Assistive technology product to universal design: a way forward.

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Assistive Technology product to Universal design: A way forward.

George Edward Torrens

Introduction

The aim of this article is to provide those involved in Design for All with an insight into ways in which we may influence United Kingdom (UK) society to be more accepting of those who have impairment; and, make new product development (NPD) more viable. This article draws upon over 25 years’ experience working with people who have impairments and live with disability.

The context of Assistive Technology (AT) products are defined within a user-centred, new product development (NPD) process. The viewpoint of the user, associated stakeholders and a wider UK society are described along with ways in which their associated preferences may be obtained.

The focus of this article is Industrial Design practice. Industrial Design (ID) may be considered to deliver the social and cultural function of a product within the constraints of physical function, manufacture and cost. A key aspect of ID practice is the manipulation of an individual’s emotions or behaviours through the user’s experience of interacting with the product. This may be viewing or sensing through to using it to perform a task.

The generic mechanisms of perception and emotional response to a product are discussed and mapped onto the given new product development (NPD) process. The semantics of words images and forms are shown to have a critical influence on the perception of an individual and society.

An example process, methodology and design tools are described that have been practically applied through many successful AT product developments. Case studies from current (2011-2012) Finalist undergraduate Industrial Design (ID) student product designs will focus on some of the principles described. The process described uses a combination of conventional evidenced-based NPD alongside specific methods of the manipulation of perception and semantic meaning. Design tools such as value web-diagrams, technology footprint, iconography and product DNA are demonstrated within the NPD examples.

New product development (NPD) process

Before reviewing methods associated specifically with Assistive Technology and Universal design, it is helpful to provide a context for their application within a NPD process. Below is a ‘double-diamond’ approach to the explanation of NPD activities that has been refined and developed by the author over the last twenty years. This is similar the basic diagram used in more recent years by the UK design Council to explain NPD. The methods and tools highlighted in this article focus on research, eliciting evidence to make informed design decisions; and, producing the optimum compromise within a design solution. In addition, design heuristics or tools are described that are employed to enhance the social and cultural function of the product design.
Assistive Technology and Universal Design

Assistive Technology (AT) product design may be considered a subset of Universal Design (Christophersen 2002) in that it provides a technology-based assistance to those with physical or cognitive impairment. This assistance is towards enabling a person to achieve Normal Activities of Daily Living (ADL’s). Barnes (2011) noted that ‘Normal’ only appeared in the English dictionary in 1884.

Much of AT product design is currently focused on the physical function of a product. However, there are many commentators who have highlighted the issues in user acceptance of AT products. (Philips 1993, Fuhrer 2003). It is the author’s experience that high quality engineered products that function safely and effectively in relation to a given task or purpose are often discarded when they do not have an appropriate component of social and cultural function. The social and cultural function is often referred to as style or the ‘x’ factor of a product.

Barnes (2011) has highlighted what appears to be endemic discrimination within UK society towards those considered disabled. From the definition of ID given earlier, it is clear Industrial Designers have the skills and knowledge to help change attitudes and behaviours in relation to AT products, leading to a change in UK society’s perception of impairment and disability. Table 1. Highlights the issues raised by Barnes. The Barnes list has been matched with a list of ways in which ID practitioners may overcome these challenges to effect social change.

Loughborough Assistive Technology-User Centred Design (LAT-UCD) methodology

The following methodology has been developed by the author over the last 25 years of working in the field of AT product design and is taught to undergraduate and post-graduate students. (Torrens 2000) Figure 2. provides a more detailed context for the application of

Figure 1. A diagram of new product development. (Torrens 2011)
the methods described.

Table 1. Shows issues within AT product design and positive

<table>
<thead>
<tr>
<th>Systemic and endemic discrimination</th>
<th>ID and Inclusivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social discrimination (despite the Equality Act, 2010, UK)</td>
<td>Social integration</td>
</tr>
<tr>
<td>Medical model and treatment reinforces segregation</td>
<td>Change perceptions</td>
</tr>
<tr>
<td>Doctrine of human adaptability and fixed environment</td>
<td>Manipulate psycho-social perception through colour, form, texture and sound</td>
</tr>
<tr>
<td>Social model (late 20th Century- early 21st Century)</td>
<td>Change behaviours</td>
</tr>
<tr>
<td>Innate social behaviour: weak/ill members disassociated from the main group</td>
<td>Manipulate response and behaviours using social doctrines semantics, social value and association</td>
</tr>
<tr>
<td>Perception: disability = weakness - leading to social stigma</td>
<td>Education and awareness</td>
</tr>
<tr>
<td></td>
<td>Role models</td>
</tr>
<tr>
<td></td>
<td>Change environment</td>
</tr>
<tr>
<td></td>
<td>User centred focus</td>
</tr>
</tbody>
</table>

Figure 2. Shows the context for some of the methods used within the LAT-UD methodology.
Market characterisation

The methods and tools shown in Figure 2. have a natural grouping of those methods that collect information to inform decision-making (red) and those which help make design-decisions (blue). The methodology may be considered to fit within the category of a mixed methods approach as defined by Creswell (Creswell 2006, Creswell and Plano-Clark 2009). The starting point for any new product development is defining the need and characterising the market the range of individuals within it. Organisations such as National statistics offices (National Statistics Office 2012) the World Health Organisation (WHO 2012) hold useful data relating to the numbers of people with impairment or who may be considered disabled. Once a market size has been established the choice of methods of manufacture may be narrowed.

For those unfamiliar with the AT market, the use of empathic modelling can provide insights into the issues faced by those with specific impairments, such as arthritis, partial sight or blindness. This form of modelling also helps a designer or NPD team ask the right questions of target or end users. Although simulation of impairments can be replicated by improvisation, there are simulations suits available such as the Second-skin system (Loughborough University 2012a), shown in Figure 3.

Brainstorming is useful to help identify issues, which may then be placed within a context using a mind-map technique. An example of mind-mapping is shown in Figure 4.

Once a background literature review has been done, unanswered questions may be investigated using product cultural probes (see Figure 5.) and observation, for example, using ethnography, system or task analysis (Cohen et al 2007). More specific questions may be posed to samples of the target market or end users through questionnaires, interview,
teleconferencing (Torrens 2011) or focus groups (Morgan 1997). The outcomes may be presented in a graphical format of web diagrams. An example of different viewpoints of end user and associated stakeholders involved with a paralympic sports product (shown in Figure 6.) may be presented in a way that enables a designer or NPD team to make informed design decisions towards an optimum comprise of requirements.

Figure 5. Shows an example of a set of product probes (Torrens 2011)

Figure 6. Shows an example of a web-diagram presenting the preferences of a paralympic athlete, coach and carer for an AT sports product. (Torrens and Black 2011)

Innovation: challenging convention

Using a grounded theory approach (Cohen 2007) a consensus for a product design specification (PDS) may be developed and further validated by the methods outlined. Once a PDS has been defined, innovation can be produced through challenging the conventions and doctrines of the target market, end users and associated stakeholders. Challenging convention is only possible when the designer has good knowledge of the market and existing conventions. The end users and stakeholders can be explicitly presented through the use of personas and scenario of use. Three case studies will provide examples of these aspects.

The use of a champion user or users in conjunction with co-design (Kemp and van Geldren 1996) has been found by the author to reduce the time taken in decision-making relating to detailing and attribute priorities within a new product design development. (Torrens 2011) Whilst only one or a small number of end users or stakeholders, many of the imbalances in the PDS may be identified and resolved before undertaking more expensive validation with a larger group. This method is particularly useful when the market is very small and end users are difficult to access; for example, paralympic athletes.

When enough information or data has been collected about a target user group or stakeholders, the information can be collated to produce predictive modelling tools, such as SAMMIECAD and HADRIAN. SAMMIECAD (see Figure 7) is a software tool that enables a
designer to define a target user for their product, check the anthropometric scale and physical accessibility of the product by the specified users. (Loughborough University 2012b). HADRIAN is a predictive tool within which an avatar may be given specific characteristics and impairments, (Porter et al 2004). The avatar is then asked to complete a specified task with a pre-defined computer generated product. The outcomes of task performance are predicted to enable a designer to keep the product and proposed method of use within the capabilities of the defined users. These design tools and others may be accessed through the AUNT-SUE website (Loughborough University 2012a).

Figure 7. Shows an example of a predicted and real usage of an ATM machine (Loughborough University 2012b)

Figure 8. Shows the front page of the AUNT-SUE website. (Loughborough University 2012a)

User Centred Design: Technology Footprint Assessment

A design tool that has been found to be an effective method of refining AT product designs is Technology Footprint Assessment (TFA). This tool is based on David Marr’s computational theory of vision perception (Marr 1982). Marr indicated that humans build up a visual map of the world from a series of visual scans, from a 2D outline through to a fully-rendered 3D environment. The TFA tool focuses on the initial scan made where we identify outlines, important to identifying visual elements that pose a threat, such as objects heading towards us or a Tiger hiding nearby, or that are food shapes (background to foreground differentiation). When applied to AT products, the author has found in previous years that effective use of technologies has visually swamped the person using it. Figure 9. provides a worked example of a person using AT products where the design team have reduced the visual footprint over the body. (Torrens 2011) The author designed and made a baby carrier for a mother with cerebral palsy, shown in Figure 10. The visual impact of the structure was minimised through the use of a single pole support thin rod holding structure and satin finish black frame. Using Marr’s theory of perception, the viewer should define the outline of the proprietary baby carrier seat and mother before the supporting frame.
Figure 9. Shows a worked example of a person using AT products and how the TF may be reduced. (Torrens 2011)

Figure 10. Shows an example of a wheelchair baby carrier designed and made by the author.

**AT product viability: Expanding your market**

A key element of the LAT-UCD methodology is the use of standardisation and modularity within the product’s design for manufacture and assembly (DFMA). Standardising on original equipment manufacturer (OEM) parts for the core physical functional components of an AT product increases the potential viability of an AT product. Standard locations and assembly interfaces within the core subassembly offer the greatest opportunity to attach a range of components that customise the product for a niche market. ‘plug and play’ technology within computer peripherals are a good example of this strategy. The author has successfully applied this design and manufacturing strategy to AT products. (Burkitt et al 1995, Torrens et al 1996).

**Case studies**

The following case studies provide exemplars of the application of the LAT-UCD methodology previously described. Three case studies each provide a snapshot of the methodology that highlights different aspects within it: A kitchen chopping board system for people with hemiplegia demonstrates a rigorous UCD approach; the design of a hearing aid for older men highlights the use of semantics to change the perception of society towards this AT product; and, a hand cycle for use with a range of different wheelchairs that demonstrates the potential for use in other markets.
Case study 1) A one handed kitchen chopping board system
The original need was identified by the designer (Rowan Williams) through family and friends. Literature review and background information on existing products was gathered that identified a gap in the market for a cutting/chopping board that was capable of being used one-handed. This was primarily aimed at those who had suffered a stroke and were living with hemiplegia. As the system developed, it became clear the product would provide a high-quality experience to any user through aesthetics and ease of use. The novel peg system has been patent registered.

Figure 11. Shows a compilation of images of the Pego cutting board system which comprises of a working finished prototype. (Designer: Rowan Williams).
The designer undertook iterative cycles of card, foam and other soft modelling in conjunction with their champion user. The product was then validated with Occupational Therapists and the aesthetic appeal with a wider range of the adults for whom this was targeted. A rigorous DFMA approach was applied to the detailing of the injection moulded parts, prototyped using rapid manufacturing techniques, which would only be viable to fund if the target market was expanded to include an able-bodied user group or consumer. The original design had semantic cues of colour, edge detail and textures that linked with high-quality kitchenware currently on the UK market. The high quality of design detailing brought the PEGO system into the mainstream market. Since the launch of the design, the designer has had expressions of interest from UK high street retailers and is currently a finalist in the Design Innovations in Plastics Awards 2012 with this product.

![Figure 12. Shows a scenario of use for the Pego cutting board system using both finished and prototype components. (Designer: Rowan Williams).](image)

**Case study 2) A hearing aid for older men**

The SONAS audio system was originally developed to alleviate the stigma associated with older men wearing a hearing aid. The designer (Alex Roper) had identified this need through his grandfather, who suffered with Tinnitus, a form of constant ringing in the ears. As with the PEGO system, the designer produced a high quality aesthetic product that had a number of elements that enhanced the viability of the product. The system used a proprietary high-performance ear plug that is custom-fitted to an individual’s ear by an audiologist. The standard OEM part matched with an external casing, which housed further OEM electronic parts. The designer validated that the scale and volume of the OEM electronic parts would fit within his outer casings. The proposed was system to be connected via Bluetooth to a base station, which also was the carry case for the earpieces, as shown in Figure 13. All items were validated for scale and usage with the target aged
males. The standardised external casing connection enabled alternative modular options to be offered to the target user. (See Figures 14 and 15). Figure 16 shows a comparison of proprietary earpieces with the SONAS. The new system has a more body-worn ornament or jewellery aesthetic, with associated visual cues, than those currently available.

The most important insight came from the designer’s brainstorming of the Brand delivery were keywords not associated with any form of impairment or disability. This led to the deliberate decision to switch the focus of presentation from an AT product to a mainstream, high-value, audio product that could also be used as a hearing aid. The change in perspective is shown in the diagram in Figure 17. Changing the perception and cognitive framing of the product opened a much larger market. The product has already won a University sponsored enterprise award and has attracted interest from venture capitalists.

Figure 13. Shows the finished appearance model of the SONAS mobile high quality sound system (Designer Alex Roper).

Figure 14. Shows a finished appearance prototype with fitted earpiece. (Designer Alex Roper)
Figure 15. Shows the modular options of colour and detail of the SONAS earpiece. (Designer: Alex Roper).

Figure 16. Shows a visual comparison between proprietary hearing aids and the SONAS (Designer: Alex Roper).

Figure 17. Demonstrates the change in perception from an AT product to an Inclusive/Universal product through the manipulation of semantics and social values.
Case study 3) A hand cycle with a modular attachment to a range of wheelchairs
The Velo hand cycle came from the University bursary placement experience of the designer (Mark Wafforne) as a researcher and designer. The designer had identified the need for an entry-level hand cycle for use in UK Schools and sports clubs that would attach to an existing wheelchair. UK sports clubs have to ensure they can accommodate all individuals who wish to take part in a sport; in this case, athletics and the equivalent wheelchair racing. The standardised system of adjustment enabled a custom attachment to be achieved with most makes of wheelchair. A similar standardised adjustment mechanism enabled the hand crank handles to be positioned optimally for different users. The novel enclosed composite belts provided a high quality visual to the design and offered some protection against dust ingress, tampering or misuse. This design is in contrast with the majority of open metal-chain systems of hand cycles currently on the market.

Figure 18. Shows the Velo hand cycle system and attachment mechanism. (Designer: Mark Wafforne)
The designer followed a conventional physical and CAD-based prototyping strategy, using a mixed methods approach to validation, as it was difficult to gain access to wheelchair athletes and coaches on a regular basis to use then as a champion user. Feedback gained from one sports coach who was involved in setting up inclusive community sports internationally highlighted a large market that had previously not been considered. In many developing countries a hand cycle format for non-ambulant people is desirable, due to the rough terrain. A modular system, as proposed, could be attached to any back unit including a tricycle system with a bench and back-board for carrying goods.
Conclusion
In conclusion, the case studies have demonstrated the expansion of viable markets may be achieved through changing perceptions and responses to an AT-focused product, using alternative words and visual forms to emphasise ‘enhanced living’ rather than ‘assisted living’. The use of the LAT-UCD methodology can produce a commercially viable and desirable AT product. Each of the products discussed have taken a need and produced a high-quality solution. By taking the generic purpose of the product, which has been effectively satisfied, new markets may be identified that require a product that delivers the same purpose.

The challenge facing AT product designers is to apply the methods described to their own practice and, within the current economic climate, take further small steps towards a more inclusive society.

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George Edward Torrens is a Lecturer in Industrial Design and Technology in the School of Design, Loughborough University. He served a four-year engineering apprenticeship before studying Industrial Design at Newcastle Polytechnic. Whilst on a placement with Professor Jim Sandhu in 1986 he undertook his first design work relating to assistive technology. He built a rotational moulding rig to produce air cells for an adjustable modular seating system he had designed for children with cerebral Palsy. After graduating in 1988 he worked as contract furniture designer and technician before he joined the Brunel Institute for Bioengineering in 1990, working for Professor Heinz Wolff and Professor Ian Sutherland. During this time He worked with Charities such as Action research, The Motor Neurone Disease Association, Arthritis Care and Age Concern. He also developed and patented a new form of splinting for Colles’ fracture of the wrist. He joined Loughborough University in 1994.

As a lecturer he has been involved in the research design and development of over 20 products for commercial healthcare and charitable groups as well as the United Kingdom Ministry of Defence. He is named inventor on four patents. He is currently a member of the Leicestershire and Rutland panel of REMAP GB, a charity producing one-off adaptions for people living with impairments and associated disability.