DESIGN FOR WELLBEING: INNOVATIONS FOR PEOPLE

A Larsson, T Larsson, L Leifer, M Van der Loos, J Feland

Abstract

There is a growing need for engineering designers to engage in creative activities that result in innovative products and technologies for the benefit of society. However, from an engineering perspective, issues of 'life quality' are currently heavily under-prioritized, particularly with regard to people with disabilities. This paper argues that both needs and solutions are now part of the designer's responsibility, and that it is crucial to make a qualitative assessment of both the potential market impact and the 'quality of life' improvements afforded by innovations. Design for Wellbeing offers a perspective on life quality that goes beyond the traditional scope of assistive technology in that it aims to help people make a transformation from an *actual* state of being to a *desired* state of being – regardless of ability level.

Keywords: Design for wellbeing, product innovation, collaborative design, design education, global teamwork

1. Introduction

Design for Wellbeing (DfW) [1] redirects the focus of product development from technology-based development to participatory product development. The primary objective of DfW is to enable people with disabilities to influence their everyday living conditions through active participation in the design of the assistive devices they use daily, but it also focuses energy on those people who are deviations off the 'normal' or 'average' consumer, along many different dimensions, not only physical ability. Consequently, the initiative uses the notion of 'wellbeing design' to broaden both the scope and the potential user base of consumer product development. The framework also offers a suitable framework to approach the rising industry demand for product innovators with experience from multidisciplinary collaboration in globally distributed teams. Thus, DfW centers on three main goals:

1. Designing innovative products for increased wellbeing.
2. Shaping the future of globally distributed collaboration.
3. Educating the product innovators of tomorrow.

In this paper, the motivation and rationale for the Design for Wellbeing framework will be described. The aim is to highlight the concept of 'wellbeing' as a true innovation opportunity that could provide significant benefits to both users and providers as well as for product development organizations in general. The paper will also report briefly on the results from two nine-month global student design projects, carried out between Luleå University of Technology, Sweden, Stanford University, USA, and the Royal Institute of Technology, Sweden. The student collaboration served as an initial experiment to investigate if wellbeing can strengthen the link between multidisciplinary education, research and innovation on a global stage.

2. The Wellbeing Agenda

In a recent report regarding future strategies for the engineering design area, published by the US National Science Foundation (NSF), engineering design is defined as a *"...socially-mediated, technical activity that creates and realizes products, systems, and services that respond to human needs and social responsibilities."* [2]

Similarly, the UK Engineering and Physical Sciences Research Council (EPSRC) writes in a fresh panel report that engineering is *"...the creative process of turning knowledge of science and technology into goods, services and infrastructure that benefit humankind."* [3] In the same report, they also note: *"...engineering improves our quality of life"*.

Within the European Commission 5th Framework Programme on 'Quality of Life and Management of Living Resources', a key action was initiated to address issues with the ageing population and disabilities. A priority was to come up with *"technological products and systems contributing to greater mobility and less dependency, both inside and outside the home, including in the work-place."* [4, p.7]

These three reports clearly indicate the need for engineering designers to engage in creative activities that result in innovative products and technologies for the benefit of society. To address issues of 'life quality' in engineering, however, should not be taken lightly. In fact, we argue that such qualities are heavily under-prioritized, particularly with regard to people with disabilities. The assistive device area is currently characterized by high-cost/low-volume development, and people with disabilities are normally excluded from the mainstream consumer market and forced through specialized channels in order to obtain their devices. This customization represents a significant cost to both the user and society, and that cost increases even further by the relatively high rate of device abandonment. In Phillips & Zhao's [5] study of 227 assistive device users, they noted that 29.3% of all devices were completely abandoned even though the need for the device (i.e. the disability) still existed. The authors related this abandonment to, for example, poor device performance and failure to take consumer opinions into account.

Even when assistive devices actually *do* improve the user's physical, sensory, or cognitive abilities, this does not automatically lead to increased quality of life. As Scherer [6] notes on the impact of assistive technology, the larger questions are too often ignored. How does the individual define 'wellbeing', 'quality of life', or 'rehabilitation success'? How does the device actually contribute to the fulfillment of that individual's needs? With Design for Wellbeing, we firmly take the stand that there is more to assistive device development than the prospect of 'fixing' people by diminishing disabilities.

- Essentially, DfW is an attempt to go beyond the traditional scope of assistive technology by helping people make a transformation from an *actual state* of being to a *desired state* of being – regardless of ability level.

The notion of designing innovative products for wellbeing thus introduces a new criterion that previously has not been adequately addressed by companies working with consumer products. Consumer products are primarily targeted at a relatively large potential user base, and most companies have not yet seen the economic potential in wellbeing design. This is perhaps because they cannot separate this new domain from the traditional assistive technology domain, which is generally perceived as low-profit, niche business.

Even if companies do realize the potential for profit, they still have to deal with the fact that wellbeing is a highly subjective concept, which is difficult both to capture and to generalize across a large user base. Fundamentally, companies need to improve their understanding of

what wellbeing is about and how to incorporate such wellbeing 'qualities' into mainstream consumer products.

The underlying hypotheses behind DfW are:

- In order to tap into the promising 'wellbeing market', and to stay ahead of the competition, companies will have to establish an exceptionally close collaboration with future users – thereby harnessing innovation opportunities that are not easily accessible to competitors.

- The only way people with physical, sensory, and cognitive impairments will get cost-effective products is through mainstream consumer product channels (e.g. one must avoid costly medical or custom channels), where designers with DfW competence are placed in corporate design teams with a mandate to extend each development cycle towards greater inclusiveness in the potential user base.

- The development of such competency requires changing designers and their formal education to include DfW thinking, user centered, and user impairment aware conceptualization.

The NSF report [2] implies that the focus of product development in the past may have been too much directed towards improving existing products and processes, while the greatest opportunity lies in the discovery of innovative products and processes. This introduces the need to successfully deal with a high uncertainty about what the end product will be, and also a high uncertainty about what the process that leads us there looks like. Obviously, this kind of 'wicked problems' [7] is nothing new within the area of engineering design; finding solutions to poorly understood problems is essentially what underlines the very idea of innovation. However, the DfW opportunity adds to the complexity that product development teams need to manage in order to design innovative products that generate both wellbeing and revenue.

2.1 Empowering Users

Since we increasingly deal with 'wicked', 'fuzzy', or 'messy' problems, we need to accept that a company, or a design team, will have major difficulties figuring out what the users need and how to address these needs. First, it is very difficult to find objective and general indicators of what wellbeing is, and second, there really is no such thing as an 'ordinary user' when discussing radically innovative solutions. Traditional market research falls short of this objective, and even some user-centered approaches lack the kind of user involvement that is needed to successfully address highly ambiguous problems. We need to empower users, so that they can inform the development process more actively. According to von Hippel [8], it is critical to identify and involve 'lead users' in the development processes, mainly because they have the following important characteristics (paraphrased):

- Lead users face needs that will become general in a marketplace, but they encounter them months or years before the rest of the marketplace.

- Lead users are positioned to benefit significantly by a solution to those needs.

As such, these users have a high motivation to solve problems, and since they are taking part in the development of solutions to their 'own' needs, they are likely to appreciate involvement in the innovation process. It is important to notice that lead users are not the same as the early adopters or pioneering customers that are commonly used for early testing. Lead users are ahead of market trends and they have needs that existing products do not meet [9]. In terms of

'wellbeing', we believe that there currently exists a vast range and variety of unmet needs, which leads us with the DfW innovation opportunity.

Empowering the users also means that we need to take an increased interest in real-world observations of future consumers. Users may not always be able to verbalize what they need, and their experience probably does not allow them to imagine possible innovations, which is why Leonard & Rayport's concept of 'empathic design' [10] resonates well with DfW. We are aiming at addressing people's needs, but we further aim to facilitate this needfinding process so that also the unarticulated needs are brought forward. With its references to the ethnographic tradition [11], this technique is well-known to the design research community, but observations in the user's own environment are still too rare in industry.

2.2 Bridging Disciplines and Distance

DfW is a global, multidisciplinary approach with research, user centered product innovation, and education as primary ingredients. The project aims to create new processes for global product development with focus on increased wellbeing for people with disabilities, including the additional goals of making a wider societal impact and providing companies with incentives to move towards a more inclusive view of the consumer population.

The framework includes participants from mechanical engineering, health science and human work science. By adopting this multidisciplinary approach, we are well equipped to manage the entire development cycle from an initial understanding of users' needs to studies of finished products in everyday use. In the health sciences and human work sciences fields, there is a vast knowledge of what it is like to live with a disability. By bringing people from these areas of expertise (and persons with disabilities) onto the product development team, we intend to give product users a more active role in developing their own assistive devices. We thereby aim to improve the wellbeing of persons with disabilities, and to develop product development methodology with respect to a more empowered user role in the process. In engineering, however, end-user participation in the development process is often restricted to initial needfinding [12] and the occasional testing of prototypes, after which the user receives a finished product. In the context of assistive device abandonment, as noted above, this may be one reason why the degree of functionality and usability is so low that some assistive-device users are even afraid of injuring themselves with their own assistive devices.

Furthermore, the increasing globalization of the marketplace means that we need to adapt our research approach to better fit reality. Previously used methods and perspectives might very well be obsolete when applied to new ways of working, so global product development calls for a global research agenda. The case is the same for education; it is not at all about using information technology to 'transfer' existing curriculum between continents, only substituting lecturers and paper for video clips and electronic documents. Fundamentally, it is about creating a learning environment that takes into account the challenges that comes with globalization, and builds upon the needs of the globalizing industry. Undoubtedly, in years to come, successful teamwork across distance is going to be an increasingly important factor in product development. Additionally, companies that seek to expand their customer base should have much to benefit from working on a global market – both in terms of getting access to a wider variety of user needs, and in terms of getting access to engineers with 'local knowledge'.

2.3 Redesigning Engineers

The DfW agenda includes changing designers and their formal education so that it, to a far greater extent, includes DfW thinking, user centered, and user impairment aware

conceptualization. The increasing importance of bringing a user-centric approach into design education has also been described by Dym et al [13]:

> *"While creativity is important, and may even be teachable, design is not invention as caricatured by the shouting of 'Eureka' and the flashing of a light bulb. Design problems reflect the fact that the designer has a client (or customer) who, in turn, has in mind a set of users (or customers) for whose benefit the designed artifact is being developed."*

Fundamentally, both needs and solutions are now part of the designer's responsibility, and it is important to make a qualitative assessment of both the potential market impact and the 'quality of life' improvements afforded by the innovation. [14] By introducing the notion of wellbeing as a guiding framework, we have the potential to deliver 'wellbeing products' through mainstream consumer channels, and to educate product innovators with useful experience from working in global teams using the latest methods and technologies.

3. Methods

DfW comprises two parallel paths of inquiry: a demonstration project and a process development project. The former project entails the joint participation of students, patients/users, and others in assessing the entire development cycle, from understanding of user needs to studying the use of newly developed assistive devices. The latter project involves researchers who investigate how the product development process can be adapted to address user needs more effectively, and how we can best integrate the engineering, business, and human work science disciplines in education, product development, and research.

3.1. Demonstration Projects

Within the framework of a final-year course entitled SIRIUS - Creative Product Development, in the MSc degree program in mechanical engineering at Luleå University of Technology, several product development projects are conducted each year in close collaboration with industry. This form of cooperation has proven very successful and has led to the development of a number of so-called Greenhouses [15] at Luleå University of Technology. During the academic year of 2003-2004, we introduced Design for Wellbeing as one of the themes in the above-mentioned course, which involved the participation of students, assistive-device users and other interested parties in joint development projects that took a particularly strong interest in developing assistive devices that are firmly based on a profound understanding of user needs. The modular nature of engineering degrees at Luleå University of Technology also makes it possible for students studying other, complementary disciplines to participate in SIRIUS. The varying background of the students provides a wide knowledge base in the project groups and an opportunity to gain understanding of the complementary relationship between different engineering disciplines. The product development process in SIRIUS is based on a systematic approach to engineering design and CAD-tools and simulations are an important part of the verification process.

The SIRIUS students were accompanied by a team of students from an equivalent course at Stanford University called *ME310: Team-Based Design Development with Corporate Partners*. ME310 is a three-quarter graduate sequence where student design teams work with corporate partners on design innovation projects. Teams gain hands-on experience working on industry sponsored projects, with significant budgets, to develop prototype products. The design environment of the course is modeled after situations faced by many engineers and designers in industry. The students learn to work in global, multi-disciplinary, and

collaborative design teams. The approach to design in the course can be characterized as rapid prototyping with multiple iterations, and it is based on the understanding that students come to the course with enough world experience to challenge the stated client requirements, build solutions to meet revised objectives using easy-to-prototype materials, and learn important and strategic lessons from the success or failure of these early attempts.

A team of students from the Royal Institute of Technology in Stockholm also participated in the DfW framework as part of the INTELiCare project, described later on in this paper.

3.2. Process Development

The process development project involves researchers who investigate how the product development process can be adapted to address user needs more effectively, and how we can integrate the engineering, business, and human work science disciplines in education, product development, and research. The aim is to develop product development methods that make it possible for cross-disciplinary teams to work confidently in heterogeneous knowledge-creation environments. In connection with this the target is to investigate how we can adapt the product development process to address user needs more effectively. The interplay between user needs and the formulation of quantifiable product specifications is a key aspect. It is also important to observe the bridges between quantitative and qualitative analyses that are necessary for assuring the success of an interdisciplinary project.

DfW represents not only a multi-science approach; it also brings people from various groups – assistive-device users and developers and interest groups – into the process. The point of departure is in cross-functional knowledge creation, whereby people from academia and the surrounding society interact as partners and equals at both the organizational and individual levels. By allowing people from different knowledge and interest areas to meet in a concrete project in which nothing can be taken for granted, perspectives must be reconsidered, and innovative new ideas can emerge and become the basis of entirely new products (i.e., not merely upgrading existing products).

4. Results

4.1 Demonstration Project #1: CRE[ATIVO]²

The team started out with only one set of keywords to frame the scope of the project: active, winter, leisure time. From these words the team started to focus on mobility devices. Through rigorous needs analysis and benchmarking of current solutions the group discovered the need for winter-adaptable manual wheelchairs. Thus, the mission statement for the CRE[ATIVO]² project was formulated:

> To develop a safe mobility device that is easy to maneuver on varied terrains and in multiple weather conditions. The device should also improve user access to facilities and transportation, while being easily transportable.

Through numerous concept generations and evaluations, a light-weight composite wheelchair and a tire cleaning system was developed. By using composites instead of metal, the weight of the wheelchair was reduced, thus allowing for the addition of extra features while still keeping the chair lighter than the most popular chairs on the market today. A center of gravity adjustment feature was added, whereby the user can adjust the center of gravity position while in the chair. This allowed for the backrest to be adjustable in different positions, giving the

user added comfort. Traction in winter was improved by the addition of clip-ons with a unique tread pattern.

One of the problems with the wheelchairs today is keeping it and the user clean. In a regular wheelchair tire, dirt and snow get caught between the spokes. The Luleå team solved this by developing a new spider-wheel with three spokes. With this solution you can easily avoid the majority of dirt and snow. The main cleanliness problem is keeping the actual tire with the traction pattern clean. The Stanford team solved this problem by developing a tire cleaner to help the user to clean the chair before entering the house, especially during the late winter and early spring when the pavements are wet and dirty.

Figure 1. Exhibition of the light-weight composite wheelchair.

4.2 Demonstration Project #2: INTELiCare

The goal of Intel's Proactive Health project, INTELiCare, was to explore, demonstrate and test a variety of home health technologies aimed at prolonging elders' independence and enhancing their quality of life. The initial focus of the Proactive Health project is on addressing the needs of elders coping with various stages of cognitive decline. The mission for the team was:

> *To develop a system that could help elderly people to prolong their independence at home and that could help relatives know the state of the elders.*

The idea was to cut time losses, expenses and the work load for the caregiver. It was also the goal to help elders remain socially active and to encourage them to initiate contact with other elders. The communication device for the elders, designed by the student team at Luleå University of Technology, gives the elders the possibility to see what their friends' availability is at the moment. If they browse through the names of their friends they can see if they want to socialize or not. Another possibility with this unit is that they can counteract cognitive decline by viewing images and explanatory text of relatives and friends by projecting these images and texts with the unit on, for instance, a table or a wall.

The Stanford team developed a caregiver device that acts as an ambient portal to important information regarding the elder caregiver. It conveys various activity levels in three categories; social activity, physical activity and daily routines.

The team from the Royal Institute of Technology produced a sensor network and a central computer logic system to relay information to and from the elder and caregiver devices. Sensors were used to monitor the users' physical and social activity levels as well as their daily routine activities.

Figure 2. Visualization of the INTELiCare elder device concept.

5. Conclusion

The findings from the research and education projects performed within the DfW agenda indicate that it provides a suitable framework for project-based, team-structured learning in global teams. The wellbeing theme, with an emphasis on the design of products and services that increase the wellbeing of individuals, seems to act as an appropriate conceptual 'umbrella', under which key challenges in industry can be approached while the educational contents can be continuously redesigned to better prepare engineering design students for a future work environment characterized by multidisciplinary collaboration in global teams. DfW meshes well with the basic concept of a new educational framework called the *d.school*, currently under development at Stanford University [16]. The d.school framework brings together business, human issues, and technology in a comprehensive approach to support the creation of tomorrow's innovations. Such an inclusive framework, carefully tuned to meet the industry's demands on the "engineer of tomorrow", also needs student and research projects that are thematically inclusive, meaning that many different disciplines can contribute and that the actual collaboration across disciplines is what spurs innovation.

Several initiatives, such as *Inclusive Design* [17], *Design for All* [18], and *Universal Design* [19] consider the possibilities for people with disabilities to participate in society on equal terms. It is important to note that DfW does not seek to replace these other initiatives, because they are indeed highly complementary. Fundamentally, what makes DfW different is that it is not so interested in optimizing products and technologies to be more 'inclusive'; it is interested in coming up with completely new solutions to completely new problems. In a

sense, the DfW innovation opportunity can be summarized as meeting previously unknown (or poorly understood) needs with previously unknown (or poorly understood) processes.

The DfW framework thus offers an extension to those initiatives by moving beyond the idea of 'fixing' people by diminishing disabilities through the design of assistive, inclusive, or universal technologies. DfW also introduces a complementary approach to help companies expand their potential user base by mainstreaming their technologies to also embrace the 'outsiders'; the people whose needs are neither well understood, nor well addressed today.

Design for Wellbeing is a perspective on life quality that goes beyond the traditional scope of assistive technology in the sense that it aims to help people make a transformation from an actual state of being to a desired state of being – regardless of ability level.

References

[1] "Design for Wellbeing", Luleå University of Technology, www.designforwellbeing.org, Accessed March 18 2005.

[2] "ED2030: Strategic Plan for Engineering Design", National Science Foundation (NSF), Workshop Report, January 2005.

[3] "The Wealth of a Nation: An Evaluation of Engineering Research in the United Kingdom", Engineering and Physical Sciences Research Council (EPSRC), Panel Report, February 2005.

[4] European Commission, Key Action 6, Directorate-General for Research – RTD - F-3 – "Quality of Life and Management of Living Resources: The Ageing Population and Disabilities", 2002, Accessed March 18 2005, europa.eu.int/comm/research/quality-of-life/pdf/ka6-ageingpopulation.pdf.

[5] Phillips, B., and Zhao, H. "Predictors of Assistive Technology Abandonment", Assistive Technology, 5 (1), 1993, pp.36-45.

[6] Scherer, M. J. "Living in the State of Stuck: How Assistive Technology Impacts the Lives of People with Disabilities", Brookline Books, Cambridge, MA, USA, 2000.

[7] Rittel, H. and Webber, M. "Dilemmas in a General Theory of Planning", Policy Sciences, 4, Elsevier, Amsterdam, Netherlands, 1973, pp 155-169.

[8] von Hippel, E. "Lead Users: A Source of Novel Product Concepts", Management Science, 32 (7), 1986, pp. 791-805.

[9] Lead User Concepts, Inc., Accessed March 18 2005, www.leaduser.com/what_is_lead_user_research.html.

[10] Leonard, D. and Rayport, J. F. "Spark Innovation through Empathic Design", Harvard Business Review, November-December 1997, pp.102-113.

[11] Blomberg, J., Giacomi, J., Mosher, A. and Swenton-Wall, P. "Ethnographic Field Methods and their Relation to Design", In Schuler, D. and Namioka, A. (Eds.). Participatory Design: Principles and Practices, Lawrence Erlbaum, Hillsdale, NJ, USA, 1993, pp.123-155.

[12] Patnaik, D. and Becker, R. "Needfinding: The Why and How of Uncovering People's Needs", Design Management Journal, 10 (2), Spring 1999, pp.37-43.

[13] Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D. and Leifer, L.J. "Engineering Design Thinking, Teaching, and Learning", Journal of Engineering Education, January 2005, pp.103-120.

[14] Feland, J.M., Cockayne, W.R. and Leifer, L.J. "Comprehensive Design Engineering: A New Path to Innovation", International Conference on Engineering Design (ICED'03), Stockholm, Sweden, 2003.

[15] Andersson, M. and Söderlund, A. "The Greenhouse Learning Concept: A New Pedagogical Approach", Proceedings of 30th SEFI Annual Conference, Florence, Italy, 2002.

[16] Stanford University Design Institute. Accessed March 18 2005, dschool.stanford.edu.

[17] Coleman, R., Clarkson, J., Keates, S. and Lebbon, C. (Eds.). "Inclusive Design: Design for the Whole Population", Springer-Verlag, London, UK, 2003.

[18] Design for All Foundation, Accessed March 18 2005, www.designforall.org/en/downloads/dossier-DfA-Fd-ang.pdf.

[19] Vanderheiden, G. and Tobias, J. "Universal Design of Consumer Products: Current Industry Practice and Perceptions", Accessed March 18 2005, trace.wisc.edu/docs/ud_consumer_products_hfes2000/

Acknowledgements

Andreas Larsson, Polhem Laboratory, Division of Computer Aided Design, Luleå University of Technology, SE-971 87 Luleå, Sweden, Tel: +46 920 491874, Fax: +46 920 99692, E-mail: Andreas.C.Larsson@ltu.se, URL: http://www.cad.ltu.se/.