Managing Complexity & Promoting Usability: A User-led Design Approach

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Everything should be made as simple as possible, but not simpler. (Albert Einstein)

Abstract

The inability of designers to meaningfully engage end-users in addressing their needs has resulted in a market saturated with unusable devices. To increase usability and reduce complexity, we propose a user-led design process where addressing user's real need is the goal rather than developing new technologies or products. Such an approach places emphasis on the process of design rather than the final product.

Introduction

We live in very complex societies. How and why such complexity has emerged is the topic of much deliberation and debate. Even more debatable is the necessity for such complexity. It appears that our complex system of managing society emerged not by design, but from a lack thereof. Technology, far from simplifying our lives, has served the cause of complexity and many have blamed it as the main reason for our complicated life styles. Tools that equip our modern lives are designed by sufficiently trained individuals who are bound by their own limitations and by those imposed on them by businesses that exploit technology purely for profit. It appears that the needs of those who use technology are often ignored. Take automobiles as an example. The primary function of automobiles is to transport people and goods. However, the efficiency of a typical automobile to transport individuals is miserably low. In fact the majority of fuel (up to 98%) is either wasted (engine inefficiencies) or used to move the very heavy automobiles themselves. Despite such desperately poor performance, vendors continue to manufacture conventional automobiles and consumers continue to purchase them. Not only do the designers seem out of touch with the actual needs of peoples and the society, the individual users appear to be "fashion victims" and do not seem capable of making choices based on usability. All this has led to what some call the "un-usability culture".

Tainter [1] argues that "*Complexity is a problem-solving strategy that emerges under conditions of compelling need or perceived benefit*". Society's response to stresses and challenges has been to become more complex. Tainter however, argues that development of complexity is an economic process with diminishing returns as shown in Figure 1.

Beyond certain levels of complexity, societies experience negative returns (point B1, C1), and become vulnerable to collapse. One reason for increased complexity, Tainter suggests, is selection of more complex solutions to address increasing challenges as simpler solutions appear to be exhausted. Tainter refers to this as the "economics of problem solving". As compelling as it is, Tainter's theory of increasing complexity and possible collapse seem to find its antithesis in nature. Nature's problem solving approach has, over millennia, led to a highly integrated system of tested and tried solutions with a great deal of sustainability. Although seemingly complex, the natural system enjoys an elegant balance of highly efficient and simple solutions. The question is therefore; can humanity faced with ever-increasing challenges devised a similar sustainable system of efficient and inherently simple solutions?

In this paper, we suggest that a fundamental change to conventional problem solving and design approach is needed to address the problem of increasing complexity. We further use a case study to demonstrate its application.

Figure1. Diminishing returns of complexity [1].

A Critique of Conventional Design and Problem-solving Approach

According to Tainter, complexity increases as new solutions are developed for emerging crises and problems. Engineering design is fundamentally a problem-solving process and has often been used to address emerging problems. The Accreditation Board for Engineering and Technology (ABET) provides the following definition of engineering design:

"Engineering design is the process of devising a system, component, or process to meet desired needs."

Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation.”

The objective of engineering design according to ABET is to meet desired needs, indicating that one of the first steps in engineering design is to define a need. This step however can be plagued with a great deal of ambiguity as individual perceptions impact the definition of needs. The distinction between the real needs and the perceived needs often becomes quite blurry, caused partly by what is referred to earlier as the “un-usability culture”. Unfortunately, too often designers focus on perceived needs rather than the real needs of the end-users or the society. The inability to adequately define “needs” (analogous to problem definition in the problem solving strategy) is therefore, the first critique of the conventional design approaches.

Another aspect of engineering design is, according to ABET, the devising of a system, component or process. Designers often tend to narrow this definition to primarily devising a “product”, whereas the final outcome of a design may well be a process or a system rather than a product. The emphasis on product development may have been driven by the commercialization of technology and the underlying drive for profit making. The consequence of such an approach is that design (including engineering design) is guided by the desire to produce a profitable product rather than addressing a real need.

Compounding the above deficiencies is the underlying failure of most designers to meaningfully incorporate the end-users in the design process. Even the so called “user-centered” design methodologies often remain essentially “top-down” in nature, providing little opportunity for end-user involvement. This has created an elitist approach to design, alienating a large portion of society whose lives are becoming ever more complex and unmanageable. Adler and Williams [2] argue that the most critical failure of the majority of prevailing design methodologies has been their inability to “*exploit user’s own capacity for innovation*”. In other words, the conventional design processes often fail to benefit from relevant insights that exist among lay end-users, referred to sometimes as “lay expertise”[3]. In essence, rapid technological advancement in the past century has created a rift between “scientific expertise” and “lay expertise”. For a design process to become fully beneficial to society, these two types of expertise must be reconciled.

User-involved Design and Problem Solving Processes

Several modified design approaches have emerged in the past two decades to address the problems

associated with the usability and relevance of products and services. The thrust of most approaches is the importance of inclusion of end-users in some aspect of the design and problem solving process. This may include end-users involvement with the identification of new products or service opportunities, design reviews, usability testing and prototype testing. A number of methods have emerged to facilitate user involvement.

Designers have long used scenarios to gain insight into end-users preferences and ensure end-users needs are considered during the design process. Scenarios are similar to stories with characters and a clear context associated with particular issue and end-user community. Personas, a variation of the scenarios, are fictional people with specific profiles and needs intended to heighten the designer’s attention to end-users needs. Market surveys and interviews are another common tool for end-user engagement. Von Hippel [4] argues that the problem with end-user surveys and interviews is that most users are also constrained by their present experiences and thus unlikely to generate novel ideas for future solutions. He introduces the concept of a “lead user”. Von Hippel defines lead users as: “users whose present strong needs will become general in a marketplace months or years in the future.” He suggests surveys or interviews should focus on “lead users” rather than a typical end-user. Other approaches such as “participatory design”, and “distributed participatory design” (particularly in computer-human interaction) incorporate various stages to encourage user input, involvement, or participation in the design and problem solving process.

Participatory design (PD) initially was proposed in Scandinavia and grew out of a desire to democratize design process by involving the end-users in the software design process [5]. The Scandinavian PD process was based on the principle of “humanization of design”: “the system is primarily designed to compensate human weaknesses or to support human strengths”. Other PD processes place more emphasis on the “democratization of design” where design process reflects the interests of system owners or those affected by the system. Both PD approaches promote an evolutionary design process with end-user involvement and reflection incorporated at various stages of design.

The participatory design process emerged in the late 1970’s to meaningfully facilitate worker’s input and involvement in the way computers were used in the workplace. As such, the primary focus of PD research has been in the arena of human-computer interaction (HCI). Although PD has been successful in varying degrees in reaching its original goal, it suffers from several limitations. An important limitation is that the PD process does not attempt to involve end-users in defining the needs (problems), since the focus of PD has primarily been defined by HCI (computers and their

effective use). As such, the participatory process may center energies and effort on an ill-defined or “perceived” need or problem. Additionally, the extent of workers (or end-users) involvement in the design can vary from “providing designers with access to workers’ skills and experiences” to more extensive involvement in the process including design, evaluation and prototyping [6]. The third limitation is that the PD process has focused mainly on technology (product) development and human interaction with the technology rather than problem solving or design of new processes. Finally, the PD projects often take place under unrealistic conditions, shielded from the conditions of real world [6].

Another extension of participatory design is the Open-Source Software Design (OSSD). This is a more informal process where large numbers of designers are involved in software development under unstructured conditions without particular specifications, project plan, schedule or deliverables. The main means of communication is through the Internet. Interestingly, a recent survey conducted regarding the OSSD community found that the community represented little diversity. For example, the survey found that 98% of designers were male, 75% less than 30 years old, 60% single and 83% without children with a large majority from Europe (particularly France and Germany) and North America [7]. The OSSD movement has led to other interesting collaborative design scenarios such as those that resulted in the development of the Wikipedia and other wiki-based resources available on the Internet. This has resulted in an informal collaborative design process with end-users involved in the evolutionary development of a product (Wikipedia, for example).

The User-led Design Process

The user-led design process is an extension of the PD process and is defined as a process of enabling end-users to have a direct role in the problem solving, design and development process and “exploit opportunities for social learning – the sharing of ideas, experiences and innovations” [8]. The goal is to improve the quality of life or address a real need or problem rather than new product development. The user-led design process typically occurs in small collaborative groups. Many suggest that these user-led collaborative approaches lead to “social creativity” which they believe is more productive than individual creativity [9]. Although user-led design processes have been employed in the past, the process itself has not been clearly defined. This may be a consequence of the process; as meaningful user involvement should lead to diversity of approaches. However, there seem to be certain shared

characteristics among user-led processes that we attempt to describe below.

Inclusion of lay expertise

Fundamental to user-led design processes is the recognition of the importance of the lay expertise and its inclusion in the process. This implies that the selection of end-users should not be solely based on the end-user’s level of technical or scientific expertise. Whereas technical and scientific expertise may be necessary during the latter stages of the design process, inclusion of lay expertise ensure that real needs are identified and simpler solutions are given priority. Tainter’s concern that new and emerging crisis lead to exploitation of more complex solutions and consequent increase in complexity may be partly addressed by the inclusion of lay experts who generally tend to select simpler solutions. Lay expertise is provided through the selection of relevant end-user groups.

Identification of needs (problem definition)

Once appropriate end-user groups have been identified, the design process must identify end-users needs. It may be important to select a large end-user community to ensure that the identified needs are representative of the selected group. Various tools may be employed in identifying end-users needs including surveys, interviews, scenarios and personas, and data from published literature. The results of surveys or interviews must then be appropriately analyzed using various qualitative analysis methods such as grounded theory to identify and prioritize most relevant needs.

Solution identification

Once a real need has been identified, the design team will then initiate the process of solution identification. The design team would be comprised of both technical and lay experts, carefully selected to ensure both comprehensiveness and diversity. Solution identification will be an iterative process characterized by the narrowing down of a large number of possible solutions. Flexible criteria and constraints may be introduced at this stage to guide the solution identification process. It is also important to note that lay experts involved in this stage may be a subset of the larger end-user group or a different end-user group (i.e., the end-user community that is involved in the solutions identification does not have to be the same as the one involved in the problem definition). It is also important that the aim should not necessarily be achievement of a 100% solution as this is against the spirit of an iterative evolutionary design process. It is also possible that a number of solutions are identified and implemented.

Solution implementation

Solution implementation (sometimes referred to as prototyping) involves implementation of identified solution(s) for the purpose of evaluation. The aim at this

stage is not to implement a final solution but to evaluate the preliminary solutions. The solutions will be implemented or tried by the end-user groups under real world conditions. Results of implementation will then be brought back to the design group for reflection.

Reflection

The reflection process will involve the lay-technical expert group that identified original solutions. The aim of the reflection process is to attempt to improve upon the original solutions based on feedback from the implementation stage. The outcome of the reflection stage would be improved solutions that can be implemented or tried by the end-user community. The reflection stage may also result in the redefinition of the need followed by revision of the solutions. The entire process is depicted in Figure 2.

Figure 2. The proposed user-led design process

The Grounded Approach to Investigating and Implementing User-led Design Projects

As user engagement and understanding user needs are important components of a user-led design process, we are devoting a section on elaborating the grounded theory approach (GT) which we suggest as a powerful tool of achieving meaningful user engagement [10]. “Only through appreciation can the texture of social patterns and the nuances of human engagement with those patterns be understood and analyzed. Without appreciation and empathy we may gather surface facts regarding the phenomenon and criticize the enterprise connected with it, but we will fail to understand in depth its meaning to the subjects involved and its place in the wider society” [11]. A grounded theory (GT) approach places analytical weight on the interpretive behaviour of the individual

(end-user) in relation to their own sense of self, others and the situations in which they derive meaning. The primary method in which to uncover these social processes is what Cooley [12] terms “sympathetic introspection” or what is now more commonly referred to as ethnography or participant observation (see [13]). Participant observation demands that the researcher commit themselves to the “social roles that fit into the worlds they are studying” [14]. Attempting to experience what their participant’s experience, feel what they feel and behave in a similar fashion gives the researcher insight into how those they study perceive the world around them. The main conceptual and methodological tenants of GT are derived from an interactionist view of human social conduct. We argue that a research mandate that advocates for a user-led perspective would do well to incorporate GT and its emphasis on the experience and knowledge of end-users.

In GT, the designers study participants within their own natural setting, and through observation and participating in their social milieu, conceptual analytical frameworks grounded in participant’s own experience are constructed. The researcher is ever cognizant never to stray too far from their participant’s common sense knowledge of the everyday world and how that knowledge is used to construct and make sense of reality. This approach is distinct from the more popular hypothetico-deductive method that is characteristic of normative approaches that rely on official reports and statistics to explain causal relations between variables. Such a methodology is unable to accommodate the perspective of the end-user and perhaps the popularity of these positivistic models and their putative objectivity is one reason end-user led approaches are so rare within engineering circles. GT as both a methodology and ontology is germane to investigating the “best practices” of user-led design processes and their emphasis on the inclusion of lay expertise and their identification of needs. The following four points propose how GT can address the aforementioned limitations in participatory design (PD) research:

- 1) *The PD process does not attempt to involve end-users in defining the needs (problems) and so these needs can appear rather ambiguous with perceived and real needs being conflated.* GT recognizes the experience and meaning-making activity of the end-user and thus their needs and definitions of their problems can be clearly articulated through its emphasis on sympathetic introspection.
- 2) *End-user involvement varies greatly.* This wide variation will be better understood as researchers committed to the GT perspective will determine the social conditions and situations that lead to variation concerning involvement (i.e. lack of involvement due

to limited recourses, due to a sense of intimidation, due to apathy)

- 3) *Overemphasizes “product” at the expense of process.* GT specializes in acquiring a processual understanding of group life and is therefore more than capable of explicating the stages involved in user-design led initiatives.
- 4) *Takes place under unrealistic conditions.* GT prefers to study individuals in their natural setting. This is appropriate given the fact that we advocate for a user-led design approach that is respectful of user’s everyday interaction with technology.

If the goal is in fact to improve the quality of life or address a real need or problem rather than a new product development, then participatory observation is required. The methodological tools of GT get to the core of the user’s experience. Observing the interaction amongst end-users and interviewing them often as the project matures, will uncover some of the misunderstandings embedded in expert-lay interactions and with this information the group can clearly define the needs of the end-user and the limitations that expertise may face given this unconventional focus on process and end-user expertise. Moving away from a 100% solution requires a trust in the emerging process of collaboration. GT analysis can identify the progress made at any stage as it collects and analyzes data before, during and after every phase of the project via its method of abduction [15] (i.e. moving back and forth between deductive and inductive analysis embedded within solution identification, solution implementation, and reflection). Although social life is complex, GT makes it simpler (not simplistic) through coding and conceptualization and thus provides a framework in which to sensitize and orient member’s toward the data that best serves the purposes of design-led usability. The emergent conceptual framework is grounded in the end-users experience and not the expert, and therefore it informs stakeholders and policy on how they can adjust accordingly to the real needs of the end-user during the reflection stage. Furthermore, testing ideas derived during reflection can once again move back into the implementation stage. GT is an excellent methodology in which to investigate the incremental back and fourth movement characteristic of the proposed user-led design approach.

Case Study – User-led Design of Technology to Improve Quality of Life for People with Dementia

A collaborative user-led design process was undertaken to improve the quality of life for people with dementia. This multidisciplinary project involved the Universities of Liverpool (Social Science), Sheffield (Architecture) and Bath

(Engineering) as well as representatives from Northamptonshire Social Services, Dementia Voice, and Huntleigh Healthcare, as well as Sheffcare and the Research Institute for the Care of Older People (RICE). RICE provided the design team contact with a large number of local people with dementia to try out prototype devices [16]. Instead of developing a product to improve the quality of life, this project first investigated what the “quality of life” meant to people with dementia. Loosely structured interviews were initiated with 26 people in the early to moderate stages of dementia and the results were transcribed and analyzed using grounded theory. Issues related to the quality of life that were most important to people with dementia were identified. During the interview stage there was little discussion of specific items related to the technology or product. The designers “were keen for the work to be led by user-needs rather than by any concern about technological feasibility”.

One of the issues that were identified during the interviews was the importance of music to the well-being of the people with dementia. Another important issue was the need for any equipment to “build on the sense of familiarity” – the way the equipment dealt with use or misuse should not be outside the common experience of the end-user. The approach meant that the design process had to be iterative and use any clues that were provided by the end-users during various stages of design. To minimize complexity and ensure familiarity, various designs of a music player were explored to reduce end-users control to one or possibly two buttons. Infrequently-used control features were hidden away from the end-user but accessible to the care giver. The design started from a simplified CD player (iteration 3a). But following end-user’s trials, two important problems were identified. First problem was opening and closing of the CD lid and the second was the delay between pressing the on button and playing of the music. To address these problems the second design iteration used solid state recordings similar to an MP3 player (3b). This prototype had two round speakers and a large illuminated button for on/off applications. Other concerns were raised as the end-users tried the second design iteration. The users confused the round speakers as on/off buttons and the start button did not clearly signal playing of music. It was decided to remove the round speakers, making speakers much less conspicuous. End-users were also asked to specify which symbols represented playing of music. Most selected musical notations as an appropriate symbol. There was also the issue of choice – user’s ability to change the type of music. Adding an additional button for music selection was not considered as it added to the level of complexity and hence confusion among the users. Instead opening and closing of the music player’s lid was deemed as an appropriate on/off mechanisms. A

large round button placed under a clear lid was then selected as a means of changing music type (3c). So far all design iterations were tested at the user's home with close monitoring. Iteration 3c was equipped with a monitoring device to determine the extent the users employed the device and was yet again tested at the end-user's homes. The results indicated that following a certain period of time (number of days) the end-users forgot about the device and the frequency of use dropped significantly. The fourth iteration (3d) was then equipped with a simple illuminated panel that would light up for two minutes every ½ hour to draw the attention of the end-user. The sign read "open lid to listen to music". This modification worked very well and the design was finalized.

Figure 3. Design iterations of the music player [13]

Conclusions

Although technology has given us a perceived notion of choice, it has also added greatly to society's level of complexity. We argue that most technologies are driven not by humanity's need, but by the desire for profitability. Many designers are becoming aware of the fundamental flaws of such an approach and new methods such as user-centered and participatory design have gained attention in the past three decades. We propose that a user-led design process, one driven by addressing user's real needs, can help tackle the problems associated with complexity and usability. The key distinguishing factor of a user-led approach is the emphasis in identifying the real needs using methods such as the grounded theory approach, evolutionary and iterative design processes informed by the end-users and evaluation of the design under real world conditions. This iterative process although inherently slower than the traditional design approach, would lead to a more diverse and robust set of solutions and reduce complexity by lowering the number of unusable devices currently marketed to the consumers. In the context of engineering design education, we propose that engineering students

should be introduced to the user-led design process through a set of real-world problems that allow them to interact with end-users in a collaborative environment.

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