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PRODUCT ARCHITECTURE ISSUES WITHIN INCLUSIVE DESIGN

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Abstract

Inclusive Design and Product Architecture are rarely considered together within the design process. However, a user's needs are fundamental and should be incorporated into the process at an early stage. Currently where persons with impairments are considered in product design it results in supplementary features added to the exterior of the standard product. To include persons with many different requirements, the correct product architecture must be adopted to avoid an exceptionally costly mistake. This paper highlights specific prominent product architecture considerations and, with the aid of a case study into vacuum cleaners, shows how careful changes to the product and its features can include many more people in its target audience.

Many of the changes that can be adopted as a result of adopting an inclusive design approach, have wider benefits. With superficial changes the product often becomes stigmatised to younger, perfectly able users. However, if the changes are considered as part of a structured product architecture, they will often benefit all users achieving a better product for everyone. Upcoming legislation will force reluctant companies to consider this market vacancy, if they refuse to include impaired persons.

Keywords: inclusive design, product architecture, vacuum cleaner

1 Introduction

Designers seldom look to consider the needs of users with impairments in the requirements specification of their products. These users are often left with inferior choice or products from which they cannot benefit the full functionality. By aiming to cover users with substantially different abilities, designers must make important decisions in selecting an appropriate product architecture. This will be crucial to the economic success of the product which if achieved will in turn persuade internal decision makers and other companies of the merits of inclusive design. An expensive cost for many companies is the marketing and advertising to increase share within a particular market sector but appear to ignore the profitable opportunities presented by new market sectors. Governments are also beginning to legislate to ensure impaired persons are not discriminated by products and environments. Companies need to consider inclusive design now before they become legally bound to do and competitors steal market share.

1.1 Current situation

Populations in developed countries are getting older, as they do so impairments become more prevalent. There is also a considerable proportion in all countries that suffer from some

disability irrelevant of age. For the UK this, in total, is estimated at 15% for the entire working population – this increases to 34% if focused on the over 50's. It is clear that the elderly age ranges are important here, 33% of the entire population are over 50, but ageing populations are causing a demographic shift and by 2021 this sector will account for 50%. Most telling of all, 60% of UK Savings are held by people who are over 50 – this statistic should ring alarm bells in any company who dismisses designing to include people with impairments as not profitable. [1] [2]

Many companies don't consider this market, of those that do, the resultant alterations are usually superficial changes such as addition of Braille or using bigger handles. Few companies consider designing for the impaired user at the conceptual stage. Some add the inclusive elements afterwards from a marketing perspective to be seen to have included users with disabilities to those able-bodied users. An example of where this has been added as a gimmick and the usage not thought through properly is in cash machines or automatic telling machines (ATM's). Many include Braille, supposedly for the blind user, the reality is only 1% of persons with a visual impairment can read Braille [3]. In the case of the cash machine the irony stretches further than the statistics, all cash machines include screens with adjacent buttons whose function or value changes depending on which level the user is at in the menu system. The Braille indicating where the "Advice Slip" and "Cash" can be retrieved from is entirely pointless if the Braille reader cannot use the remainder of the machine. Such a cash machine can be seen in figure 1.

Figure 1 : Cash machines use Braille pointlessly

However, the story isn't all bad, there are companies who are making positive and beneficial steps towards designing more inclusively. British Telecom (BT) worked in collaboration with the Royal National Institute for the Blind (RNIB) and the Royal National Institute for the Deaf (RNID) to produce the Big Button Phone. This phone has bigger than average buttons with clear and large labels to assist those with visual impairments and large volume controls to amplify the sound for hearing impaired users. Within a month of its launch it was BT's 4th best selling phone and the 9th best selling on the high street. Although it isn't a market leader it has made BT substantial profits through design that is essentially common sense. [4]

Understanding how impaired persons use products is key to appreciating what alterations will be of real benefit. Many users work round the problems a poorly inclusively designed product introduces by developing "coping strategies". An earlier study [5] by the first author revealed is it common in the UK within the elderly market to find users with multiple radio sets, sometimes within the same room. The users highlight cognitive difficulties in retuning to different radio stations and also programming preset buttons. They buy multiple sets and ask relatives to tune them to different stations as a coping strategy. Specially designed gadgetry is also available to allow users to cope with problems such as food packaging. These often are poorly thought through and although allow the user to access a set of functions they would otherwise be excluded from, introduce a new set of dangers. The gadget shown in figure 2 is

Figure 2 : Jam-jar opening gadget

designed to help those with dexterity problems to open bottles and jars. It confuses the user interviewed and when demonstrating its use almost catch her fingers in its claws. [5]

Inclusive design focuses on users with impairments but its solutions often also benefit the perfectly able user who often find difficulties with standard products. Many people experience difficulties with vacuum cleaners particularly when carrying up and down stairs. A solution to help those with mobility and dexterity impairments in lightening the load of the cleaner but without reducing suction would equally benefit the ordinary user, developing a better product.

Every product is different and as a result the method adopted to design inclusively will vary from company to company. By encouraging companies to focus on inclusive design when they consider their product architecture, the advice will enable them to make an informed choice as to the best solution for them.

2 Product Architecture Spectrum

The spectrum identified in figure 3 shows a number of product architecture options to companies hoping to inclusively design. Several key points are highlighted and are explained in more detail below but it is important to realise this is a continuum and a company may find the ideal position to include as many as possible to be anywhere along it. Moving from left to right the number of product variants per customer increases. Although developing one product for all may seem the cheapest, to stretch a product's target audience to include all may become very expensive.

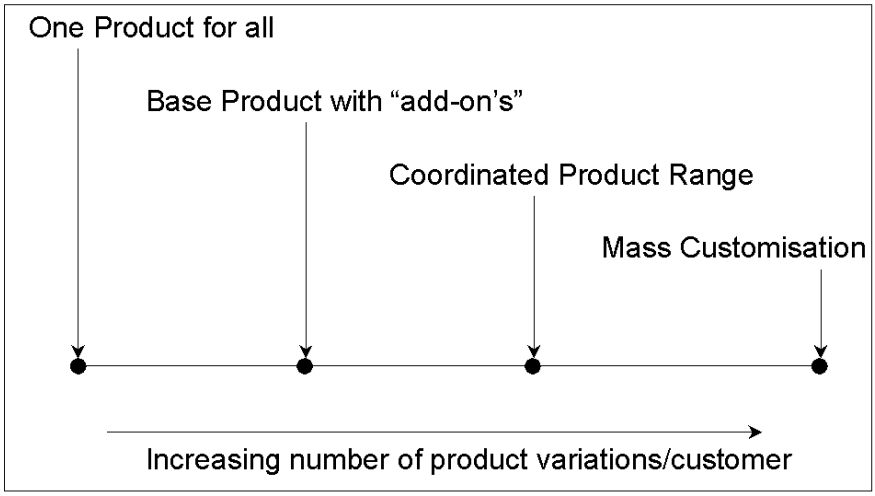

Figure 3 : Product Architecture Spectrum

By some it is considered that an ideal of inclusive design is “one product for all”, this allows everyone to use every product and avoids any exclusion. In figure 4(a) the circle represents the target population of the product, the square is the entire population. The aim of “one product for all” is to stretch the boundaries of the target population to include more, figure 4(b). Why this may be possible for simple products, as the complexity increases and the target population becomes more impaired, the regions that the one product has to cover become harder to reach, symbolised by the corners. There is also a danger as the product begins to include more impaired users it becomes stigmatised to the unimpaired user as in figure 4(d). The ultimate danger is to focus purely on the most severely impaired users and stigmatising the product to such an extent that no one else is interested in the product, figure 4(e). However one product for all is also identified as practically unacceptable – the cost to develop one product that works for every person regardless of impairment would be financially crippling for any company.

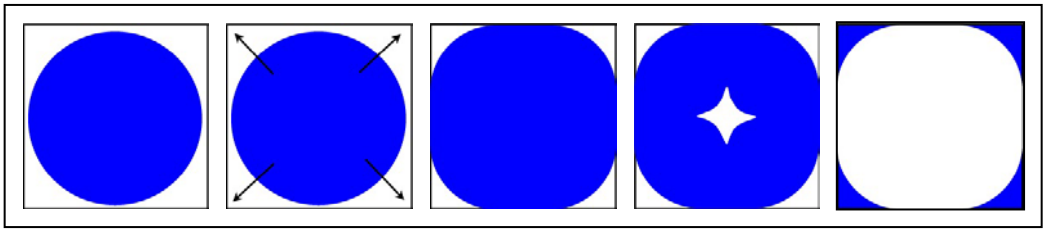

Figure 4 : (a) One for all (b) Push the target boundaries (c) Increasing difficulties (d) Danger of stigmatising (e) Ultimate danger

Increasing the number of variants leads to an architecture that uses a base product with “add-on” modular components. Socially this still holds some of the ethics of “one product for all” as everyone can use almost the same product. Economically it is more sensible to stop at some stage in developing one for all and focus on specific modules to cover other sectors, see figure 5(a). To illustrate these concepts, particularly suitable examples can be found within the car industry. A base product that has slight variations can be seen clearly in the Ford Galaxy, Volkswagen Sharan and SEAT Alhambra people carrier models. In this case, identifying one car as the base product, some features would have to be removed before the additional ones are added. All 3 cars are the same when considering the chassis and bodywork but variations are made to the interior controls and external styling features such as the headlights. Should this modular approach not make a substantial difference to the number of persons included, the variation can be made greater by decreasing the prominence of the base product, figure 5(b). The Fiesta, Puma and Ka all feature the same chassis but vary substantially on engine options, styling and interior space.

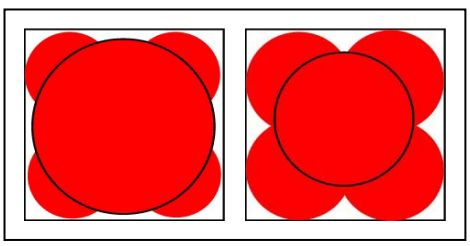

Figure 5 : (a) Base Product with "add-on's" (b) Base product less significant

A Co-ordinated product range is the next major position on the spectrum (figure 3) and although the natural progression in the representation maybe of the form in figure 6(a), a

model where products target audiences are different sizes and overlap is more realistic as in figure 6(b). Many household product ranges fit this section of the spectrum, irons, kettles and toasters all occur as examples. Often when companies conceive a product range they aim to share many components between the products as possible, to benefit from the same product development savings as “base product with add-on’s”. When co-ordinating products within a range, companies often focus on varying function, style and cost – so far there is little evidence or co-ordinating to cover persons with different impairment.

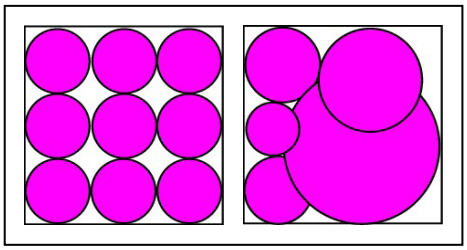

Figure 6 : (a) Concept product range (b) Realistic Product range

Although “One Product for all” is identified as an ideal of inclusive design, another ideal, at the other end of the spectrum, is mass customisation. Having a product specifically honed to a user’s individual attributes and requirements must in its definition be more suited than a product that has to suit the entire population. Mass Customisation can be further broken down into two types; semi-customisation can be better thought of as “pick ‘n’ mix”. This is very common particularly within the car industry. For example the Ford Street Ka offers customers a number of different options on many components that number over 500 different combinations. For the more popular Ford Focus, this increases to over a million [6]. Clearly it is not possible to stockpile all these options so some customisation must be done, within the confines of the options, after the customer has ordered. Less common is where a specific product is created based on the user’s needs without being confined to a particular set of options. Examples of this may include cloth tailoring or building design. Both can be visualised in figure 7.

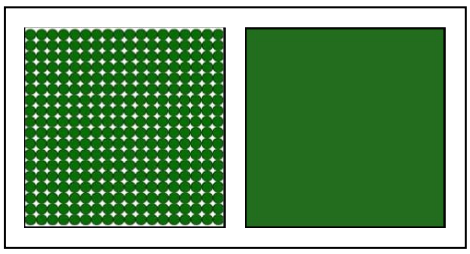

Figure 7 : (a) "Pic n' mix" customisation (b) Full mass customisation

3 Vacuum cleaner case study

Choosing a product to focus on as a case study for this paper, it became clear that although inclusive design can be applied to any product, to appeal to industry, the solutions could not be too abstracted from convention. Originally kettles and irons were considered but after closer study it was discovered that these offered relatively little variation in the marketplace. To convince industry that alternatives were viable, it was necessary to find a product range that already offered substantial variation. The vacuum cleaner offered the familiarity of kettles

and irons in terms of a common household product but has substantial variations in the architecture between uprights, cylinder, bagged, portable, multi-floor cleaner, etc….

Analysing the current options available from different companies, the position of the vacuum cleaner market can be found to be somewhere between base product with add-ons and a co-ordinated product range. Often different models from the same company will share some major components, for instance the motor and fan, but models vary widely in terms of size, power and purpose, figure 8.

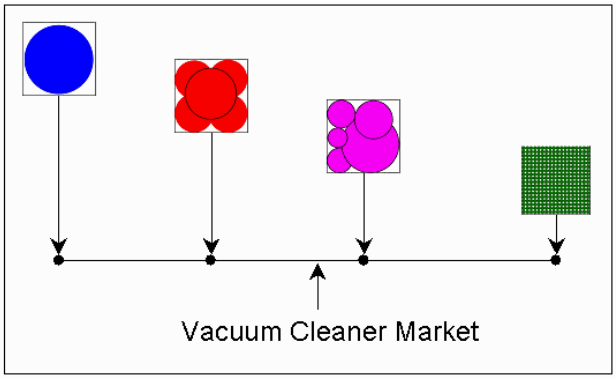

Figure 8 : Position of Vacuum Cleaner Market in Product Architecture Spectrum

As identified previously, the main problem with vacuum cleaners is their weight. Carrying the cleaner up and down stairs often presents problems, many users interviewed, both impaired and unimpaired, developed the same coping strategy to have a separate cleaner for each floor. In order to make a vacuum cleaner more accessible to all, one very obvious amendment is to reduce the weight. The heaviest component of almost all current cleaners is the motor driving the vacuum. To reduce the weight of the motor there are two options, use lighter materials or reduce the power. Using lighter materials will naturally increase the cost or reduce the reliability. Reducing the power rating of the motor will reduce the suction power unless the area of the aperture is also reduced. This then enters an infinity loop, as at what point is the cleaner light enough? When is the cleaner too small? Follow the loop sufficient times and the result is likely to suggest a handheld, rechargeable cleaner, a large departure from the upright cleaner at the beginning.

Knowing when enough people have been included is not the only issue. The weight of a vacuum cleaner has its own benefits, heavy cleaners push deeper into carpet pile allowing them to clean deeper and sufficiently on fewer passes. There are also components such as a beater bar that also assist better cleaning but are removed from the portable handheld models. A full understanding of the product and how its functions and components are interlinked is important to avoid making unpredicted and unwanted changes. Sometimes it won't be possible to reach a perfect solution, knowing when to stop is key.

Looking at the wider problem is vital for designers to challenge the accepted answers and find new products and methods. Within the vacuum cleaner market, two solutions are currently gaining reputations for potential to challenge the standard models. Research into robotics has now made small cleaners, which recharge themselves and have algorithms to assess the most efficient cleaning pattern, affordable for the domestic environment. Although lacking the power of the upright models, they do offer significant benefit to severely impaired users who may always be excluded regardless of any modification a designer makes to an upright. Common in North America, central vacuum cleaning systems are becoming popular in newly built homes. Piped networks are distributed throughout the living space and are connected to a

central, powerful motor that generates the vacuum. A hose and tools can be connected to the system at a number of sockets reducing significantly the weight the user must carry around. Both options would currently cost the user between 4 to 5 times a top-of-the-range upright model.

4 Branding

Issues concerning branding affect a company's impetus to adopt inclusive design. Designing for and being recognised as being popular with the young and unimpaired is an aim for most companies. Developing a branding relationship to a youthful customer is seen as important as many customers will remain loyal to the brand for the remainder of their life. Spending the same money marketing to the elderly is clearly not as profitable. Many companies worry to be seen targeting the older user as a product that caters to the elderly/impaired may be viewed as stigmatised to the younger customer.

Rather than seeing branding as a hurdle to inclusive design, companies should be encouraged to use branding as a key tool in exploring previously ignored markets. It isn't always necessary to use the same brand within the same company, consider the Ford case: Ford owns as a parent company Jaguar, Austin Martin, Land Rover, Volvo and Mazda as well as its self-branded Ford Cars. Each brand has its own very individual customer base and Ford wouldn't even consider branding a Jaguar as a Ford or a Volvo as Volvo-Ford. Although not ideal, it is feasible for companies to use different brands to target different sectors of the market if they have concerns that aiming for everyone will discourage some users.

The use of sub-branding is already beginning to penetrate the household product market: Miele have recently launched a range a vacuum cleaners as MieleArt, stylish slimline cleaners with different fascia designs. Porsche and Siemens have been collaborating for several years on a range of kitchenware including kettles, coffee makers and toasters. With a brushed steel finish these again aim at the expensive, stylish market rather than one to design inclusively.

5 Exclusion Scales

A set of scales exists, developed by the Engineering Design Centre (EDC), that assess how many persons a product excludes and therefore how inclusive it is. Currently they focus on the users by judging their abilities and capabilities and using data from a survey carried out across the UK in 1995 [1] [7] an estimate of the number that share that level of capability can be achieved. The scales are divided into 3 major capability sectors and further subdivided into 7 minor areas as follows;

Table 1 : 7 scales of impairment

Motion	Sensory	Cognitive
Locomotion	Vision	Communication
Reach and Stretch	Hearing	Intellectual Function
Dexterity		

Behind each of these scales lies a list of capabilities ordered by severity. To determine the exclusion of a particular product, the investigator looks through the list to find the least severe capability that would exclude a user from that product. The less severe the capability is, the

more persons the product excludes. At each level, the severity can be related to the number of the population excluded using the survey data.

From a product design perspective the scales are helpful but not ideal, where they are numerical, they lack consistency. For instance under Dexterity, one capability is "Cannot pick up and carry a 2.5kg bag of potatoes with either hand". This is the only reference made to ability to lifting and carrying a specific weight; a designer ideally needs to know for many more weights how much of the population they are excluding.

5.1 Exclusion in Vacuum Cleaners

Returning to the vacuum cleaner case study, assessing only from motion scales as weight changes shouldn't affect either sensory or cognitive scales. Further details of how the assessment figures are reached can be found in [1]

Reach and Stretch Exclusion	=	0.55 million
Locomotion Exclusion	=	6.65 million
Dexterity Exclusion	=	3.3 million

Figure 9 : Bending down to operate

The Reach and Stretch exclusion is the most difficult to improve upon without a radical redesign of the upright cleaner as the limiting ability here is "Has difficulty holding either arm in front to shake hands with someone". Without changing the entire operation this will remain limiting within this section. In Locomotion, the limiting capability is having to bend down to touch either toes or knees. By relocating the controls to the top, near the handle and thus removing the need to bend down, an additional 3.8 million people could be included. This purely focuses on the vacuum cleaner's operation and ignores having to bend down to remove any obstacles or to plug the cleaner in if power sockets are at low level. Dexterity, as mentioned before, only has one mention of lifting and carrying weight, so working under the assumption that only negligible fraction of the population are unable to pick up and carry, if the weight can be reduced to below 5kg, then this exclusion is removed.

To sum these exclusions to obtain a total is incorrect since often users will have several impairments and would be counted twice. Nevertheless a substantial number of people can be included by simple, common sense improvements. Furthermore, the product hasn't become stigmatised by adding features that detract more able users, indeed they would be more likely to buy a product that was lighter and reduced the need to bend down. Inclusive design can often create better products for all, not just include more people.

The current position of the vacuum cleaner market in the product architecture offers a variety of options for the customer. Many have a good design but often exclude on weight grounds. As identified weight is largely affected by the motor size and this also is a common component companies attempt to use in different product models. An improved product architecture may see the vacuum cleaner market shifted to somewhere between a co-ordinated product range and mass customisation. This would allow impaired persons to pick any model they desired but have the motor size changed to suit their capabilities. This would change the way people purchase vacuum cleaners, and would have to wait for the correct motor to be fitted to the appropriate model. There is likely to also be a cost increase but customers are often prepared to pay more for a product better suited to their needs.

6 Conclusion

Inclusive design is more fundamental than adding larger handles and Braille, identifying the correct product architecture and understanding how changes to existing designs propagate is vital.

As the vacuum cleaner case study showed, inclusive design isn't always straightforward and simple, obvious beneficial changes can rapidly propagate into detrimental and stigmatising ones. The product architecture will vary for individual companies and individual products within them but an understanding of all the options available will be necessary in adopting the correct strategy. Subsequently, no one document can outline for every potential product, the correct architecture but can educate on the differences between the various options and indicate the types of products to which these maybe applicable.

Branding is used as a facility to target different markets, but it will benefit greatly if a brand is associated with a product that is exceptionally helpful and allows a user to regain their independence. Users are much more likely to return to a brand for the next product they look to buy if they've associated a positive experience with that brand.

More fundamentally, determining who is the user and subsequently capturing their needs is a beneficial approach to design at large. Determining the product's requirements from a user-focused approach is more likely to yield a successful product. Inclusive design is good practice for all design.

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