Countering Design Exclusion Through Inclusive Design

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Abstract
The world population is aging and the number of people who are experiencing a loss of functional capability is also on the increase. There is a need to design 'inclusive' products to accommodate this wider range of capabilities and to develop metrics to assess the success of such products. Successful inclusive design requires a balance between the demands a product makes of its users and the users' capabilities, along with a number of design metrics and data to enable their evaluation. If the balance is not correct, then there is the potential for design exclusion.

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1. COUNTERING DESIGN EXCLUSION
One of the steps to ensuring that designs are as genuinely inclusive as possible is to provide metrics for defining the level of inclusivity attained for a given product. However, while it is useful to know who and how many can use the product, that information will not provide guidance on how to include more.

Conversely, knowing who and how many people cannot use the product and why they cannot do so immediately highlights the aspects of the product that need to be improved. For example, if a product excludes a significant proportion of the population because the users either cannot hear or see the output from the product, then designers know to re-design the features involved in providing the output to the users.

The underlying principle of countering design exclusion is that by identifying the capability demands placed upon the user by the features of the product, it is possible to establish the users who cannot use the product irrespective of the cause of their functional impairment. Consequently, by re-designing the product to lessen the demand, a wider range of users can potentially be included and no one is excluded unnecessarily by considering one cause to the detriment of others. To support this concept of countering design exclusion, it is necessary to consider methods of assessing the features of a product and the user's interaction with them to establish the capability demands placed upon the user.

1.1 Defining inclusive design
Design typically involves the identification of a need, creation of solutions to meet that need, and then a review to ensure that the need is met. Consequently, when considering a design approach it is necessary to also consider the measure of success, i.e. the point at which the design is considered to have met the stipulated requirements. However, the stipulated requirements themselves have the potential to exclude certain sections of the population from using the resultant product. As an example, consider a kettle that must boil a minimum volume of water and therefore has a minimum associated weight with the water inside it. Users of the kettle will be required to have enough strength to lift that minimum weight. Anyone not having such strength will not be able to use the kettle, irrespective of other design decisions made or product requirements stipulated.

The recognition of limits on the intended user population set by the requirements leads to a possible working definition of inclusive design: i.e. that "*an inclusively designed product should only exclude the users that the product requirements exclude*." The corollary of this is that the design fails to be inclusive if people are excluded from using the product even though they possess the functional capabilities to meet the demands of the product as specified (as compared to the actual product developed). Any discrepancy between the demands of the product and the demands of the requirements implies that the designers have introduced new capability demands on the users that are not essential attributes of the product.

This discrepancy provides the basis of a metric for measuring whether a design solution is successfully inclusive. It also raises the question of the level at which the requirements should be set. Taking the example of the kettle, how much water should it hold? A smaller capacity decreases weight and increases inclusivity, but the marketability probably decreases. A strategic decision is therefore required regarding the balance between the marketability of the product and the level of population exclusion, and hence potential market size.

In summary, possible measures of the inclusive merit of a product depend on two key criteria: the merit of the requirements that define it; and its merit when judged against those requirements. However, such a definition is focused on only two of a number of possible populations. In practice there are a number of others that can (and should) be considered.

1.2 Defining populations
The most logical place to begin is to define the terminology for the global population being considered, i.e. the absolute maximum number of people who could use the product. This may be referred to as the WHOLE POPULATION.

The removal of those who are prevented by law, safety considerations and irremediable lack of capability from using the product leads to the concept of the IDEAL POPULATION. This is the maximum population that a product could possibly target under ‘ideal’ conditions. For example, if the requirement was “to produce a product for delivering hot drinks in a cup,” the exclusions would include potential users who are unable to:

- lift/manipulate any cup-size container of hot liquid;
- understand how to handle hot liquid safely;
- distinguish a suitable cup-like container from other objects.

Under ideal conditions each new product will first be defined by a specification or set of requirements before any product concepts are developed. Those users who could use an idealized product based on those requirements (i.e. one that is unconstrained by the technical limits and trade-offs that affect any real, tangible product) can be thought of as the ‘requirements’ population. However, this definition is problematic because it is hard to define a particular stage of the product design cycle where the requirements are fixed, short of the final product itself. Consequently, explicit definitions of a ‘requirements’ population are difficult to specify. Therefore, it is better to specify a population where it is acknowledged that the population will change, based on how the requirements develop and evolve. This may be referred to as the NEGOTIABLE MAXIMUM POPULATION, where ‘negotiable’ implies that this population can change as the requirements change.

As the design process progresses, concepts and prototypes will be developed. Hence, at any stage from initial concept through to the final design solution, the inclusivity of the product can be assessed from the physical properties of the prototypes. The people who could actually use the product, based on its physical properties, are referred to as the INCLUDED POPULATION.

At no point in the above definitions is the ‘target’ population referred to. This is because there are so many ways in which it may be described. For example, the whole population is the utopian target solution, the ideal population is the best that can be achieved and the negotiable maximum may be what a product designer is happy to reach. Consequently the concept of a target population is difficult to specify. Nonetheless, one possible ‘target’ population that may be of interest is the INTENDED (SALES) TARGET POPULATION. For example, the intended target population could be particular age groups such as the over-75s, or particular marketing stereotypes or socioeconomic groups. The size of the target population and its composition is independent of the negotiable maximum and included populations.

In summary, these five populations may be referred to as ‘WINIT’ (Whole-Ideal-Negotiable-Included-Target) and used to form the basis of measures of success for inclusive design (Fig. 1).

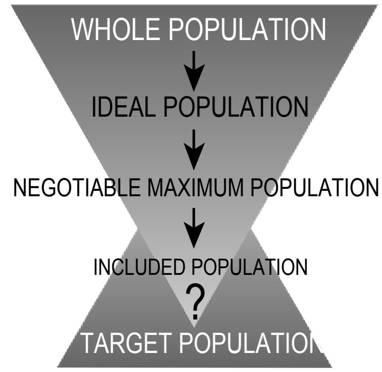

Figure 1. The WINIT populations

1.3 Defining measures of inclusive merit

Having defined the types of populations being considered, it is possible to enumerate the ratios between them. These can be interpreted as measures of the inclusive merit of the product. For example, the ratio between the whole and ideal populations gives an indication of the level of exclusion associated with the concept task, irrespective of the solutions developed.

$$\text{Inclusive merit of ideal product} = \frac{\text{ideal population}}{\text{whole population}} \times 100\%$$

The ratio between the negotiable maximum and ideal populations reflects the level of exclusion that has been generated by the development of the product requirements.

$$\text{Inclusive merit of requirements} = \frac{\text{negotiable max. population}}{\text{ideal population}} \times 100\%$$

The ratio between the included and negotiable maximum populations indicates the level of exclusion generated by the particular configuration of the product at that point in time. As the design progresses and the requirements are refined more explicitly (for example, in the light of the development of the prototypes), this ratio should approach 1.

$$\text{Inclusive merit of the design} = \frac{\text{included population}}{\text{negotiable max. population}} \times 100\%$$

The ratio between the included and ideal populations is the most important as it provides a direct comparison of how good the product is compared to its theoretical maximum.

$$\text{Inclusive merit of actual product} = \frac{\text{included population}}{\text{ideal population}} \times 100\%$$

Finally, the ratio between the included and intended populations shows how successfully the product meets the needs of its intended sales target population.

$$\text{Sales merit of actual product} = \frac{\text{included population}}{\text{target population}} \times 100\%$$

So far the discussion has progressed on the assumption that different populations can not only be defined, but also be enumerated. The following sections explore this assumption.

2. USER DATA

Estimates of the prevalence of disability derived from any study depend on the purpose of the study and the methods used [2]. Since disability has no 'scientific' or commonly agreed upon definition [3], a major problem lies in the confusion over terminology. However, the International Classification of Impairments, Disabilities and Handicaps (ICIDH) represents a rationalization of the terminology frequently used. The ICIDH identifies impairment, disability and handicap as consequences of diseases and presents a classification for each. This model can be extended to accommodate the effects of aging and accident (Fig. 2).

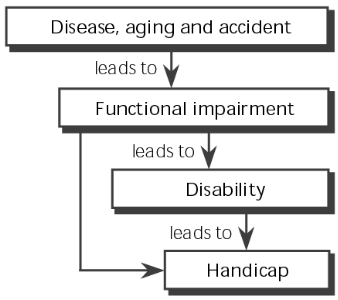

Figure 2. A model of disability (adapted from [4])

The ICIDH also defines disability as "*any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being*" [4]. This definition has been used widely for both disability research [2, 5] and design research [6]. However, such language is now generally considered too negative and it is preferable to describe users in terms of their capabilities rather than disabilities. Thus 'capability' describes a continuum from high, i.e. 'able-bodied', to low representing those that are severely 'disabled'. Data that describe such continua provide the means to define the populations that can use given products, thus leading to the possibility of evaluating metrics for inclusive design.

2.1 Multiple capability losses

Traditionally, design research tends to focus on accommodating single, primarily major, capability losses. The reasons for this are two-fold. First, single major impairments are often the most noticeable and therefore are the easiest to inspire the necessary motivation to address them. Second, such impairments are the easiest to understand and are comparatively easy to compensate for, as there are no complex interactions with other capabilities.

Unfortunately, many people do not just have single functional impairments, but several. This is especially true when considering older adults. Consequently, designers need to be aware of the prevalence of not only single, but also multiple capability losses. Therein lies a problem, as most user data focuses on single impairments.

3. BRITISH DISABILITY SURVEYS

This section describes data, assembled by the UK government as a means of assessing future care-provision requirements in Great Britain, which may be adapted for product evaluation. These data include the Survey of Disability in Great Britain and the Disability Follow-up (DFS) to the 1996/97 Family Resources Survey (FRS).

3.1 The Survey of Disability in Great Britain

The Survey of Disability in Great Britain [2] was carried out between 1985 and 1988. It aimed to provide up-to-date information about the number of disabled people in Britain with different levels of severity of functional impairment and their domestic circumstances. The survey used 13 different types of disabilities based on those identified in the ICIDH [4] and gave estimates of the prevalence of each type. It showed that musculo-skeletal complaints, most notably arthritis, were the most commonly cited causes of disability among adults.

An innovative feature of the survey was the construction of an overall measure of severity of disability, based on a consensus of assessments of specialists acting as 'judges'. In essence, the severity of all 13 types of disability is established and the three highest scores combined to give an overall score, from which people are allocated to one of ten overall severity categories.

3.2 The Disability Follow-up Survey

The Disability Follow-up (DFS) [5] to the 1996/97 Family Resources Survey [7] was designed to update information collected by the earlier Survey of Disability in Great Britain [2]. The results showed that an estimated 8 582 200 adults in Great Britain (GB) – 20% of the adult population – had a disability according to the definition used. Of these 34% had mild levels of impairment (categories 1-2 – i.e. high capability), 45% had moderate impairment (categories 3-6 – i.e. medium capability) and 21% had severe impairment (categories 7-10 – i.e. low capability). It was also found that 48% of the disabled population were aged 65 or older and 29% were aged 75 years or more. These results are summarized in Figure 3.

For the purposes of product assessment, 7 of the 13 separate capabilities used by the surveys are of particular relevance. Each capability is represented by a scale that runs from a minimum possible 0.5 to a maximum possible 13.0. Note though, that not all of the scales extend across this complete range, with some having maximum values of only 9.5.

These individual capability scores may be grouped into three overall capabilities, computed via a weighted sum and mapped to a 0-10 scale utilizing the categories above:

- motion – locomotion, reaching and stretching, dexterity;
- sensory – seeing, hearing;
- cognitive – communication, intellectual functioning.

For example, a person's motion capability is derived from consideration of their locomotion, reaching and stretching, and dexterity, using a weighted sum where:

$$\text{weighted sum} = \text{worst score} + 0.4 \times \text{2nd worst} + 0.3 \times \text{3rd worst}$$

The weighted sum is then mapped from the resulting 0-18.5 (the maximum possible upper limit) scale to a 0-10 scale.

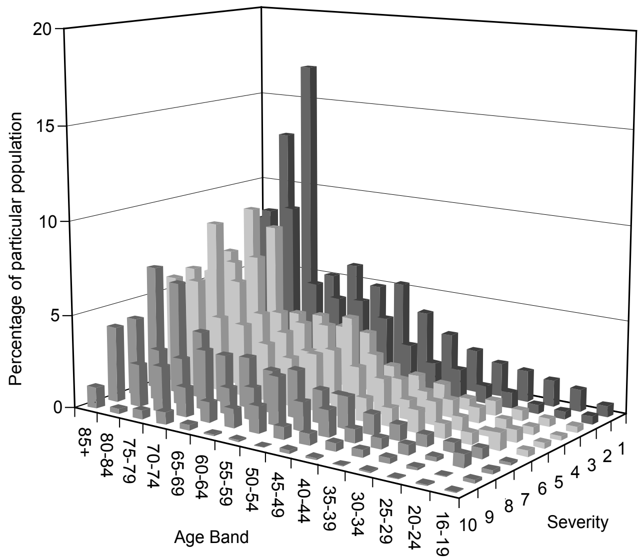

Figure 3. Distribution of disability for GB

3.3 The prevalence of capability losses

A summary of the DFS data is presented in Figures 4 and 5 for the 16-49 years old and 75+ populations. Note that the figures show *capability*, not *impairment*. Perhaps the most striking feature is the order of magnitude difference in the scales used for each figure. While the graphs have similar distributions, the percentage of those with a loss of capability in the 75+ age band is 10 times higher than for the 16-49 band.

In terms of the prevalence of capability losses, the expected distribution for each capability would show the largest proportion of adults with little or no impairment of that capability. Fewer adults would exhibit moderate impairments and fewer still would be severely impaired. It can be seen that the locomotion capability (the ability to walk), for example, follows the expected distribution. However, dexterity does not. The dexterity impairment distribution shows very few people with low impairment, then an increase for medium impairment, and finally a decrease for high impairment. The explanation for the discrepancy lies in the process of data collection.

The data for the DFS was gathered by interview, with the participants being asked to 'self-report' any impairments. As such, no consistent measures of performance were used, simply the opinions of the participants as to how difficult they found performing particular actions or activities to be. Locomotion difficulties are more noticeable because they often have a defined end goal, such as reaching the top of the stairs, or keeping pace with someone else. As such, when someone's locomotion capability becomes reduced, it is easier to recognize. The same applies for vision and hearing, which also follow the predicted distribution of severity. Dexterity, however, typically degrades gradually over time, and there are no obvious measures of one's own dexterity performance. It is difficult to assess whether it is a little harder to pick up something than it used to be, or if glass jar lids seems a bit tighter than they were a few years ago.

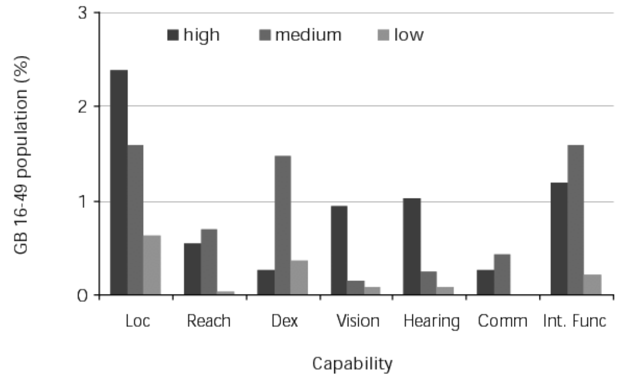

Figure 4. Capabilities for GB 16-49 population

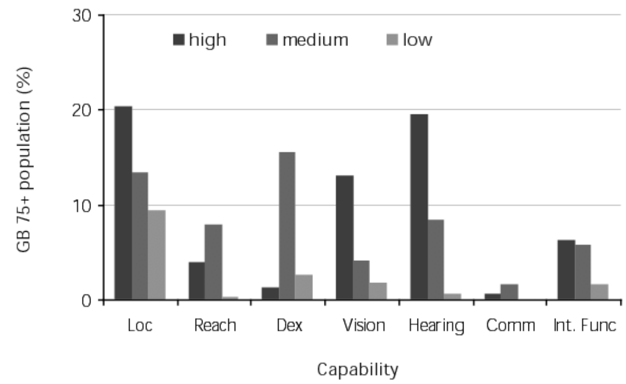

Figure 5. Capabilities for GB 75+ population

The above example illustrates the importance of considering the process by which population capability data is collected. Only by knowing that the DFS was gathered by interview and self-reporting was it possible to understand the distribution of dexterity capability.

3.4 Multiple capability losses

Many people will, at some stage of their life, exhibit more than one capability loss. From a design perspective this is important since each loss has the potential to cause exclusion. Design improvement needs to address each capability loss if the full benefit of the improvements is to be realized. The disability surveys provide valuable information for analyzing multiple capability losses. For example, Table 1 summarizes the data extracted from the Disability Follow-up Survey. It is evident that at least half of those with some loss of capability have more than one loss of capability.

3.5 Summary

The analysis of capability data generates useful information for designing for a wider range of user capabilities. However, different definitions of disability and data collection methods used for surveys often result in data that is not immediately comparable. Hence it is important to identify the purpose for which the data is required, the consequent nature of the data needed and thus the most appropriate data source. Even after this process, it may still be necessary to modify and adapt the data to meet the specific information need.

Table 1. Multiple capability losses for GB

Loss of capability	Number of GB 16+ population	Percentage of GB 16+ population
Motion	6 710 000	14.3%
Sensory	3 979 000	8.5%
Cognitive	2 622 000	5.6%
Motion only	2 915 000	6.2%
Sensory only	771 000	1.6%
Cognitive only	431 000	0.9%
Motion and sensory only	1 819 000	3.9%
Sensory and cognitive only	213 000	0.5%
Cognitive and motion only	801 000	1.7%
Motion, sensory and cognitive	1 175 000	2.5%
Motion, sensory or cognitive	8 126 000	17.3%

Multiple capability losses present particular challenges for designers and if their importance is to be fully appreciated, comparable capability data is essential. Hence, despite some reservations regarding the DFS data, it does at least provide some insights in this area.

4. CASE STUDIES

A range of domestic products have been assessed to quantify typical levels of design exclusion. In each case, the demands made by the product were estimated using the seven capability scales. An overall demand was calculated as a weighted sum of the three highest demands and the number of users unable to meet all seven demands was evaluated, taking account of multiple capability losses. The results are shown in Figure 6.

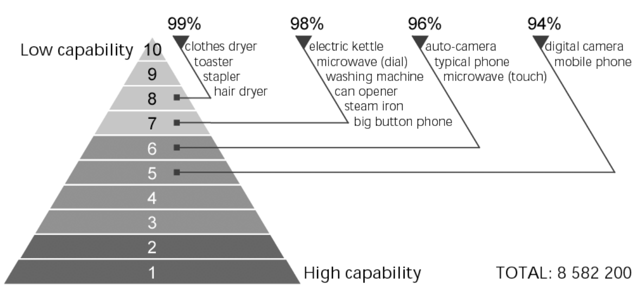

Figure 6. Product demands and exclusion

The *product demands* are divided into ten levels, with the lowest band (1) corresponding to the highest capability demand and the top level (10) being the least demanding and most inclusive. Different shading is applied to differentiate high capability demand (score 1-2); moderate capability demand (score 3-6); and low capability demand (score 7-10). The whole user pyramid represents 8 582 200 adults with functional impairments, 20% of the GB adult population. The percentages shown represent exclusion across the GB 16+ population. For example, products scoring 5 will exclude 6% of the GB adult population by the functional demands they make upon users. The following sections take a more detailed look at the assessment of a range of kettles.

4.1 The kettle

Early kettles (A), such as the one shown in Fig. 7, were made of metal and suspended over a hearth. They had a large handle mounted above the body of the kettle which doubled as the means of suspension. Such kettles required limited dexterity and were well balanced for carrying and pouring. The corded electric kettle (B) retained the shape and balance of the earlier models, but had the disadvantage of the additional dexterity required to insert and remove the cord.

In contrast, the early plastic jug (corded) kettles (C), although lighter, introduced a new problem. The side-mounted handle changed the balance of the kettle, making it more difficult to use for those with limited upper-body strength. The more recent arrival of the traditional shaped cordless kettle (D) has partly resolved this issue although the overall weight of these metal kettles (plus the heating elements) remains a problem for users with limited strength.

Figure 7. A range of kettles

The increasingly diversified kettle design does not guarantee better inclusivity of the product. Kettles designed more to be fashionable and for social rather than practical acceptability (e.g. kettle E) may be prone to failing usability and accessibility testing. However, when designers are aware of the issue and address the problem explicitly, innovative solutions come as a result, such as the 'no-pour' concept kettle (F). The three cordless kettles (D, E and F) will be assessed in the following sections.

4.2 Specify context of use

The first step of the assessment process is to state any assumptions regarding the environment in which the kettle is to be used and the sequence of actions encountered when using it. In this case, it will be assumed that the kettle will be positioned to suit the height and mobility of the user. The basic actions required would be: to pick up the kettle (or the removable jug of kettle F); carry it to the nearby water tap; fill the kettle with water; return it to its base; switch it on; and pour the boiling water into a cup.

4.3 Assess capability demands

The second step of the assessment requires the determination of the number of users excluded from using the products as a result of the mismatch between their capabilities and the functional demands made by the kettles. This is calculated by assessing the levels of each of the functional capabilities required to undertake the actions listed above.

Consider first the relatively heavy traditional cordless kettle (D). The handle makes it easy to carry, and the colored switch button is big and obvious. It is possible to fill it with water through the broad spout without opening the lid, which is tight and hence may require two-handed operation.

When pouring water to a cup, the user needs to tilt the kettle to a steep angle with caution, as the broad spout is prone to spilling water. The inner water gauge is difficult to detect and the shiny chrome surface will easily be marked by water.

The 'fashionable' kettle (E) with its matte surface is more stain resistant. It is very well balanced when sitting on the base, but difficult to balance when being carried. The spout is narrow and pointed - good for pouring water into a cup, but not for filling water through. The user needs to open the stiff lid by using the very small knob.

The water gauge is hidden inside the kettle, hence the user needs to find it by looking into the dark interior through a small opening. Finally, the black on/off switch is positioned under the black handle and attached to the black base, which makes it hard to find. In addition, the filter demands high dexterity to remove and replace.

The novel kettle design (F) is a new solution that arose from the design team working with disabled users. The designers identified problems with the use of traditional kettles and identified the following priorities for an inclusive kettle:

• safety (heat of unit/boiling water);

• filling (spout size/location, water level, lid remove and replace);

• pouring (seeing cup, tipping, weight, secure grip, low strength);

• lifting (weight, accurate water level);

• base (stability, cable management);

• stigma (not for "the disabled").

The innovative solution is an aesthetically pleasing, light-weight, 'no-pour' kettle with a cool wall, audio alert, auto-retractable cable, and a water level indicator also marked in Braille. However, it is not yet on the market.

The assessment of the capability demands placed on the users by each of the kettles is shown in Table 2. It is clear that the no-pour kettle (F) excludes fewer users that the other two designs and that the 'traditional' design (D) is better that the 'stylish' design (E).

Table 2. Comparing levels of exclusion

Capabilities	Kettle D (1.7 litre)		Kettle E (1.7 litre)		Kettle F (1 litre)	
	Minimum requirement	Total 16+ excluded	Minimum requirement	Total 16+ excluded	Minimum requirement	Total 16+ excluded
Locomotion	n/a	0	n/a	0	n/a	0
Reach and stretch	6.5	365 000	6.5	365 000	6.5	365 000
Dexterity	5.5	2 105 000	3.0	2 727 000	7.0	945 000
Vision	5.0	319 000	4.5	387 000	8.0	137 000
Hearing	n/a	0	n/a	0	n/a	0
Communication	n/a	0	n/a	0	n/a	0
Int. functioning	7.0	305 000	6.0	488 000	10.5	60 000

However, care must be exercised with these results. First, there may be double counting, where users have more than one capability loss. Second, the capability data is not validated for product assessment. The first of these points will now be considered.

4.4 Eliminate multiple counting

As mentioned already, an individual may exhibit more than one loss of capability. Older users typically experience multiple minor capability losses, and many disabilities are accompanied by other losses of capability, mainly due to disease. Where data is available regarding the prevalence of particular combinations of capability, it is possible to allow for multiple losses when estimating exclusion.

In the case of the Disability Follow-up Survey, it is possible to calculate such prevalence data from the records of the individual interviews. Hence, the total number of users excluded as a result of the demands made by a particular product can be estimated by finding the number of users excluded by at least one of the individual capability demands.

For example, it can be shown that for those users excluded from using Kettle D, 587 000 have more than one loss of capability that contributes to this exclusion. Therefore the total number excluded is only 2 506 000 (Table 3), rather than the 3 093 000 suggested by Table 2.

The results of a similar analysis for Kettles E and F, identifying the total number of users excluded from the GB 16+ population, are also included in Table 3. In all cases the total number of people excluded is less than the sum of those excluded for the individual capability losses.

Table 3. Total exclusion for the GB 16+ population

Capabilities	Kettle D (1.7 litre)		Kettle E (1.7 litre)		Kettle F (1 litre)	
	(%)	(people)	(%)	(people)	(%)	(people)
Total excluded	10.6	2 506 000	13.7	3 234 000	5.2	1 229 000

Note the difference of over 0.8 million people in the exclusion figures for kettles D and E, two kettles that are readily available. Kettle F has the potential to include at least 1.25 million new users.

4.5 Evaluate inclusive merit

The inclusive merit of each of the kettles in Figure 7 could be evaluated if sufficient data were available regarding their design history, i.e. their design targets and requirements. This is not the case. However, it is possible to show a typical calculation.

Consider first the ideal product: this device should demand no more of the user than the action of drinking from a cup, for this is the fundamental common activity that all users wishing to consume a hot drink have to perform, irrespective of how the drink was made. Anyone who cannot do this cannot reasonably be expected to be able to operate a kettle full of hot water, which will, in all circumstances, be a more difficult task (the kettle is heavier, a wider range of movement is needed, the kettle is more complicated to operate than a cup, etc.). Hence, those users who could not safely drink from a cup are excluded from the analysis.

In practice, the idealized 'kettle' described by the requirement of matching the same capability demands as drinking from a cup would have to be more like a drinks machine where no filling and pouring are required. The actual product may resemble that shown in Fig. 7(D); a device that is relatively heavy when full with a nonilluminated switch, stiff lid and potentially awkward pouring motion. Conversely, the product requirements may suggest a smaller kettle with a clearly marked and illuminated switch.

The results of a capability assessment for the ideal product, product requirements and actual product are shown in Table 4. Significant increases in the number of users excluded in response to each capability demand are evident in moving from the ideal to the actual product.

Table 4. Comparing levels of exclusion

Capabilities	Ideal product		Product requirements		Actual product	
	Minimum requirement	Total 16+ excluded	Minimum requirement	Total 16+ excluded	Minimum requirement	Total 16+ excluded
Locomotion	n/a	0	n/a	0	n/a	0
Reach and stretch	8.0	116 000	5.5	495 000	4.5	654 000
Dexterity	9.5	211 000	7.0	945 000	5.5	2 105 000
Vision	8.0	137 000	5.5	198 000	4.5	387 000
Hearing	n/a	0	n/a	0	n/a	0
Communication	n/a	0	n/a	0	n/a	0
Int. functioning	9.5	115 000	8.0	188 000	7.0	305 000

Table 5 shows the total number of users excluded from the GB 16+ population. Note that the results suggest that there are over two million people in Great Britain who can drink from a cup, but are unable to use a typical metal 1.7 litre kettle to boil the necessary water.

Table 5. Total exclusion for the GB 16+ population

Capabilities	Ideal product		Product requirements		Actual product	
	(%)	(people)	(%)	(people)	(%)	(people)
Total excluded	1.0	486 000	3.0	1 419 000	5.6	2 616 000

Merit indices may be calculated for the ideal product, product requirements and actual product. These are shown in Table 6 for GB 16+ and GB 75+ population.

Table 6. Merit indices for the GB population

Inclusive merit	Whole population		Ideal product		Product requirements	
	16+	75+	16+	75+	16+	75+
Ideal product	99%	96%	100%	100%	-	-
Product requirements	97%	89%	98%	93%	100%	100%
Actual product	94%	81%	96%	85%	97%	91%

It can be seen that the ideal product includes nearly the whole population for all users aged 16+, whereas the actual product includes only 94% of possible users. The situation is worse for users aged 75+ where 15% of possible users (represented by the ideal product) are excluded from using the actual product. Yet the product requirements suggest there is much room for improvement without compromising the basic concept of a kettle. A lighter, smaller kettle with a clearly marked and illuminated switch (represented by the product requirements) would only exclude 9% of possible users in the same age range.

The merit indices provide a means to evaluate the relative merit of a particular design in the context of the best that might be achieved. Hence, they provide a measure of the potential for improvement. Merit indices may also be derived for particular target markets since exclusion varies with age and gender. Care, however, must be taken when designing to achieve target indices. It is important that particular user groups, for example those with loss of vision capability, are not repeatedly excluded as an easy means to meet such targets.

5. COUNTERING DESIGN EXCLUSION

Assessing capability demands and merit indices is only a part of a larger process required to counter design exclusion. There is a need for a range of tools and techniques to help designers and design managers with this task. The inclusive design cube (Figure 8) was proposed to assist in the visualization of the scale of exclusion and the resultant design task [1].

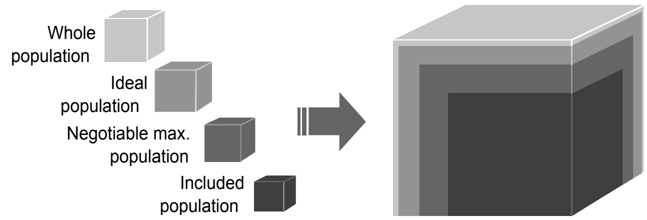

Figure 8. The inclusive design cube

The axes represent motion, sensory and cognitive capabilities. Hence, the cube conveys a sense of the overall level of exclusion and some indication as to its source. Exclusion is then best addressed by looking first at the sensory axis, followed by the cognitive axis and finally the motion axis.

The sensory axis addresses how the user perceives information from the product. This involves assessing the nature and adjustability of the output media used, their appropriateness for the required functionality, and the physical layout of the product and its interface. The cognitive axis assesses the matching of the product behavior to the user mental model. Once the output media (channels) are defined, the functionality (and content in the case of an information product) can be added to the product and evaluated. Cognitive walkthrough [8] is a popular technique for mapping the product behavior to that expected by the user. The motion axis focuses on the user input to the product. This involves assessing the nature and adjustability of the input media, their appropriateness for the providing the necessary functionality, and the physical layout of the product.

Areas of design exclusion can also be superimposed on 'bubble' diagrams [1] to assist the designer in identifying appropriate directions for product improvement. For example, there is significant coupling between vision and dexterity capability, which is pertinent to kettle design (Figure 9).

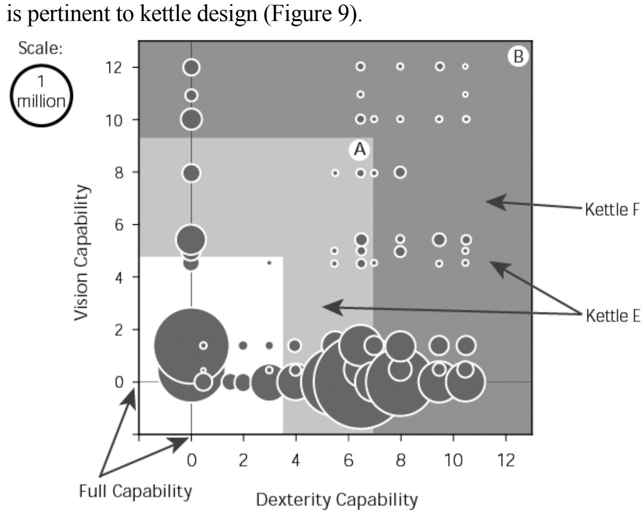

Figure 9. Multiple capability losses

Polygons A and B combined together illustrate the exclusion of kettle E for vision and dexterity demands. Polygon B, on its own, illustrates the exclusion of kettle F for the same capability demands. Thus polygon A shows the difference between the exclusion of kettle E and that of kettle F, which corresponds to some 1 897 000 UK adults just for those two capabilities. This level of exclusion would extrapolate to over 10 million people in a country the size of the USA.

It is obvious that if kettle E is to be improved to achieve the same level of inclusion as kettle F, both vision and dexterity demands need to be reduced simultaneously. The reduction of vision demand will only include those bubbles hugging the vision axis in Figure 9, but not those in the coupling region (off-axis). Such information is useful to designers, because when they improve products, it is important to know if the changes proposed will indeed include more users, or whether certain users will still be excluded for some other reason.

6. CONCLUSIONS

Inclusive design will only be encouraged when managers and designers are able to see more clearly the impact that their design decisions have on the usability of their products.

An approach to reviewing product requirements and concepts has been presented, which can be used to highlight areas of particular concern in an emerging product. This Inclusive Design approach incorporates a user capability range that does not configure an 'average' user. This has the advantage of enabling the manager and designer to consider all potential users with multiple combinations of capabilities.

The question as to whether a company should pursue separate product variants for high-capability and low-capability users, or for older and younger users has not been explicitly discussed. This issue is left for individual companies to resolve in the light of their preferred branding and marketing strategies. Inclusive design does not specify 'one product for all', rather it promotes a more acute awareness of design exclusion and the impact of product development decisions on such exclusion.

The kettle case study, in identifying the scale of exclusion, also shows how important it is to implement a structured approach to the design process. It illustrates how design choices, such as the size of a kettle, can exclude large numbers of the population. In addition, it has shown that users may be excluded from using a product as a result of decisions made at any stage of the product design cycle. It is critically important that designers and product development managers are aware of this latter point to avoid inadvertent design exclusion when specifying products.

Further work is underway to quantify typical inclusive merit indices for a range of common products. This will serve to encourage design improvements, particularly where actual products do not meet the potential of the ideal products.

7. ACKNOWLEDGMENTS

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