IMPLICATIONS OF INCLUSIVE DESIGN FOR DESIGN EDUCATION

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ABSTRACT
By 2021 it has been estimated that almost half the UK population will be over 50 and have some physical impairment. Although this trend has made the need to develop a more user-oriented engineering design process more acute, it has proven difficult to reconcile qualitative user knowledge with the traditionally object-oriented design process. It is argued that including users, particularly those with impairments, and understanding their experiences could inform design and help students better understand technical concepts. A framework, from research in Human Computer Interaction (HCI), is suggested as a possible means for integrating user knowledge with engineering design education, practice and research.

Keywords: Inclusive Design, Impairment, Vernacular Creativity, Ethnography

1 INTRODUCTION
It has been estimated that by the year 2021 almost half of the entire population in Britain will be over the age of 50 and, almost invariably, ageing results in increased impairment – whether this is sensory, dexterity or mobility related [1]. Significantly, however, such disabilities are now considered ‘functional impairments’, as is reflected in the World Health Organisation’s (WHO) recent change from the *International Classification of Impairment, Disability and Handicap (ICIDH)* to the *International Classification of Functioning, Disability and Health (ICF)*[2].
In the design community, response to such trends has been best articulated in the emerging ‘inclusive design’ movement – the goal of which is to create products that are easy for everyone to use and to understand. Inclusive design is, however, one particular notion, distinguished by certain concerns (such as design for the elderly), that reflects a more general shift in design towards a more user-centred development process. This paper argues that a particular focus on the user also has the potential to provide insights that might help students better comprehend engineering concepts.

2 HUMAN FACTORS
While it would be disingenuous to argue that there has been hitherto no regard for the user in design, it would be fair to say that designers have tended to rely on an object-centred process that has encouraged a rigorous, often solely technical, approach to design problems – exalting the technical over the human. Indeed, it is through these methods that designers have defined their profession, as Margolin observes [3]: ‘*As methods are clearly the province of professionals who have been initiated into them, we*

tend to view those outside the professional culture as being consigned to the roles of consumers or users.'

The history of design movements, and the nature of design practice, has thus betrayed a desire to establish a 'design science' [4]. Increased appreciation for the user, however, introduces a new and different problem that the practitioner must learn to overcome – a problem that traditional methods and perfectly engineered solutions for users may not be able to solve. Naturally then, limitations of traditional approaches are most salient in human factors and interaction design – areas concerned with supporting human interaction with artefacts.

2.1 User-Centred Design

Attempts in these fields to define a community, with a consensual philosophical and theoretical basis of study, have pooled concepts from a range of disciplines, each with their own internal conflicts and debates [5]. Unsurprisingly, the turbulent provenances of these different notions have resulted in a fragmentary foundation for interaction design, with the use of many of the appropriated concepts now rendered controversial at best. In psychology, for example, although the nature of cognition remains ill-defined the information-processing model has been allowed to dominate design for decades [6].

That a unified, coherent approach to interaction design has yet to be established does not, however, mean that attempts made have not been instructive. Indeed, the body of work that has amassed suggests an increased recognition of the direct contribution users can make to the design process itself.

Early attempts to integrate user-centred design with an engineering approach considered usability goals as measures of when the iterative design process could stop [7]. Similarly, early applications of ethnographic techniques to design were restricted to the simple identification of user requirements through task analysis – essentially used for the initial requirements analysis phase [8]. This is a peculiarly limiting role for a technique, with its origins in anthropology and sociology, which essentially aims to observe and engage to develop rich descriptions of cultures and contexts.

More recent analyses and techniques have been developed, however, that aim to provide particular insights and provoke different interpretations in novel ways. Cultural probes, for example, are packages containing various materials (such as cameras, maps and postcards) sent out by designers to aid their understanding of people [9]. They are intended as "… in some ways, like the projective tests used by psychoanalysts … they elicit revealing fragments from participants which inform and inspire our designs." [2]

Empathic modelling has also been proposed as a way for designers to genuinely understand the experiences of different users. It involves the simulation of various impairments followed by interaction with a range of products to identify specific problems. Coins, for example, can be taped to the back of joints to simulate different problems with dexterity or tinted glasses can be used to reduce vision.

2.2 Inclusive Design

Of particular note, however, are the Helen Hamlyn Institute in London and Certec, a division of the Department of Design Sciences at Lund University's Faculty of Engineering. Both groups are encouraging new perspectives and are attempting to identify, explain, standardise and promote new methods through in inclusive design.

What is clear from the approaches of both is that acknowledgement of a more fundamental role for the user goes beyond user needs. It means accepting users as co-designers, developing a mutual, shared understanding with them – even learning about design from them. Such a new perspective does necessitate new theoretical and methodological approaches, but approaches that allow for new interpretations for engineering design.

What, however, are the implications of this for design education? If, ultimately, the success of a product is determined not just by the efficient engineering solution, but also by individual perceptions and interpretations, how can students *know*, and design for, these? Can insights be gained and new opportunities identified for future design practice through consideration of different interpretations? How is a qualitative understanding to be reconciled with technical knowledge?

3 TECHNICAL FACTORS

It is significant that many of the emerging inclusive design approaches have their origins in the arts. Focus on development of a technical understanding or the translation of these qualitative results into engineered solutions is conspicuously absent from many of the techniques. This is scarcely odd when it is exactly this intersection that has frustrated development of a coherent user-centred approach: "… working out just what the highly detailed activities mean in terms of the actual construction of technical systems supporting the activities observed has emerged as a perennial problem …" [8]

The solution to this problem may, however, lie in the collaborative activity itself, in the potential for designers to learn about engineering design from users in everyday contexts. As has been noted elsewhere [10], students have difficulty understanding certain engineering concepts. It is also well established that students are inclined towards an inductive learning style – with experiences allowing students to derive general principles and develop meaningful conceptual models that can be applied to new situations [11]. Indeed, much work has been done into the key role played by mental models and analogical reasoning in engineering [12].

Interestingly, just as students must reconstruct their common-sense mental models of the world to understand engineering concepts, so too must users to understand a new product. Often, successful operation depends on their mental model complementing the designer's model of the system. If this is not possible, users create their own, perhaps incorrect, models to structure their understanding and will adapt artefacts and the environment to help ease the physical and cognitive burdens they present [13], [14]. This could also be thought of as a form of distributed cognition [15].

3.1 Vernacular Creativity

Recently, the term 'vernacular creativity' has also been coined to describe adaptations made by users to products, normally to add extra features or improve functionality. While not yet academically defined, the term nevertheless provides an interesting interpretation of this behaviour – particularly for inclusive design. With most products being designed for the able-bodied, people with a functional impairment have more reason to adapt products and their environment. It is proposed here that an understanding of these adaptations could provide new insights for engineering design practice and education.

Consider, in addition to the cognitive adaptations users make, the physical adaptations that are also made. In order to reduce the force required for opening a window with a lever handle, for example, people with limited strength (such as the elderly) will extend the handle. Others, even those with no impairment, will slide a wooden spoon through the top of a corkscrew to provide better control or use screwdrivers for levering off the lids of paint tins [16]. Each of these are instances of vernacular creativity, yet engineering principles can also be inferred from them – the handle extension increases the moment around a point, as does the screwdriver and the spoon. Everyday situations could thus provide meaningful contexts for engineering concepts.

3.2 Experience Design

Increased attention to what has been termed 'experience design' also offers new opportunities for the exploration and understanding of technical concepts. This new perspective proposes that, ultimately, it is experiences that are designed, not things. Bill Buxton [17] explains the difference between experience and interface design by way of his experiences with orange juicers – specifically, the cadence of the different levers.

He describes how the Mighty OJ has a "direct linkage between its lever and the jaws … a simple rack-and-pinion gear mechanism [gives a] constant gear ratio." while the leverage mechanism of the OrangeX has a "camming effect [that] varies the gear ratio … so the pressure [required] is reduced". Of particular note in his description is the distinctly technical terms used: rack-and-pinion, gear ratio, camming.

In this way then, engineering principles can be directly related to experiences the student can appreciate, and even sympathise, with. Indeed, students themselves should be encouraged to be more reflective in their own experiences – to suggest solutions or improvements to existing products with which they interact. A very different, and arguably more meaningful, understanding could result through this as opposed to the rote learning of algorithms – particularly when, as Bodner notes [18] many students find mathematical arguments and models insufficient reason to reject their naïve models.

3.3 Mental Models

Mathematical models are traditionally used to provide predictive and explanatory powers, yet mental models, such as metaphor and analogy, often serve the same function [19]. The particular mental model we use to frame a situation or artefact significantly influences and constrains our understanding – as the literature on metaphor demonstrates [20]. With regard to the framing of engineering problems, much could, perhaps, be learned from the vernacular frames developed by users.

Consider, for example, electricity – because its mechanisms are invisible, it is often explained through analogy. A study of the analogies used to understand this phenomenon suggested that they could indeed influence student accuracy with particular problems [12]. It was found, for example, that those who considered electricity to be 'flowing water' performed better with circuit problems containing batteries than resistors – because of their familiarity with the behaviour of water – while those with a 'teeming crowds' analogy had greater success with resistors – because of the familiar concept of people moving through narrow gates.

Of course, people's mental models can be, and often are, flawed [14], yet the very act of interpreting a product through a user and identifying problems from the vernacular solutions encountered and recounted, could emphasise singular issues that a student may not have considered – even allow them to recognise problems with their own mental models.

4 COGNITIVE ETHNOGRAPHY

Importantly, each of the areas discussed above – adaptations, experiences and mental models – all reinforce the now recognised need for situated learning [2] and evidence of a bias in engineering students towards inductive reasoning certainly supports the use of some fieldwork in engineering education [11], [18]. Abduction could provide a structure for such an education.

Abduction has long been used in science, but few acknowledge the technique [2] – indeed, the 'scientific learning cycle' is inherently abductive, comprising as it does of the phases of exploration, concept introduction and concept application [18]. Like induction, it begins with the observation of empirical facts but it also accepts that existing theories will determine interpretations of the observations [2]. Theories can thus be developed and presented to solve observable phenomena – with the governing principles being used to explain observations [11].

Hollan et al. [21] recently proposed an abductive framework for research in Human Computer Interaction and it is argued here that it could equally apply to engineering concepts and be used in design practice and education. The approach brings together many traditional ethnographic techniques such as interviewing and observation but, rather than focus on meaning in words, meaning is also given to actions and instances of distributed cognition grounded in the context of activity (Figure 1). 'One must know the processes actors engage in and the resources they use to render their actions and experiences meaningful' [21]. While making a significant commitment to observation and participation, it calls for this to be used to generate questions for experimentation.

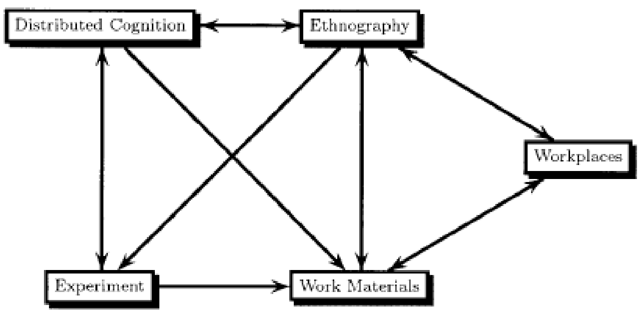

Figure 1 Integrated Research Framework (from Hollan, Hutchins and Kirsh, 2001)

Using ethnography in particular, the problems experienced by people with functional impairments could be identified and richly described - providing unique insights for students and practitioners. Exploration of how products have been adapted, the meanings they have been given and the roles that they play for these individuals could make engineering more meaningful for students while also helping them better understand problems of the present and problems that they might face in the future.

5 CONCLUSION

With an ageing, and increasingly impaired, population, the range of experiences and interpretations of artefacts cannot be adequately understood by the designer alone, and certainly not by traditional techniques. It is therefore time to engage with users and recognise them as colleagues (or 'co-designers') in a participatory design process. Appreciating the way in which products are understood (or misunderstood), experienced and adapted has the potential to inspire innovate design and provide unique insights that might otherwise have been missed.

Importantly, engaging and understanding users could provide a context for students to learn engineering concepts, whether by recognising flaws in user (or their own) interpretations or by inferring principles from everyday adaptations. Not only is this the preferred and natural way to learn, but it might also ensure that people are made integral to the design process and, therefore, that everyone can contribute to the future of design.

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