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Enhancing Biomedical Design With Design Thinking

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Abstract – **The development of biomedical equipment is justifiably focused on making products that "work." However, this approach leaves many of the people affected by these designs (operators, patients, etc.) with little or no representation when it comes to the design of these products. Industrial design is a "user focused" profession which takes into account the needs of diverse groups when making design decisions. The authors propose that biomedical equipment design can be enhanced, made more user and patient "friendly" by adopting the industrial design approach to researching, analyzing, and ultimately designing biomedical products.**

I. Introduction

Innovation in biomedical product design is largely driven by a process known as 'scientific thinking'. 'Understanding' is the driving characteristic of this methodology and it is realized through an evaluation of the 'correctness' of theories through a generally linear analytical evaluation by 'thoroughness' to eliminate uncertainty and 'testability' to determine the efficacy and repeatability of the results. The lexicon of scientific thinking is dominated by terms such as True/False, Correct/Incorrect, Complete/Incomplete, and Provable/Unprovable. Biomedical design is also tempered by issues of correctness of diagnosis and procedures and the relative values of Better/Worse. Scientific thinking is a research based and results-oriented process that has served biomedical design well, resulting in a continuous stream of innovative and effective products and procedures.

Contrasting with scientific thinking is a new way of fueling creative innovation that has emerged in the industrial design profession called 'design thinking' This methodology is characterized by several distinct contrasts to scientific thinking. First, it deliberately celebrates the ambiguity of design opportunities and focuses on qualitative, rather than quantitative data. Problems are loosely defined and goals are stated in qualitative terms. Rather than concentrating research exclusively in the targeted application area, design thinking encourages ambiguity by exploring similar situations in dissimilar areas of application. This divergent approach to research may likely produce strong feelings of anxiety to one committed to scientific thinking, but tempered with the ability to at some point converge disparate ideas into a better and more coherent idea is a normal progression for one immersed in design thinking. This way of exploring disparate 'solutions' and embracing ambiguity and surprise is perhaps an evolutionary outgrowth of industrial design's beginnings as an 'art'. The profession has evolved, however, from its artistic underpinnings to a position of combining the freethinking, emotional and creative aspects of an artist with the efficacy, focused, verifiable, and practical concerns of the scientist.

Clearly, there are substantial differences between 'scientific' and 'design' thinking. The rigor and analytical approach characterized by scientific thinking is clearly valid and effective, but perhaps so concerned with analytical and quantitative factors that qualitative aspects may not be fully realized. Design thinking, in contrast, focuses on qualitative issues, particularly as related to users' needs and desires. If a biomedical device has functional efficacy, but is so intimidating or off putting to users that proper utilization is impaired, is the product truly effective? Is a device that is not intuitive in its use as possible or difficult for a clinician to use as effective as it could be? It is the opinion of the authors that in order to maximize biomedical design to the widest possible group of user constituents that the resources of biomedical designers and industrial designers be combined.

II. Design Research

When conducting research, 'scientific' thinkers usually limit their investigation to the current state of the art products and processes. Their inquiry is fact-based, concentrating on current products, treatments and data. This inquiry is normally focused only on the topic at hand. 'Design' thinkers, on the other hand, cast a much broader net with the intention of exploring other similar situations with divergent user groups and user needs, but not necessarily in the same application area. They are comfortable with the ambiguity in this non-linear process and rely on it to identify non-traditional design opportunities. "Design researchers must go beyond what they can find: to see more than is visible, and to learn more than can be heard. Accordingly, design research is an act of imagination, just as much as design itself." This concept may be difficult for scientific thinkers to understand or accept, but it is one of the basic ingredients of design thinking. Industrial design research is paradoxical in it very nature, being both empirical and imaginative. Scientific thinking concentrates on the process of treatment while design thinking emphasizes the user experience of treatment. While scientific thinking relies on a functional analysis of existing products and treatment, design thinking includes a qualitative analysis, particularly

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from the users' point of view. Design thinking also encourages exploration of products and treatments in seemingly disparate areas. For example, research on head trauma diagnostic devices might include an exploration of sport headgear, primitive treatments, or even culturally-based headwear, not knowing where such inquiry might lead, but confident that the serendipity of irrational discovery is a potent and recurring opportunity.

III. Product Conceptualization

The influence of design thinking on product development begins with the very definition of the problem and product objectives. Scientific thinking defines an objective and the process for achieving that objective. Further, it defines the process for determining the efficacy of the solution. Generally speaking, this is a linear process with little or no ambiguity and no opportunity for radical conceptualization. Design thinking, in contrast, thrives in ambiguity. While the objective might be clear, how to achieve it is not. As discussed, the research conducted by design thinking is freewheeling and includes seemingly disparate areas of exploration. The outcome of this approach often produces a new perspective on possible solutions. Design thinking thrives on the ambiguity of the process and the lack of process structure. It is a continuously iterative process, alternately creating new concepts followed by evaluation and testing, both quantitatively and qualitatively. As numerous solutions are developed and evaluated, there is a continuous evolutionary process of concept synthesis. What begins as a divergent process ultimately evolves into a convergent process of refinement, finally resulting in a design concept that is thoroughly tested for efficacy and user-centered friendliness. This process of testing is focused on both functional and qualitative values. This process must be holistic in the inclusion of all stakeholders, including users, clinicians, manufacturers, regulatory agencies, distributors, insurance providers and others.

IV. Case Studies

The Industrial Design program at Virginia Tech does not 'specialize' in the education of discipline specific designers. We no more concentrate on biomedical design than on automotive, toys, consumer appliances, sporting goods, or furniture design (though our graduates practice successfully in all of these areas and more). Instead, we teach our students how to navigate design problems in any discipline using the basic tools of design thinking. If there is a particular concentration of our curriculum other than developing design thinking, it is the nurturing of a concern for the users of our designs. We are committed to maximizing the quality of the user experience, be it in terms of functionality, cultural appropriateness, user's self-esteem, aesthetic identity, and emotional well-being (pleasure). To demonstrate that orientation, we offer the following brief case studies of undergraduate projects that demonstrate how design thinking has enriched biomedical product concepts:

Glucose monitoring device for teenagers.

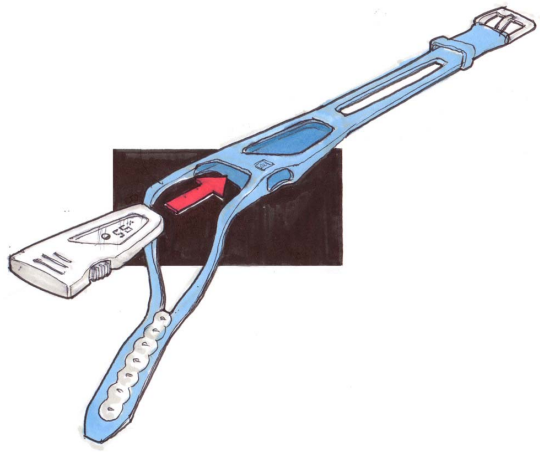

Figure 1. Glucose monitoring device for teenagers.

This project was challenging in its technical requirements of monitoring, displaying and recording of blood-sugar levels among teenagers, but presented even more of a challenge to create a design that teenagers would actually wear in the presence of their peers. The product solution was an article of clothing (belt) that presented a strong and age appropriate fashion statement while discretely containing the monitor.

Mobility assist device for the elderly.

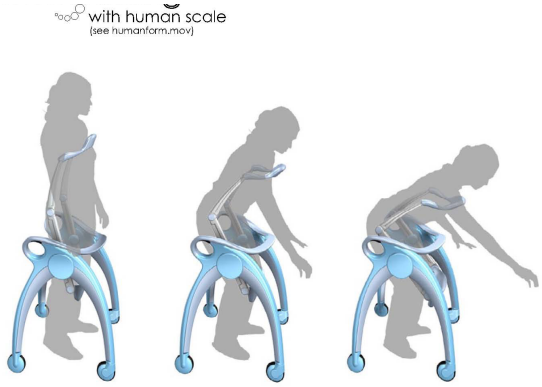

Figure 2. Mobility assist device for the elderly.

The student research for what is often described narrowly as a 'walker' revealed other opportunities to enrich the lives of the users. By carefully and sensitively observing the all-day activities of users, they realized that conventional walkers provide no assistance in standing for long periods while doing such normal tasks as preparing meals or folding laundry. Their solution includes an upper-body support structure that supports their weight while enabling the use of both arms for other tasks. Their seemingly disparate research into automotive suspension systems led them to the incorporation of an electrically modulated magnetic dampening fluid that allows the users to easily adjust the resistance of the support for various tasks and conditions.

Digital x-ray platforms for infants and juveniles

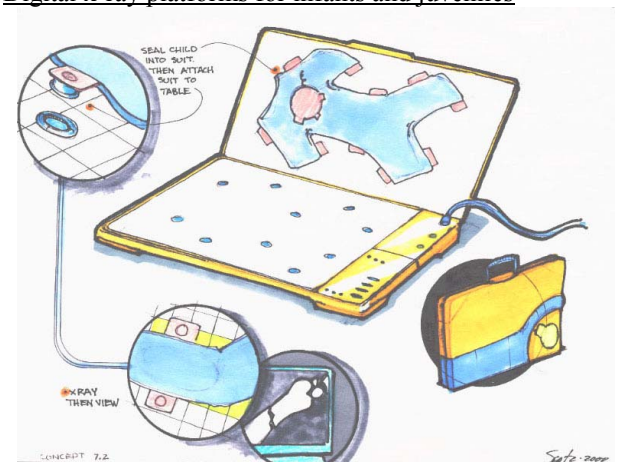

Figure3. Digital x-ray platform for juveniles and infants.

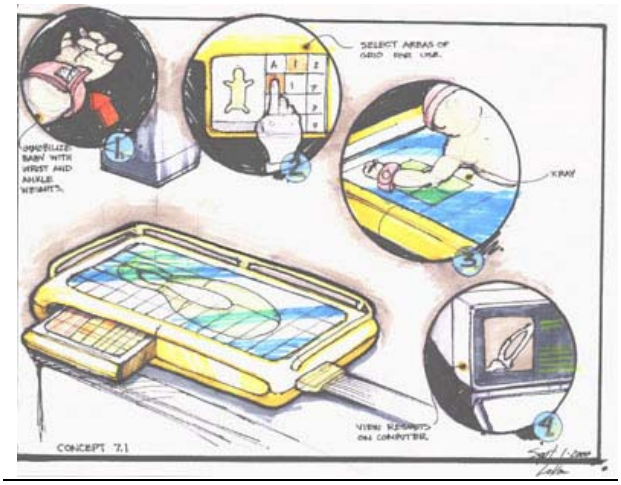

Figure 4. Digital x-ray platform for juveniles and infants.

An analysis of existing x-ray devices indicated a lack of devices designed for infants and juveniles. Clinical observations by the student designer led to this development of a modular system tailored to infant behaviors, movements, and attention spans. While there is no technical innovation in terms of recording and imaging, there is a world of improvement in terms of patient and parent comfort, speed of set-up, and functional confidence.

V. Conclusion

The authors believe that *Design Thinking* in biomedical product design offers the opportunity to move beyond the limitations of present linear processes without sacrificing the critical issue of functional efficacy. They further believe that design thinking offers clear benefits over scientific thinking for increasing the efficacy of biomedical designs for all stakeholders involved. Together, industrial designers and biomedical designers can create more effective and humanistic product solutions.

References

1. Ireland, Christopher. "Qualitative Methods: From Boring to Brilliant." Design Research Methods and Perspectives. 2003. Massachusetts Institute of Technology Press.

2. Johnson, Bonnie McDaniel. "The Paradox of Design Research." Design Research Methods and Perspectives. 2003. Massachusetts Institute of Technology Press.

3. Laurel, Brenda and Lunenfeld, Peter. "Design Research Methods and Perspectives.

4. Owen, Charles L. "Design Thinking. What It Is. Why It Is Different. Where It Has New Value". Institute of Design, Illinois Institute of Technology. 2005.