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Design Tool for Enhanced New Product Development in Low Income Economies

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Abstract: In order to alleviate poverty throughout the World government and non-government organisations provide aid in the form of essential household products. These products typically include cook stoves, water filters and LED lights. However, evidence suggests that these products are not always suitable for Low Income Economies (LIEs) which has resulted in a number of high profile product failures. In response to the growing need for appropriate New Product Development (NPD), this paper presents the development of a tool to assist industrial designers create appropriate and long lasting solutions for those in poverty. Data was collected from the analysis of existing products, a survey, interviews with NGOs & industrial designers and a field trip to Myanmar. The results were used to identify attributes required for effective, long-lasting product design. This was used to create a tool for designers which was found to enhance understanding of appropriate NPD for LIEs.

Keywords: Industrial Design, Low Income Economies, Developing Countries, New Product Development, Design Tools

1. Introduction

Throughout the World the poor suffer from; hunger, deprivation and powerlessness which has compelled government and non-government organisations to work towards reducing poverty. Current estimates state that 896 million people live on less than $1.90 a day (World Bank 2016), which demonstrates a critical need to raise the living standards of those in Low Income Economies (LIEs) and provide them with essential household products such as cook stoves, water filters and solar powered lighting to help them escape the trap of poverty. Initiatives aimed at facilitating the design of these essential products could be described as sporadic during the last few decades, which appear to have lacked momentum or direction.

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However, recently there has been renewed interest in the design of these products and design students are reported to be "chomping at the bit" (Pilloton, 2009) to design socially beneficial products. In part this interest has been due to the rise and availability of design methods and awareness of current global issues such as poverty and sustainability. These issues represent today's biggest wicked problems, making it timely for industrial designers to contribute with new innovative ideas (Kandachar 2012). Despite this renewed interest, there are a limited number of design tools, which specifically focus on the design, and assessment of a product. Most current design tools focus on employing user centred design methods, the development of products for micro-enterprise (Austin-Breneman & Yang, 2013), investigations into cross culture design (van Boeijen 2015) and Designing for the Base of the Pyramid (Castillo, Diehl, & Brezet, 2012). Each of these approaches provides significant value to designers, and helps them understand users, cultures and enterprise, but there are no tools, which provide guidance to designers during the development process. The inherent visual nature of industrial designers means they would benefit with tools that they could use during the design process to ensure their products are effective and long lasting. Consequently, this research aims to enhance New Product Development (NPD) and assist designers understand the unique requirements of products for these markets. It is expected that this new knowledge will enable industrial designers to; evaluate product concepts during the initial design phase, evaluate existing products when re-designing or improving the solution and evaluate multiple products to understand which is most suitable. To achieve this, the following research questions have been created to guide the study:

1. What attributes create long lasting and effective products for LIEs?

2. How can this information be used to assist designers create and evaluate products for Low Income Economies?

1.1. Historical Context

The first well-known advocator of design for these markets was Victor Papanek in his publication 'Design for the Real World' which challenged designers to work on products for Low Income Economies and move away from the traditional purely profit-oriented commercial ventures. Papanek (1985) believed that industrial designers should "Design for people's needs rather than for their wants, or artificially created wants" (Papanek, 1985) This concept was later mirrored by the economist F.E. Schumacher (1973) who believed that providing an intermediate technology could solve the problems of the poor, by creating products requiring less capital investment. During this time Bonsiepe (1977), a design thinker and academic, took this further by proposing that for design to successfully help LIEs it must be embedded in the technology policy of the country. Bonsiepe (ibid) believed that the traditional 'hardware/artefacts' focused industrial designer could do very little to satisfy the needs of millions in poverty. However, if designers were able to distribute their knowledge to others that could have a profound effect on LIEs (Bonsiepe, 1977). These discussions culminated in 1979 during a joint conference between the International Council of Societies of Industrial Design (ICSID) and the United Nations Industrial Development Organisation (UNIDO), which resulted in the Ahmedabad declaration stating, "design [to] be a powerful force for the improvement of the quality of life in the developing world" (ICSID

and UNIDO, 1979). This declaration recognised the importance industrial design had to the growth of a country and aimed to embed design into national development plans for LIEs (Coward & Fathers, 2005). However, little happened in the preceding years and it was not until 1982 during the Design Policy Conference at the Royal College of Art, London, that Mohammed Loos argued that designers were not having a positive impact on LIEs. Instead of assisting people in LIEs, some western designers were reducing the confidence of indigenous people by the way they promoted and sold their own products (ibid). Again, there was little evidence of progress to the conference and there remained limited literature published regarding the design of products for LIEs (Margolin, 1989). The few articles that were published between 1980 and 1990s focused mainly on technology transfer and the development of an LIE into NewIy Industrialised Country (Er, 1993). However, during the late 1990 and 2000s there was a resurgence of interest in the field with contributions from Er (1997), Coward & Fathers (2005) and Donaldson (2008) who proposed an update of Bonsiepe's original design model, a review of design of LIEs discourse and the analysis of products for LIEs. Interest in this area has slowly continued to grow.

1.2. Current role of Industrial Design in International Development

Since the Millennium, industrial design as a profession has moved away from solely creating "objects that grace the pedestals of art museums" (Brown, 2008) and instead has applied its methods to solve bigger issues. This has enabled designers to imagine the world from a different perspective and help solve complex problems, sometimes known as Design Thinking. At the same time, approaches to international development have also begun to change, because some large aid initiatives have historically done little to raise living standards. In some cases aid programmes have resulted in a reduction of government accountability because "governing elites no longer need to ensure the support of their publics […] they do not need to raise revenues from the local economy, as long as they keep the donors happy" (Moss, Pettersson & van de Walle 2006). This reliance on donor support and lack of public engagement can also be seen in a number of products distributed by NGOs, because "unlike most [other] market transactions, the recipient of aid goods often has no ability to signal their dissatisfaction by discontinuing the trade of money for goods" (Polak & Warwick, 2013). This means that Non-Government Organisations (NGO) can deliver any product, regardless of the quality, or appropriateness, because often there is no feedback loop for the users to express their dissatisfaction (Donaldson 2006). In order to avoid these problems, Prahalad (2006) presented an alternative approach where products and services are sold to users in small packet sizes using microfinance schemes. This market based approach encourages local entrepreneurs and large multinationals to make a profit by selling essential products. These products are typically sold to the survival market that earn less than $3,260pa living at the bottom of the economic pyramid. The adoption of a market-based approach is attractive in that they can simultaneously alleviate poverty while making a profit (Diehl 2007). Despite some reservations, this represents a fundamental shift in the approach of the aid sector, and one that industrial design can add value. One important element for industrial designers is that NGOs have begun to recognise users as consumers, as opposed to charity recipients. This has meant that leading design consultancies such as; IDEO, Frog and Fuseproject are being employed to use user centred design methods to help create new solutions. This approach puts an emphasis on user involvement during the

design process. A UCD methodology highlights the importance of working with key stakeholders prior to beginning the design process and involving them in design decisions. International Development Enterprise (iDE), use this method and have consequently, helped thousands of people out of poverty by selling essential products (treadle pumps and agriculture tools) using micro financing schemes and loans. According to Polak (2008) the founder of iDE, the advantage of this approach is that it creates a sustainable business model in which the user has greater attachment to the product as they have invested their earning into it. This also means that the manufacturer can reinvest profits in further developments, which support the local economy.

2. Methodology

In order to answer the research questions three data collection methods were used which enabled the researcher to triangulate the findings. The first was a systematic review of 64 existing products, followed by a survey of 34 NGOs and industrial designers and 18 semi-structured interviews. The final data collection method was a case study with a Social Enterprise in Myanmar (Burma), this involved a field visit to the organisation and observations of the product design and development process. Each method has been used to explore the subject in greater depth, providing a complete picture of the structure of NPD for LIE products, see Figure 1.

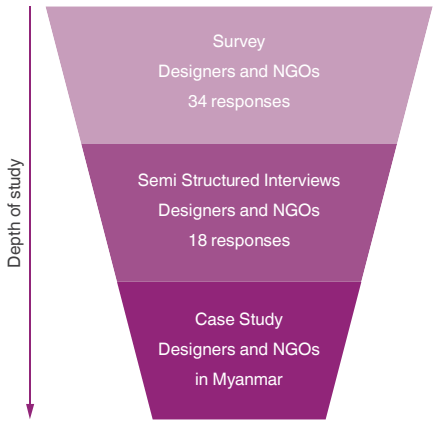

Figure 1 Depth of primary data collection

Thematic analysis was used to interrogate the data, which involved identifying codes and grouping them together into themes, these themes form the basis for interpretation (Braun & Clarke, 2006). The results of this analysis led to the creation of a design framework which was converted into a design tool and trialled with 30 undergraduate design students at Nottingham Trent University, UK. This was part of a wider study investigating approaches to enhance product development. The study adopted a grounded theory approach allowing the subject to be studied from multiple perspectives and expand on existing research to create new insights (Robson, 2011). The exploratory nature of grounded theory meant that analysis and interpretation was conducted at an early stage. Allowing the researcher to draw conclusions and inform further study as it progressed (Charmaz, 2006).

3. Results

Evidence from the analysis showed a number key attributes which can lead to an effective design. It was found that if an industrial designer takes these into account during NPD the final product will last for longer. To visually show key themes a word cloud was created, Figure 2.

Figure 2 Product analysis word cloud of commonly occurring themes

The main attributes required for a successful product were Affordability and Usability. However, data gather from the case study suggested that other attributes such as; Acceptability, Convenience and Quality were just as important to the uptake of the product. Further thematic analysis, consisting of the grouping of codes into themes resulted in the identification of eight key attributes. According to the data products, which display these characteristics, appear to be longer lasting and have greater impact than those, which do not. These were arranged in no particular order;

- Affinity
- Desirability
- Reparability
- Durability
- Functionality
- Affordability
- Usability
- Sustainability

Table 1 Indicators for Products Designed for LIEs.

Attribute	Description
Affinity	Affinity is the connection users have with a product, primarily on an emotional level. Interviews with NGOs highlighted that purely functional products resulted in lower uptake and a lack of consistent use, compared with products which provided an emotional attachment.
Desirability	Designers who were interviewed stated that as well as being aspirational products needed to be aesthetically desirable. The nature of a global economy means that users in LIEs are equally exposed to the styles, fashion and types of products seen in the developed world.
Reparability	Products purchased by LIE consumers represent a significant investment. It is therefore important that when failures occur, products can be repaired or returned. Two approaches to this have been found in interviews with NGOs and designers; either products are designed to be repaired by local craft or tradesmen, or alternately, they can be supplied with a warranty to receive a replacement.
Durability	The hostile nature of LIEs typically means that wear rates are higher and products need to be designed and built with a higher level of durability and robustness.
Functionality	Functionality is an important factor to consider according to interview data and product analysis. Typically, users neglect products which fail to provide their functional expectations.
Affordability	Interview data highlighted that the price of a product is crucial, not only to the users but also the NGO. The literature suggested that there is a trend for NGOs to move away from donating products and instead providing micro-finance, micro-credit and loans which enable users to buy their own products. Although still in the early stages of adoption this can affect the design approach and it is important to establish who the consumer is at the start of a project.
Usability	Product analysis revealed that many products come with picture diagrams showing how they work and how to use them. This is effective, but it is important to embed usability into the core design of the product. Designers interviewed stated that by including the user in the initial design phase enabled enhanced input into product usability.
Sustainability	Sustainability has been split into two parts; firstly, it is important to consider environmental sustainability in terms of material choice, end of product life and overall environmental costs. Secondly, the product distribution needs to be sustainable in the existing economic market. Evidence from interviews suggests that if products are distributed for free in the same markets where locals sell similar items this skews the markets and reduces the demand for sold products.

The inherent visual nature of designers and the need for a method of product analysis during NPD meant that a spider diagram was used to display the attributes. The eight attributes were arranged around the spider web and given values from zero to five (five being the highest). These enabled designers to rate products and concepts against each of the attributes and shade in the middle. This method provides an overall evaluation of the product concept and highlighted strengths and weaknesses of the solution see Figure 3.

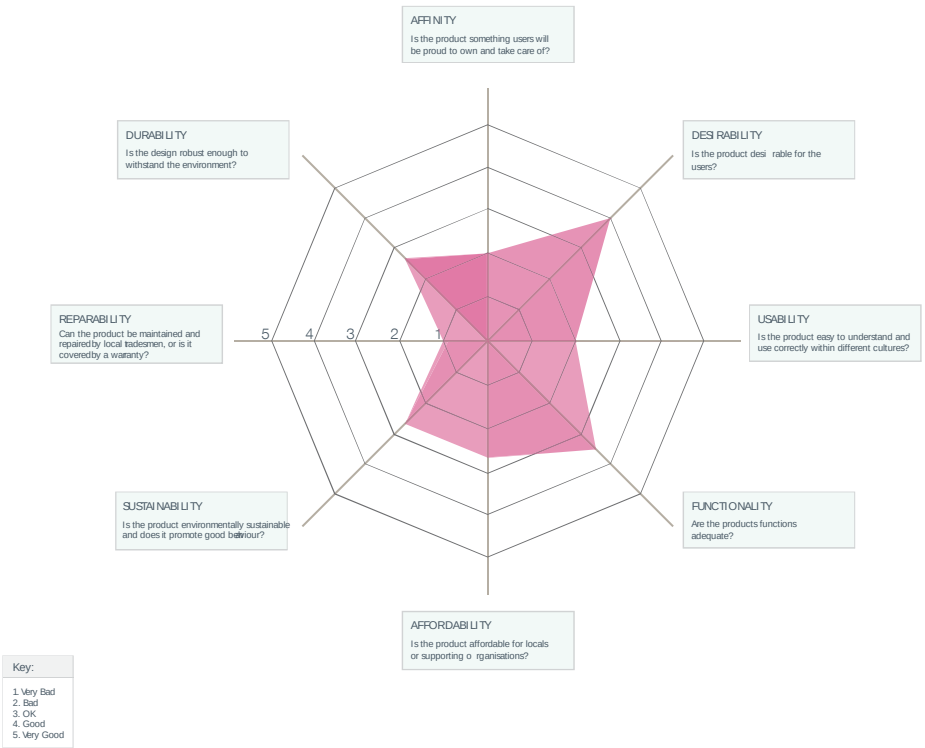

Figure 3 Product Analysis Spider Diagram

It is expected that this method can be used in three ways,

- To evaluate product concepts during the initial design phase
- To evaluate existing products when re-designing or improving the solution
- To evaluate multiple products to understand which is most suitable

In addition to the eight attributes, thematic analysis revealed a number of further considerations deemed by the interview participants to be important when designing for this market. It was decided that these were not suitable for inclusion in the spider web as they were not directly related to the design of a physical item, but were found to contribute to the effectiveness and up take of the overall product. These were (in no particular order) Funding, Users, Need, Distribution, Scale, Manufacturing Location, Quality and Convenience, and can be seen in Table 2.

Table 2 Further Considerations for Products Designed for LIEs.

Consideration	Description
Funding	Funding represents a significant challenge to industrial designers and NGOs, according to participants understating the aims and objectives of the funding body is critical to creating successful products. As a designer it is important to understand the business model which surrounds the project.
Users	There is currently little evidence of UCD in the majority of products designed for LIEs. This is therefore an important aspect to consider when designing a product.
Need	Identification of a real need is critical to the product effectiveness. Participants believed that often the need for the product was not well researched or understood and accounted for a number of failures. Furthermore, participants were wary of solutions which aimed to tackle multiple needs as they felt that these products were often unsuitable and did not provide an optimum solution for any of the needs.
Distribution	A high number of participants spoke of last mile distribution and the impact of a product on local markets. Therefore, when designing it is important to consider how easy the product will be to distribute in terms of size and weight, sometimes described as the 'lumpiness' of a solution.
Scale	In order to make a significant impact of poverty many of the participants believed that reaching large scale was important.
Manufacturing Location	The manufacturing location of a product is an important factor to consider. Evidence shows that there was little difference in the uptake of a product if is manufactured locally or internationally. There are advantages and disadvantages of each method, if a product is manufactured internationally; the design process is typically quicker and more efficient, which can result in higher quality outcomes. However, shipping, import tax and the availability of spare parts becomes more challenging. Alternatively, if product is manufactured locally, the development of skills can help to skill the workforce and provide them with an income. However, this can result in a slower development process, where a high percentage of time is spent educating locals and can lead to reduced product quality.
Quality	Users are looking for products which are of high quality, yet still an affordable price.
Convenience	Participants stated that users often neglected products which were not easy to use and incorporated into their daily routine, especially if the solution has been designed to promote behaviour change.

Interview participants were exposed to a draft version of the spider web to get feedback. It was found that they liked the simplicity of the model; but were concerned that the attributes could be ambiguous, if clear definitions were not provided. To overcome this and create a useable design tool which could be disseminated to designers it was decided that a set of assessment cards should be created to support the spider web and provide users with a detailed explanation of each attribute. Cards are becoming a common format for design research tools, as they are a quick and easy reference for designers (Evans 2013).

The analysis of existing design cards which included; IDEO Method Cards (IDEO 2002), iDCards (Evans & Pei 2013), Design with Intent Cards (Lockton 2010), Crossing Cultures Cards (van Boeijen 2015) and the Social Issue Cards (Lofthouse, 2014) highlighted four attributes which are commonly used in design tools.

- A thought provoking leading question
- Further information and or detailed descriptions of issue
- Case studies to show examples of good practice
- Strong images to illustrate the focus and draw attention

These insights have been used to guide the creation of a set of cards to explain in detail each of the indicators and additional considerations. The card, seen in Figure 4, has a primary question on the front face, with follow up questions to reflect on during the design process. On the reverse face a case study has been briefly described as an example of best practice, this approach was adopted for all the cards.

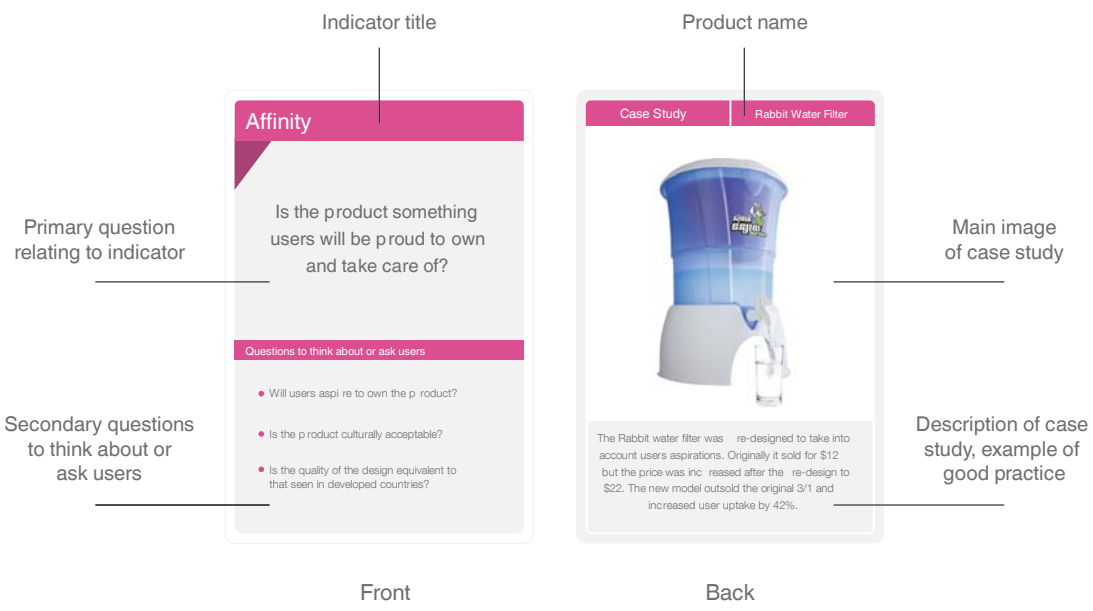

Figure 4 Card Design

The complete set consists of 16 cards; eight attribute cards for use with the product assessment spider web and eight additional considerations to be used throughout the design process. The full set of cards can be seen in Figures 4 and 6.

Figure 5 Product Assessment Cards

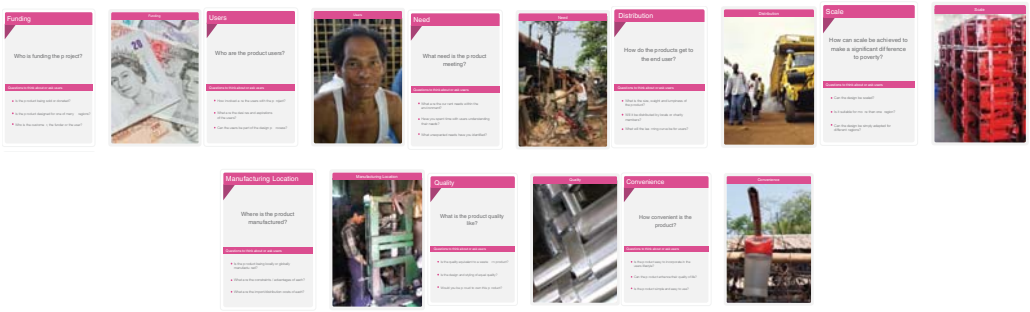

Figure 6 Additional Consideration Cards

These cards were prototyped at Loughborough University, UK and used with a copy of the spider web printed on a separate page.

4. Evaluation of Design Tool

The tool (which included the spider web and cards) was evaluated at Nottingham Trent University (NTU) with 30 second year BSc Product Design students. NTU was chosen for the study as the students were embarking on an Engineer without Borders Challenge during part of a module in Sustainable Design. Engineers without Borders (EWB) are an international organisation which aims to empower new engineers to remove barriers to human development by designing solutions to alleviate poverty (EWB-UK, 2013). During the second week of the project the students were divided randomly into six groups of five and asked to analyse two products from the 64 products used during the product analysis. Each group was asked to use the spider web and cards during the analysis to evaluate the design.

The products chosen were:

- Delagua Water Filter
- Lifestraw
- Lifesaver Bottle
- NoKero LED solar powered light
- Tough Stuff LED solar powered light
- Adspects self-adjustable glasses

Every attempt was made to ensure the products represented an even spread of categories and each group was given a physical product along with an information page about the design (the information on the page was used as a prompt see Liamputtong (2011)). Each group was asked to use the cards and complete a blank spider web. After the first product analysis the products were swapped and each group was asked to analyse a second product, providing two data sets per product. Following the analysis of products, each student was asked to individually complete a questionnaire in which they discussed their opinion of designing for LIEs and if they felt their focus had changed as a result of the exercise and tools.

The results of this evaluation have been divided into two sections, the first provides an analysis of the spider web, and the second investigates the student's opinion of the tool and if it changed their approach to design for LIEs.

The results shown in Figure 7 highlight the difference between the two groups in the analysis the same product. In some cases, for example, Tough Stuff, Lifesaver and the Life Straw both groups produced a similar result. In particular, the students believed that the Lifestraw and Tough Stuff were durable, usable and functional products but they lacked the ability to be repaired easily and were not considered sustainable. When these results are compared to findings from the product analysis, there was a relatively high degree of similarity results. For example, in the product analysis of the Life Straw it was reported by Boisson (2010) that some users broke the product in half, while trying to repair it and that the product had to be thrown away after one year. This highlights the inherent lack of reparability and sustainability in the product and proves that the students were accurate in their analysis. However, it was also evident that not all groups provided a similar result for product scores. This can be seen in the assessment spider webs for Nokero where the two groups produced very different scores. In this case Group 1 gave a conservative score between 2-3, whereas Group 2 scored higher in the region of 4-5 for each of the indicators. It is expected that there will be differences in the two sets of results, as the spider web method is relatively subjective and not all the students had a great depth of knowledge of each product.

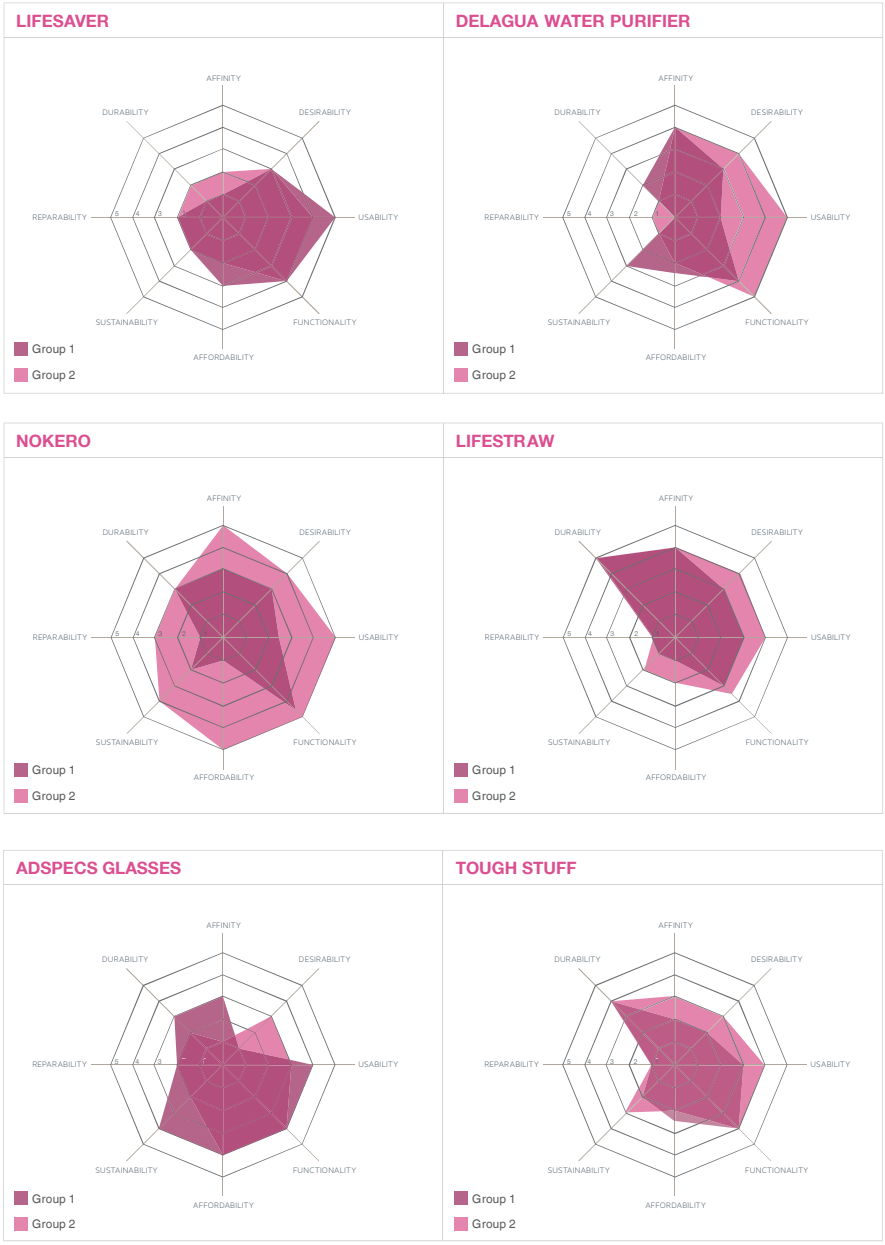

Figure 7 Evaluation of products using Spider web method

Following this assessment each group was asked to present their finding to the rest of the class. This allowed the researcher to make notes on the reasons they gave for the score of each indicators. It was initially evident that students liked using the spider web as an analysis tool, making reference to the cards to justify their decisions, see Figure 8. The students described how they carried out the analysis which typically involved looking at materials, the strength of the design, testing the functions and commenting on the visual and aesthetical elements. References were made to using the assessment cards during the process, especially if the students were unsure of an indicator. However, it was also observed that in some cases the scores were given without much consideration and highlighted the subjectivity of the method.

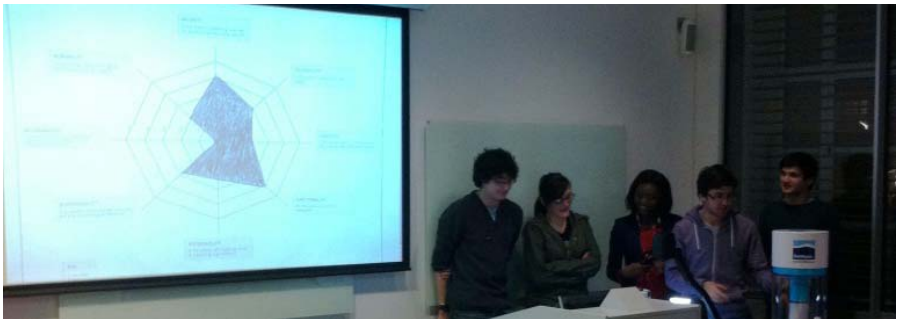

Figure 8 Group presentations at Nottingham Trent University

The second part of the evaluation involved asking students a series of questions, based on their experience using the tools. Initially the students were asked about their previous experience designing for, or background knowledge of LIEs, 58% stated they had limited or no experience designing for LIEs and equally limited background knowledge. When asked if using the tools had increased their knowledge, 85% responded that they had 'learnt more about designing for these regions' with 78% believing they were now better equipped to design products for LIEs. Students were then asked if they believed the tool was accurate and providing them with helpful information which would result in an improved design. 57% agreed that the information was effective and found that it was useful at highlighting areas for improvement, however some participants (13%) believed that there were some 'ambiguous' results and it was sometimes 'difficult to know how to rate a product' this ambiguity was likely to be caused by the subjective nature of the assessment tool.

Further questions were asked about the presentation of tool and if the students thought it was an appropriate design. 63% liked the design, finding it 'simple', 'quick and easy to use – especially the cards', however, some students commented that it would be better to have an online version of the analysis which could 'work out the score automatically'.

6. Discussion

This study formed part of a wider investigation which demonstrated the need for greater understanding into what constitutes an effective design of products for LIEs. The identification of 16 indicators (cards) and the subsequent creation of a design tool (16 cards and spider web) helps to enhance current NPD. When the tool was trialled it was found to be effective in educating designers and enabling them to get a greater understanding of current products. The spider web was easy to use and participants were confident at assessing existing products. It is expected that this form of assessment will be used during the design and development stage enabling designer to evaluate their designs. This will support existing methods such as user centred design methodologies and cross culture studies carried out by van Boeijen (2015).

One of the unique elements of the tool was the emphasis desirable products, which was highlighted by participants and in line with publications from Polak (2008). The tool helps designers ensure that products are not just technically suitable but also include aspirational and desirable features. However, during the study it was found that the spider web was

quite a subjective method and did not always provide a robust analysis of the product. This was particularly evident in areas of desirability, usability and reparability, students struggled to rate these areas. Although this could be seen as a hindrance, when used in conjunction with the assessment cards and other user centred design methods, it is predicted that the analysis will be more reliable. Even if full user centred design is not possible, the cards provide case study examples of exemplary solutions, which will act as a memory aid for designers (see Bevilacqua, Emanuele, & Giacchetta, 2012) to ensure they have considered each aspect of the design if designing remotely.

7. Conclusion

This study highlighted there is a lack of knowledge about the appropriate design of products for LIEs. This can have a direct effect on the product outcome and ultimately the livelihood of people living in poverty. Consequently, this study investigated factors required to create long lasting, effective products which resulted in the identification of eight assessment indicators and eight additional considerations. When these attributes are considered during the NPD process evidence suggests that products have a greater long-term uptake. The visual nature of designers and rapid adoption of design tools provided an opportunity to disseminate these findings into a set of cards and assessment spider web, creating a design tool. The initial tool was prototyped at Loughborough University, UK and evaluated by students at Nottingham Trent University, during an Engineering without boarders' competition. It was found during this study that the spider web and cards were effective in guiding and educating designers how to design for these markets. Although part of a wider study this investigates demonstrates how design tools can be created as a form of dissemination that can be utilised by designers. Further study is required to develop and refine the tool.

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