age Suit (Cardoso & Clarkson, 2007; Meyer-Hentschel, 2007).

Product designers can use these tools in a product's conceptual phase to simulate an evaluation based on user disabilities. If the tool is used with similar products, the results help designers understand user problems and can design prototypes that alleviate those problems. If the tool is used during rapid prototypes trials, then the results might indicate the changes that should occur with the design under development. In both cases the outcomes rely upon the way the task is simulated and problems prioritized.

Digital simulation tools

Similarly to the physical simulation tools, there are digital simulation tools to evaluate a product's design. There are a variety of digital human modelling (DHM) applications developed to simulate human interactions virtually (Duffy, 2009). These computer-based tools are integrated into CAD models that enable designers to assess design concepts during the conceptual phase.

Among the digital simulation tools available, the following tools include programming to highlight inclusive design approaches and are the most common in academia:

- HADRIAN (Porter, Case, Marshall, Gyi, & Sims Neé Oliver, 2004)
- INCLUSIVE CAD (Macdonald et al., 2007)
- VERITAS (VERITAS D4.1.3_v2, 2010)
- VICON (Kirisci, Thoben, Klein, & Modzelewski, 2011).

The simulation results depend on the anthropometric data set and the ergonomic methods used in the applications, as well as the task performance simulated by the designer. The task simulation is normally performed according to the designers' assumptions, which might be defined by their knowledge of the product, the users, and the interaction the users will likely have with the product (Lämkull, Hanson, & Roland, 2009).

The Use of Accessibility Evaluation Techniques and Tools in Industry

Although the range of techniques and tools described in the previous section are currently available to evaluate accessibility in new product development, these tools and techniques have not been widely used by industry (Zitkus, Langdon, & Clarkson, 2011). According to past research, the industrial adoption of accessibility evaluation tools is strongly connected to their impact on the design process and the design activity. This means that such tools should be cost effective for the company and should be easily integrated to the time and budget allocated to the project (Vanderheiden & Tobias, 2000). Additionally the benefits of using these tools and techniques should be clear to the design team (Goodman-Deane, Langdon, & Clarkson, 2010). However, the following aspects of the accessibility evaluation techniques might affect acceptance in industrial contexts:

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[1] All the three simulation apparatus are commercially available: http://www.age-simulation-suit.com, http://www.mhmc.de, and http://www.inclusivedesigntoolkit.com/betterdesign2/gloves/gloves.html.

- According to Burns, Vicente, Christoffersen, & Pawlak (1997) one of the reasons that designers rarely search guidelines during the design activity phase is the lack of contextual or specific information. This weakness, added to the differences among the theoretical basis of guidelines, probably hinders their use. Although "the need for internationally coordinated standards" was recognized and actions were recommended by Stephanidis and Salvendy (1998, p.126), there is still no significant progress in harmonizing international guidelines. Additionally, guidelines' data are presented in descriptive texts and tables, which is not an effective way to display data for designers, as pointed out in past studies (Macdonald et al., 2007; Milne et al., 2005).
- The value of user participation techniques is often undermined by the time needed to recruit and select a representative sample of users. As a result, user participation is rarely adopted in industrial contexts (Sanford, Story, & Ringholz, 1998). In addition, although the involvement of elderly and disabled users in the design process is generally recognized as beneficial (van Rijn, Sleeswijk Visser, Stappers, & Özakar, 2011), concerns about ethical issues, such the vulnerability of elderly or disabled people, is often cited by industry as reasons to not engage in this technique (Newell, Carmichael, Morgan, & Dickinson, 2006). Moreover, when reassessing a product's design changes, a company will need to recruit additional end-users, which adds time and energy to the process.
- Physical simulations are time consuming because gathering data for multiple disabilities means that a user must calibrate the tool multiple times to gather different levels of impairment data. Moreover, reassessing the product's design changes means someone will have to repeat this procedure, which adds time and energy to the process. Additionally, task performance and design problems are prioritized based on a designer's assumptions, which can produce erroneous assessments.
- Similarly to physical simulations, for digital simulation tools, the task performance and design problems are prioritized based on a designer's assumptions, which can produce erroneous assessments. Some tools provide pre-recorded videos that designers can watch to see exactly how some people use products. Watching these videos can provide a reference for designers when they are digitally simulating a task while developing a product. This visual reference can help to limit some erroneous assessments and guide designers toward more accurate design choices. For instance, HADRIAN has a library of videos that show different users performing a range of tasks, such as the different coping skills used by people with disabilities to use certain products (Marshall et al., 2010).

Despite the risk of incorrect assumptions, the digital simulation tools are the most integrated approach used by design teams among all the techniques and tools reviewed in this section. The integration of CAD software with accessibility tools facilitates quick feedback and stimulates design discussions during the design process (Loudon & Macdonald, 2009). Moreover, considering the industrial context, it is important to emphasize that the impact on the design process (time and budget) can be minimal when using CAD models. In our experience, the earlier a concept design meets the users' requirements, the fewer the changes to the design process, and thus, those changes are likely to be implemented.

Figure 1 shows the accessibility evaluation techniques and tools in coordination with the design process.

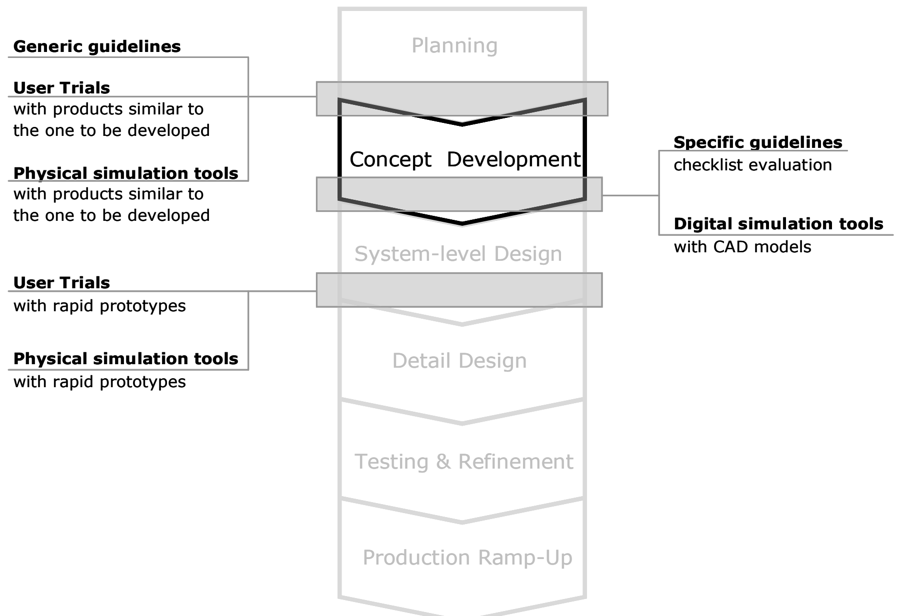

Figure 1. The integration of accessibility evaluation techniques with the design process (also named concept development in the process adapted from Ulrich and Eppinger, 2008)

Apart from the guidelines, the other accessibility evaluation techniques and tools presented in Figure 1 are strongly based on task performance of a product. We recognize that there are design features in everyday products that by their user-demand exclude part of the population. For instance, some products have small buttons placed close together that make the buttons difficult to see and press for people with vision or dexterity problems. Other examples include products that are too heavy for elderly people to carry, products that use text fonts that are too small to read, or some products use foreground and background colors that are illegible for colorblind users. However, in spite of those major limitations, designers could still include small changes in their designs, such as having the option to change the font size or color or background color, to make a final product more accessible to a wider range of users—or consumers

The approach of our research is to show that, in many cases, by making small changes in design features, designers end up with more inclusive products. Therefore, uncomplicated accessibility evaluation techniques and tools that overcome small problems could be integrated into the design activity. The subsequent sections present our investigation of how we demonstrated the inclusive design tool and then discussed the implications and challenges of using such a tool within industrial design practices.

Methods

We conducted the study with 20 experienced industrial designers from six European design consultancies. The design consultancies specialize in product design, research, and innovation for a broad range of industrial sectors and clients. The sample of designers included product and interface designers of everyday small appliances, such as kettles, phones, remote controls, and toasters, as well as graphical designers and packaging designers.

We gathered data by observing and interviewing the designers. We observed how the designers work and how they conduct meetings. For example, we observed the tools that they used to sketch and model their designs and how they researched and presented new ideas in design meetings. We interviewed designers in five of the six design consultancies; we only observed designers in the sixth design consultancy. We took notes during the observations and completed in-depth interviews after the observations. We conducted the in-depth interviews in the designers' work environment where we had the chance to see mock-ups, sketches, and photorealistic presentations of design concepts. This helped us to understand what the designers were describing in the interviews. We audio-recorded the interviews and then transcribed the conversations later.

At the beginning of the interviews, we asked the designers to describe their background, their experience in the field, and their role in the consultancy. The experience of the 20 designers varied from junior designers to senior industrial designers and the heads of design teams. Only three designers had less than four years of design experience. The majority of them had more than 10 years, and seven of them (head of design teams) had more than 20 years of design experience. The interviews focused on how the design process starts and progresses, the role of the designers, how user and other design requirements are specified, and how they evaluate new concept designs. The names of the companies and the designers have been replaced by titles like "Company A" and "D1" to maintain the anonymity of all participants. Table 1 details the number of participants in their respective position, company, and the way they participated in the study.

Table 1. The Participants' Specialization and the Study Participation

Company	**No. of participants**	**Participant specialization**	**Study participation**
Company A	2	Product Design Managers	Interviewed
	2	Product Designers	Interviewed
	1	Interface Designer	Interviewed
Company B	1	Product Designer Manager	Interviewed and observed
	1	Packaging Designer Manager	Interviewed
	4	Product Designers	2 interviewed and 2 observed
	1	Packaging Designer	Interviewed
	1	Graphic Designer	Interviewed
Company C	1	Product Designer Manager	Interviewed
	1	Product Designer	Observed
Company D	2	Product Designers	Interviewed
Company E	1	Product Designer Manager	Interviewed
Company F	1	Product Designer Manager	Observed
	1	Product Designer	Observed

Near the end of each interview, we presented each designer with an interactive "inclusivity" or accessibility tool developed in Google SketchUp, which is a three dimensional (3-D) modeling software that is available for free[2] (the script language is also freely available). We wanted to provide designers with an interactive tool built into a 3-D context because these are the types of tools that designers are familiar with. Although this tool was in the very early stages of development, it was something that designers could use that exemplified an interactive way to supply designers with information about inclusivity. We built this tool using simple codes in the Ruby program language. The interactive settings were not fully implemented as it was in the development phase. Therefore, the tool was only used for demonstration purposes. We demonstrated the tool for the participants. The example emulated the design of a simple medicine pack and proposed an interactive way to check the legibility of the letters on the pack. The demonstration (illustrated in Figures 2 to 5) followed the sequence below:

[2] Google SketchUp is a free 3-D modelling tool that can be used in architectural, engineering, or industrial design projects with an online 3-D models repository and integration to Google Earth. Free download is available at http://www.sketchup.com.

1. Design a box (with color and material) and add text (with font size and style).

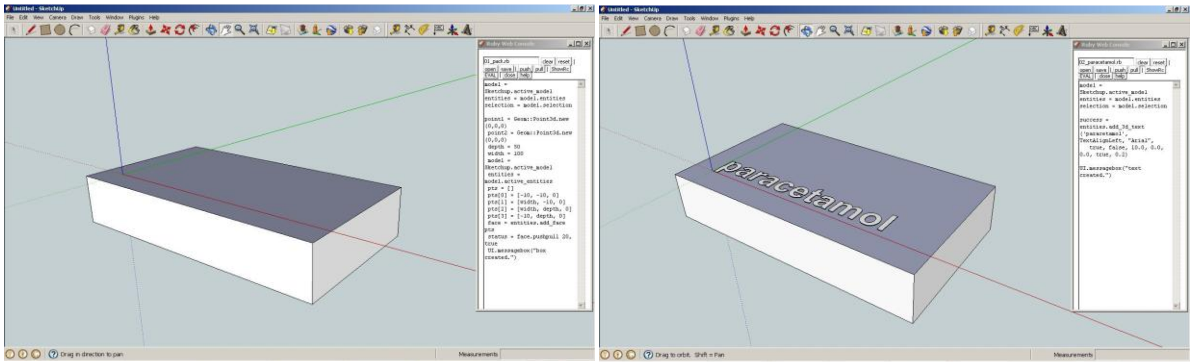

Figure 2. Designing a box (left) and adding text (right)

2. Set the ambient light and set the reading distance.

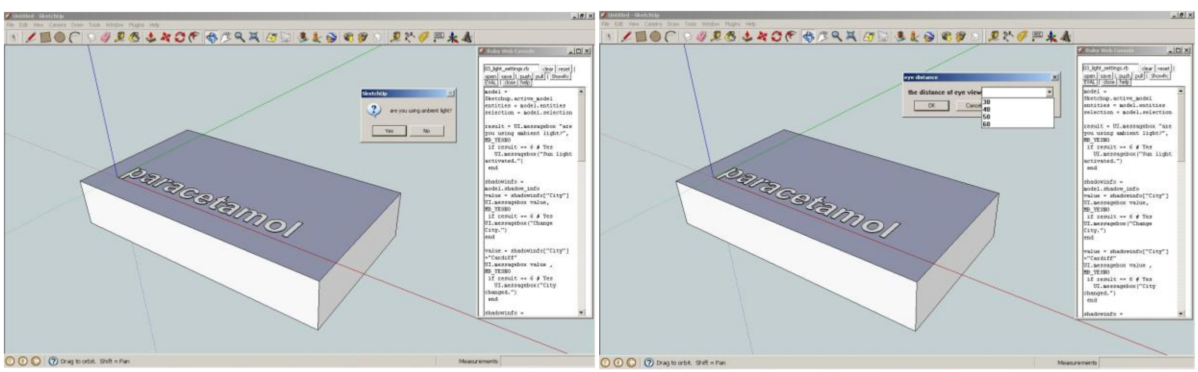

Figure 3. Setting the ambient light (left) and the reading distance (right)

3. In the **Tools** drop-down menu, select **Inclusive design**, then select **visibility test**.

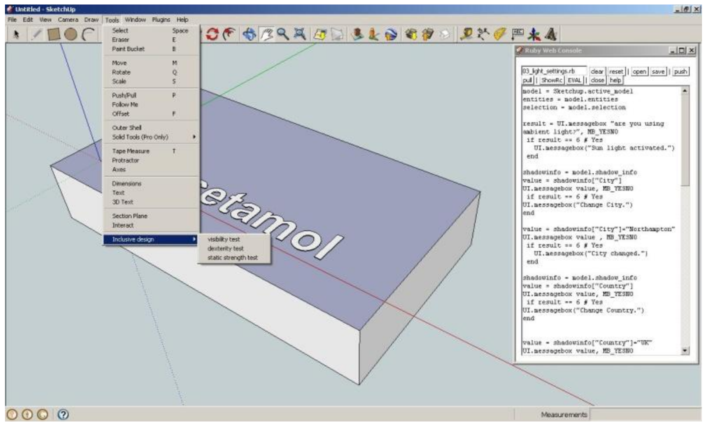

Figure 4. Selecting the inclusive design test, in this case, visibility

4. An alert box opens that describes the range of population excluded from reading the text on the box and gives some advice regarding font size, style, and background/foreground color contrast.

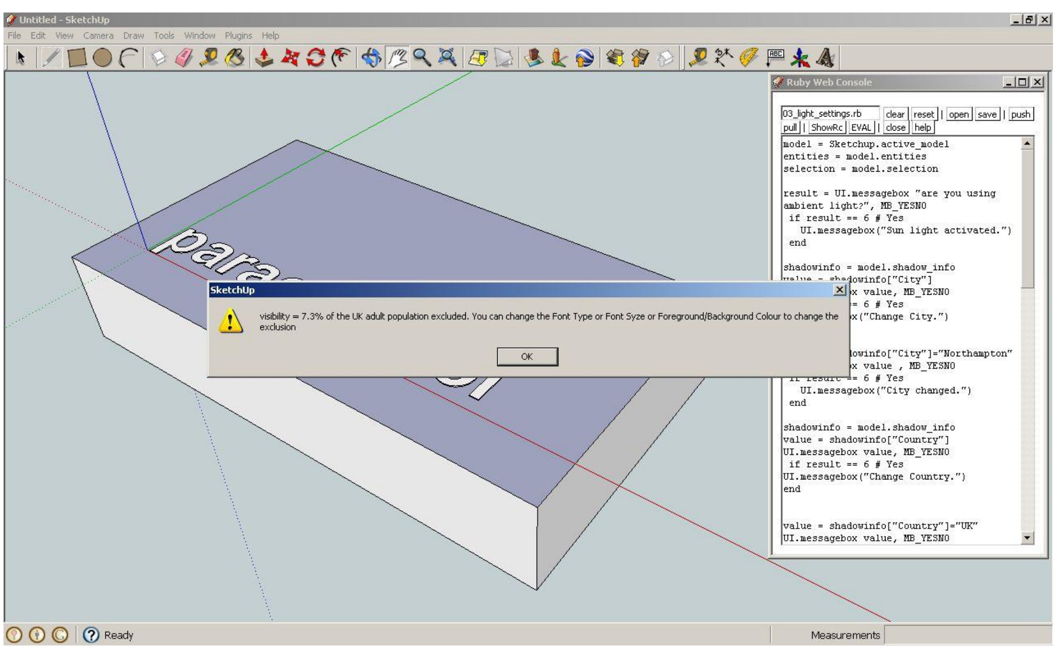

Figure 5. Showing the inclusivity result of the visibility test—an exclusion of 7.3% of the UK adult population

The reason for showing an alert box (or message box), such as the one in Figure 5, is to give designers an understanding of how inclusivity information could be useful in understanding the needs of potential users of a new product. The recommended action that follows the inclusivity information can guide designers toward creating more legible, or more inclusive, features.

This tool demonstration stimulated conversations among the designers. They talked about the pros and cons of the tool's interface and the functionality of an inclusive tool. They also talked about the information provided by the tool and how it relates to current design practices. As mentioned before, we recorded these conversations and transcribed them later. Portions of the conversations are highlighted in the following Results section.

Results

We added the transcripts from the interviews to the observation notes and then coded and categorized them using Atlas.ti, which is a computer program mainly used for qualitative data analysis. Codes in this study represent facts, behavior, process, procedures, and other aspects that are related to a design process or constitute a design activity. We took care to ensure that the same code was not duplicated for a single participant under the same interview topic. This procedure prevented the reoccurrence of codes that were only based on single views, which legitimized the growth of each code according to its reoccurrence and its relationship to other codes or co-occurrence according to each participant's views. Every time relevant information was recognized by the software in a transcript, old transcripts were re-analyzed to find out how the views of past participants related to that particular aspect (Corbin & Strauss, 1990).

To gather designers' opinions about the design process, the differences between design domains, and the understanding of clients' roles, we summarized, framed, and presented the major findings of this study to the designers—our participants. The outcomes of these feedback sessions helped to correct misunderstandings and confirmed some of the results, but also brought new insights to this type of research.

In order to triangulate our data, we used multiple data sources: different research methods (including the continued presentation of our research outcomes to the designers) and a careful coding process.

Inclusive Interactive Tool for the Design Practice

The first and most important issue was whether the designers believed that an interactive tool built into design software would be useful. The designers had a positive response to the concept. The product designers associated the inclusive design advisor tool with tools to evaluate the mechanical or structural aspects of 3-D models, such as mould flow, stress-strain, and finite element method analyses tools, for example. Most of the product designers compared the 3-D inclusive design advisor to mould flow analysis, which is a software used to validate the design of plastic parts and injection moulds by emulating the moulding process. The use of such a tool reduces the need for prototyping design concepts and the risk of manufacturing defects.

All product designers we interviewed liked the idea of using 3-D software to incorporate an inclusive design analysis. However, they did say that the interface could be two dimensional, but it should be integrated into a CAD software (such as SolidWorks or Pro-Engineer) but not Google SketchUp. The comments below illustrate their sentiments (the reference is the participant ID, for example, D2 is designer number 2).

> *"So, if there was a tool which can plug into CAD which allow us to set up different ergonomic parameters, certain aspects of dexterity, or visual acuity, or things like that, and then to be able to see and to get some kind of feedback with that. So, that would be useful, I can't see why it wouldn't be. . . . A support system in CAD can pull in data of different areas. . . . If the principle is to design in CAD, I think you should have as much information as possible in that environment" (D2).*

> *"Two dimensional could be useful in 3-D software, not in terms of graphic stuff, but I guess a 2-D ergonomic database.. . .That easily gives you that information—it would be quite useful" (D4).*

According to some product designers and all other designers (packaging, graphic, and interface designers) an interactive advisor related to the legibility of text, icons, or any other graphic interface should be built for graphic designers into their respective tools.

> *"I think that most of the design agencies use Illustrator or Photoshop. So if it is incorporated on that it would be part of the tool* [we] *are used to use*[ing]*" (D5).*

Many of the comments, however, highlighted that while the designers liked the concept of the tool, the adoption of such a tool would be guided mainly by the needs of the client[3] instead of the designers' work routine. In the next sections, we analyze the process described by the designers that justifies these comments.

What Drives Design Activity

The interviewees among different design teams mentioned a similar process that happens at the initial stage of the design process. Usually, designers are guided by a brief—a document that provides information about the new product's functionality, components, manufacturing, environment considerations, and potential user's characteristics. Regarding the latter, participants emphasized that user's data are restricted to market views, which means target market and commercial requirements. User's information is normally general demographic information like age or social class.

> *"It* [the brief] *is pretty much sketching information in terms of detail. It will be more related to functionality, actually with commercial requirements, target market, 50 to 80 years old people. . . . The detailed user requirement beyond demographics is rarely passed on" (D12).*

> *"About the user . . . how it is specified, it tends to be a target user group and that can be quite unsophisticated. . . . One* [client] *said when I asked about the target market, 'It is for someone like you. . . .' So, it needs some discussion to figure out what is like that. . . . But largely they* [the client] *would speak about the target market" (D7).*

Accessibility, however, "is not something that always got designated time within the process" (D1). In fact, according to the designers, sometimes the brief is focused on a main issue or a key requirement that drives the design activity, which may compromise other requirements. For instance, some designers mentioned "design for manufacturing" or "emotional design." The comments below describe types of key requirements frequently received from clients:

> *"The requirement of the project might be a simple aesthetics job. It might be the case where someone comes to us with a pack of components and they want a pretty box" (D3).*

> "[The design] *is also to solve problems like a bottle neck in production. So,* [it] *doesn't change the product to the user, very much, but it is a massive change for the company and they can produce much more quickly" (D9).*

Nevertheless, according to the designers, if it is part of the project requirement to consider accessibility, then they usually look for data in books, tables, the Internet, or specifications in guidelines.

How Designers Use Accessibility Tools

As user's data is quite limited in the brief, designers have to manage their time and budget to get user's information from other sources. The designers mentioned that often some research starts taking place earlier in the conceptual phase. The research can happen in different ways to provide different information, such as competitors' data, technical specifications, and also user's information.

We observed that the Internet was very useful in supplying one of the designers with technical data of components. Another designer found ergonomic data, and two other designers found information with technical data about materials on the Internet. The interviewees confirmed that the Internet is used to find out more about end-users, but designers outlined that in some cases they also follow specific guidelines while designing.

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[3] Client in this paper is the person who represents the interests of the company that is hiring the service of the design agency. The client commissions the project to the designers, as well as takes part in meetings to discuss or select design proposals.

How guidelines are used at this stage

The responses indicate that designers mainly rely on guidelines, though their comments also highlighted that they find the information of these sources deficient and sometimes incompatible to their needs. They mentioned that they balance the deficiency of the guidelines by including some live assessments, such as self-evaluations and user trials, as highlighted in the comments below.

> *"A lot of it* [the adequacy to user requirements] *is based on common sense. We tend to tell to ourselves what is legible or not. . . . I think lots of it comes with experience. The way our minds work it becomes obvious if something is small and illegible. . . . There are standards which drive how large a piece of text should be. You can print things out in various sizes and get feedback from the user group" (D3).*

> *"I think lots of time*[s] *that happen*[s]*—that stuff* [accessibility considerations] *comes from experience. . . .You are making subconscious decisions of what is good and bad accessibility. So, I think most of that* [is] *coming from trying and testing ways of doing things" (D6).*

> *"My approach would be to print out or to create different variants of the design and then just test that with people. . .talking to people" (D1).*

How user trials are used at this stage

Although the possibility of incorporating users in accessibility tests was mentioned, all interviewees stressed that user observation or user trials only take place in the process if the client considers it important and the funding is provide in the budget, which rarely happens. As a result, user's involvement in the process scarcely occurs.

> *"…even when I worked in companies that project things specifically for the elderly, it was rare in the extreme anybody who was elderly would be involved in the process. . . . The users were not part of the process" (D2).*

It is important to underline that the designers highlighted that the user's needs, such as those related to accessibility and usability, are only one part of the requirements that the designer has to deal with. They emphasized that design is a compromise activity, where decisions are made all the time and costs are involved in every option taken. However, the observations did not highlight whether the process of searching for users' data is rigorous.

> *"… the product is not only the users themselves, we have to consider who's gonna assemble it by making assembly easier. How it is built. If it's gonna need maintenance. . . . And at these days, going through the product* [life cycle]*, at the end of its life and the need for being recycled" (D13).*

> *"Historically in packaging I reckon that it can be sometimes* [a] *more cosmetic approach. The focus is on maybe the visual identity of the pack, the brand . . . because to be honest, in many stages there are simple costs and practicality costs, but all are the primary drivers before we get* [to] *things like accessibility" (D8).*

It seems to us that among the designers interviewed and observed there were two groups:

- Designers who are more proactive in terms of user requirements research. They look for other means to understand the end-user as a way to add value to the design. They responded positively to the presented inclusive design advisor tool.
- Designers who are used to and satisfied with self-evaluation of concept designs. They seem to think that their experience and knowledge about users are enough to cope with accessibility and usability of new designs, given the usual constraints of a project's resources. Hence, for them, the need for an inclusive design advisor is not a priority.

Both groups, however, highlighted that the views of the client regarding the end-user are mandatory in order to implement a more user-centered design process. According to this study, often the designers do not take into account the end-user capabilities unless it is required in the brief to conduct usability tests. During this study's interview and observation process, our research group's general impression was that the focus of the designers' higher-education was on the aesthetics and functionality of new designs and that users' capabilities were not considered a high priority, if considered at all. If designers were trained to consider the diversity of end-users' capabilities as a design priority, they would incorporate time for inclusive design analysis (whether user trials or another accessibility/usability evaluation method) in their work routine in the same way that they incorporate time for creative work.

The Relevance of the Information About Inclusivity

Another aspect of the inclusive interactive tool that caught the designers' attention was the percentage of the UK adult population excluded. For the designers there is always a target market that guides the design activity. Exclusion information based on a percentage of the entire population is generally not considered a significant factor in a product's target market.

> *"In nearly all of the products we work on, the portion of the population might not be applicable. . . . We would assume that some people will be excluded, and that is acceptable for that product be successful. Still it is from client perspective . . . I'm not sure. When you get a result like 7.3% of the population will be excluded, the question is which part of the population is it talking about? Because if it is excluding 80% of people over 75 years old females from North East, so that is really important if the product is aiming that. . . . The detail of that is useful; that is what we need to know I guess" (D2).*

According to half of the designers interviewed, noting the percentage of the population that could be excluded from using a product would be valuable if it could be divided into demographic groups—age, social class, etc. These groups are often associated with market requirements. The other half did not comment on this specific matter, they only highlighted that they work with a target market that is established by the client. Therefore, according to their responses, the exclusion percentage is irrelevant if the client is not targeting the group that is being excluded.

The Designers' Responses Compared to Previous Studies

The designers' responses to this study confirmed that direct involvement with users rarely happens in commercial projects, which is a problem already underlined in past literature (Dong, Clarkson, & Cassim, 2005; Sanford, Story, & Ringholz, 1998). Any extra information regarding user's data should come from the designers own research. This research, however, is limited due to the project's budget and timescale, as a result of which user's requirements may be restricted to ergonomic tables available in books or on the Internet. However, these tables generally do not consider a wide range of people, including the elderly and the disabled.

In situations where accessibility is part of the design requirements, then the designers mentioned that they would use guidelines to comply with the users' needs. However, in this study, the deficiencies of guidelines are confirmed by many of the participants' interview responses. The broader the scope of guidelines the less it supports the design activity (Burns et al., 1997; Choi, Yi, Law, & Jacko, 2006; Law, Yi, Choi, & Jacko, 2008).

The Designers' Responses to the Inclusive Design Advisor Tool

In the interviews, the designers gave their opinions about the practicalities on how the inclusive design advisor tool could be integrated into their current development process and the relevancy of the information that a tool, such as the inclusive design advisor, provides.

The inclusive design advisor tool

The idea of providing designers with an interactive tool built into the tools they use in their work routine was well accepted. However, there was a difference of opinion here. In the industry, product designers tend to design in 3-D modeling tools, such as CAD, and at some point all the information about the new concept, including graphic information, is integrated in this software to produce a photorealistic rendering. However, in other design domains, designers do not use 3-D modeling software. For instance, designers told us that packaging design does not necessarily use CAD software; it depends on the type of package being developed. For example, cardboard packaging design generally uses graphic programs, such as Corel Draw or Illustrator, to design the packages. There is no need to make a 3-D digital model because the package that is produced has to be opened or cut-out from flat cardboard. Moreover, it is unnecessary to use a 3-D CAD program to design all the graphic design elements that are featured on the package. Those design elements can be produced in Photoshop or Illustrator, which are both 2-D graphic software programs. Consequently, as professionals in accessibility and usability, we need to consider the variations across different design domains before proposing inclusivity interactive tools incorporated into design tools.

Although the product designers stressed that an interactive tool should be built into 3-D modeling tools, none of them were users of Google SketchUp. They mentioned that they use other software like ProEngineer, SolidWorks, Rhinoceros, and Alias. We chose SketchUp, however, based on its free availability and free access to the program language.

The information provided by the tool

From our interviews and observations, it seems that designers think about a target market within an entire population and that some people will naturally be excluded from this target market. As mentioned by Gill (2009), small- to medium-sized design consultancies tend to face the pressure of costs and tight deadlines from the client that constrain designers' decisions. Therefore, unless clients request specific inclusive designs or designers can convey to their clients that the benefits of improving the design to be inclusive is to their advantage, our objective of providing more inclusive information using design tools will not succeed. Therefore, information on inclusion is not only a matter for designers and their consultancies, but a matter for clients to consider as well.

For future studies, we need to rethink our approach and explore other possibilities to show the lack of inclusivity in design concepts and products. The question is how can we help commercial industries accept the need to make products a little more inclusive and how can we develop tools or techniques to help industry achieve this?

Recommendations

The study highlighted the current way in which designers evaluate users' requirement and how an inclusivity tool could be adapted to the design practice. Therefore, the findings indicate the need for future work in the following areas:

- **Inclusive design tools.**
    - Incorporate an inclusive design advisor into different computer graphic tools to work in tandem with a range of design domains. For instance, depending on the type of object or design, a plug-in application could be developed for the types of software used in the industry to make products, packaging, and graphic elements.
    - Test the inclusive design advisor tool by studying it in the field with actual products being developed. In doing so, tool developers could gain essential knowledge into the inclusive design research field. Developers could see whether designers would consider the results of the tool and change the design of a product to be more inclusive. Tool developers could also see to what extent designers are able to make decisions without consulting the client.
- **Clients.** Interview clients and observe them at client/designer meetings to understand the influence and role clients have in the design process. This would contextualize the client/designer dynamic alongside the design process. In addition, it could clarify the type of inclusivity information that is effective to clients.
- **Education.** Provide information and education about the importance of inclusive design. According to this study, some of the designers self-evaluate the products' accessibility for users. Some designers that participated in this study do not see the need to apply inclusive design techniques or tools in their practice.

Based on this study, it seems to us that not all the designers consider the value of inclusive or universal design—the value being to promote independent living and to reduce frustration when using a product. Therefore, some of them are not fully motivated to sell the benefits of inclusive design to their clients.

In addition to educating and providing more information to the design industry, future research could evaluate the role of higher education institutions to see if the programs are teaching and promoting universal or inclusive design.

Conclusion

Incorporating inclusive design advisors into computer programs already used in the design industry could be a viable way to integrate inclusivity and accessibility concepts and practices into the design process. Supplying demographic-specific knowledge about inclusion could be an effective way to help guide designers and their clients to see how designing more inclusive products can help their sales. Because, as we discovered during this study, the design process is often a trade-off between different client-driven priorities and requirements and the practicalities and costs of designing and manufacturing a product.

There also could be further investigation into ways to help designers and clients understand the benefits of universal or inclusive design. To accomplish this, there could be future studies that interview clients and observe client/designer meetings to discover the fundamentals of such relationships. Putting the client/designer dynamic into context may highlight how user requirements influence the design process and vice versa. Also, understanding the clients' motivations and requirements could clarify how an inclusive design advisor tool should and could work to inform clients and designers of inclusive design practices.

In this study, we examined the current industry design practice with the intention of developing or implementing an inclusive design tool. However, the results of this study show that the current non-adoption of accessibility evaluation tools is a systemic problem. Based on our interviews and observations, we discovered that it is not common for clients to include accessibility requirements into their product requirements. We also discovered that designers often do not evaluate accessibility or usability unless they are required to by the client. Therefore, to break this cycle it is necessary to work on different fronts: Design software plug-in tools to help clients and designers see the value of inclusive design, and provide information about the value of inclusive, universal design by investigating the client/designer dynamic and investigating to see if and how higher education presents and teaches inclusive, universal design to see if improvements can be made.

Tips for Usability Practitioners

We described an exploratory study investigating the industrial design practice in order to accommodate inclusive design techniques and tools. The following tips are recommended for those who may conduct exploratory studies with designers in industry:

- Take advantage of being in industrial settings. You may experience some challenges, for example, difficulties in planning activities and defining dates because the demands of the field and clients most often define those parameters. However, the value of working in the field rather than in a controlled, academic environment could provide very accurate and illuminating information.
- Provide designers with an interactive example of what you are proposing, even if it is in a very early stage of development. Although our tool was intended to exemplify an interactive way to supply designers with information about inclusivity, the tool also prompted valuable discussion among the designers about inclusivity.
- Present your findings to the participants to garner more feedback and comments. In the case of this research, the feedback sessions strengthen our relationship with the design consultancies and corrected misunderstandings that clarified and confirmed some of the results related to the design process.
- Use the media or tools that participants are familiar with. An example from this study would be using 2-D software (Photoshop, Illustrator, and Corel Draw) for graphic designers and packaging designers and using 3-D software (ProEngineer, SolidWorks, Rhinoceros, and Alias) for product designers and some packaging designers.

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References

Allsop, M., Holt, R., Gallagher, J., Levesley, M., & Bhakta, B. (2010). The involvement of primary schools in the design of healthcare technology for children. In P. Langdon, J. Clarkson, & P. E. Robinson (Eds.), *Designing Inclusive Interactions* (pp. 209-218). London: Springer.

Beecher, V., & Paquet, V. (2005). Survey instrument for the universal design of consumer products. *Applied Ergonomics, 36*(3), 363-372.

Burns, C. M., Vicente, K. J., Christoffersen, K., & Pawlak, W. S. (1997). Towards viable, useful and usable human factors design guidance. *Applied Ergonomics, 28*(5-6), 311-322.

Cardoso, C., & Clarkson, J. (2007). User simulation in product evaluation. In R. Coleman, J. Clarkson, H. Dong & J. Cassim (Eds.), *Design for Inclusivity - A practical guide to accessible, innovative and user-centred design.* Aldershot, Hampshire, UK: Gower Publishing Limited.

Choi, Y. S., Yi, J. S., Law, C. M., & Jacko, J. A. (2006). Are "universal design resources" designed for designers? *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility* (pp. 87-94). Portland, OR: ACM

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology, 13*(1), 3-21.

De Couvreur, L., & Goossens, R. (2011). Design for (every)one: Co-creation as a bridge between universal design and rehabilitation engineering. *CoDesign, 7*(2), 107-121.

Dong, H., Clarkson, P. J., & Cassim, J., Keates, S. (2005). Critical user forums - an effective user research method for inclusive design. *The Design Journal, 8*(2), 49-59 (1460-6925).

Duffy, V. G. (2009). *Handbook of digital human modeling: Research for applied ergonomics and human factors engineering.* Boca Raton, FL: CRC Press, Taylor & Frances Group.

Eisma, R., Dickinson, A., Goodman, J., Syme, A., Tiwari, L., & Newell, A. F. (2004). Early user involvement in the development of information technology-related products for older people. *Universal Access in the Information Society, 3*(2), 131-140.

Gill, S. (2009). Six challenges facing user-oriented industrial design. *The Design Journal, 12*(1), 41-67.

Goodman-Deane, J., Langdon, P., & Clarkson, J. (2010). Key influences on the user-centred design process. *Journal of Engineering Design, 21*(2-3), 345-373.

Green, W. S., & Jordan, P. W. (1999). *Human factors in product design: Current practice and future trends*. London: Taylor & Francis.

Hitchcock, D., & Taylor, A. (2003). Simulation for inclusion - True user centred design? *Include 2003 Conference Proceedings*. London.

Kirisci, P. T., Thoben, K.-D., Klein, P., & Modzelewski, M. (2011). Supporting inclusive product design with virtual user models at the early stages of product development. In S. J. Culley, B. J. Hicks, T. C. McAloone, T. J. Howard, & A. Dong (Eds.), *Vol. 9 - Design methods and tools part 1* (pp. 80-90). Presented at the International Conference on Engineering Design (ICED11). Somerset, UK: The Design Society.

Lämkull, D., Hanson, L., & Roland, Ö. (2009). A comparative study of digital human modelling simulation results and their outcomes in reality: A case study within manual assembly of automobiles. *International Journal of Industrial Ergonomics*, *39*(2), 428-441.

Law, C. M., Yi, J. S., Choi, Y. S., & Jacko, J. A. (2008). A systematic examination of universal design resources: Part 1, heuristic evaluation. *Universal Access in the Information Society*, *7*(1-2), 31-54.

Loudon, D., & Macdonald, A. S. (2009). Towards a visual representation of the effects of reduced muscle strength in older adults: New insights and applications for design and healthcare*. Proceedings of Digital Human Modeling: Second International Conference, ICDHM 2009*. San Diego, CA: Springer.

Macdonald, A. S., Loudon, D., Rowe, P. J., Samuel, D., Hood, V., Nicol, A. C., (2007). Towards a design tool for visualizing the functional demand placed on older adults by everyday living tasks. *Universal Access in the Information Society, 6*(2), 137-144.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies, 55*(4), 587-634.

Marshall, R., Case, K., Porter, M., Summerskill, S., Gyi, D., Davis, P., & Simms, R. (2010). HADRIAN: A virtual approach to design for all. *Journal of Engineering Design, 21*(2-3), 253-273.

Meyer-Hentschel, G. (2007). Design goes universal. *Thexis – Fachzeitschrift für Marketing* (24) 28–32.

Milne, S., Dickinson, A., Carmichael, A., Sloan, D., Eisma, R. & Gregor, P. (2005). Are guidelines enough? An introduction to designing Web sites accessible to older people, *IBM Systems Journal*, *44* (3), 557-71.

Moore, P. & Conn, C. P. (1985). *Disguised: A True Story*. Waco, Texas: Word Books.

Newell, A. F., Carmichael, A., Morgan, M., & Dickinson, A. (2006). The use of theatre in requirements gathering and usability studies. *Interacting with Computers, 18*(5), 996-1011.

Nicolle, C., & Abascal, J. G. E. (2001). *Inclusive guidelines for human computer interaction.* London: Taylor & Francis.

Norman, D. A. (2002). *The design of everyday things*. New York: Basic Books.

Porter, J. M., Case, K., Marshall, R., Gyi, D., & Sims Neé Oliver, R. (2004). Beyond Jack and Jill: Designing for individuals using HADRIAN. *International Journal of Industrial Ergonomics, 33*(3), 249-264.

Rode, J. A., Toye, E. F., & Blackwell, A. F. (2004). The fuzzy felt ethnography—Understanding the programming patterns of domestic appliances. *Personal Ubiquitous Computing, 8*(3-4), 161-176.

Sanders, E. B. N. (2000). Generative tools for co-designing. In B. Scrivener & Woodcock (Eds.), *Collaborative Design*. London: Springer.

Sanford, J. A., Story, M. F., & Ringholz, D. (1998). Consumer participation to inform universal design. *Technology and Disability, 9*(3), 149-162.

Stappers, P. J., van Rijn, H., Kistemaker, S. C., Hennink, A. E., & Sleeswijk Visser, F. (2009). Designing for other people's strengths and motivations: Three cases using context, visions, and experiential prototypes. *Advanced Engineering Informatics, 23*(2), 174-183.

Stephanidis, C., & Salvendy, G. (1998). Toward an information society for all: An International research and development agenda. *International Journal of Human-Computer Interaction, 10*(2), 107. doi:10.1207/s15327590ijhc1002_2

Ulrich, K., & Eppinger, S. (2008). *Product design and development*. New York: McGraw-Hill/Irwin.

Vanderheiden, G., & Tobias, J. (2000). Universal design of consumer products: Current industry practice and perceptions. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 44*(32), 6-19-16-21.

van Rijn, H., Sleeswijk Visser, F., Stappers, P. J., & Özakar, A. D. (2011). Achieving empathy with users: The effects of different sources of information. *CoDesign, 7*(2), 65-77.

VERITAS D4.1.3_v2, V. (2010). *Project Presentation and Project Description Leaflet*.

Zitkus, E., Langdon, P., & Clarkson, J. (2011), Accessibility evaluation: Assistive tools for design activity in product development. *SIM Conference Proceedings, 1* (pp. 659-670). Leiria, Portugal : IST Press.

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