A113

Codesign in Virtual Space:

Including Everyday People in Product Design

James Arnold, Andrew Barrow, and Richard Teynor, The Ohio State University

Introduction

Getting everyday people involved in the product design process has its advantages. Whether through the multitude of methods available through design research or simply by giving customers options to customize their own products through mass-customization, user-centered design has facilitated the development of innovative products; both in terms of addressing previously unmet customer desires and profitability for the business entity who offers them. While there are many ways to include the end-user in the produce design process, this paper focuses on new and developing methods of including everyday people in the design process through leveraging virtual/digital space enabled by computer technology.

Most industrial designers have heard about or practiced some kind of design research as we work through the design process. This can include: intuitive design, where our own experience or otherwise putting ourselves in the customer's place can serve us as we act as the customer advocate; Informed Design, where we receive information from research (or researchers) from outside the design team; ethnographic design, where we study everyday people as they become subjects of design research; and participatory design, where we include everyday people in the design process through methods used to help them express their hopes, dreams, and creativity (see Figure 1).

Intuitive Design	Informed Design
Ethnographic Design	Participatory Codesign

Figure 1.

All of these approaches can serve, either directly or indirectly, to involve everyday people in the design process. They can also be used in combination as the situation dictates. Each approach is part of the greater whole of people/human/user-centered design.

Here, we will focus on participatory codesign in virtual space. Participatory design, or physical codesign, methods used in product design research are well documented ways of helping everyday people express their dreams of how products can be designed. Currently, these methods help researchers, designers, and potential end-users of products collaborate and generate innovative ideas during the research and design process using methods such as collage making, workbook/journaling, and Velcro modeling (Dresselhaus, 2000; Sanders & William, 2001; Squires & Byrne, 2002). Participatory design can and does extend into the more evaluative and refinement stages of product development. Everyday people can help evaluate concepts through such methods as human factors testing and offer feedback or respond to concepts and prototypes in order to validate or make corrections to design work. Further down the design process, everyday people can participate in future design by experiencing the product in the real world and offer help in the design of evolutionary/next generation products that may be offered in the following model year.

Codesign in Virtual Space (CoDeViS) offers another avenue for participatory design research and customer collaboration. It leverages the power of computer technology – not as a replacement for physical codesign methods, but as a supplement. CoDeViS is facilitated not only simply through email and web site interfaces that allow different people and groups to connect, but in virtual 3D space. This can be done at various stages of the design process and through various media/channels of collaboration (see Figure 2):

CoDeViS in Design	*Collaborating with CoDeViS*
Concept Generation	File Storage/Transfer Media
Prototype Refinement	Intranet/Network
Product Customization	Internet/Website

Figure 2.

Inviting customers into the design process can, of course, be problematic. Issues of time and cost burdens to product development cycles immediately come to mind. These issues may limit the involvement of everyday people in the design process, regardless of the potential for human-centered design and innovation. The usual time and cost requirements of participatory design can be significantly reduced using methods of codesign in virtual space because computer technology can be leveraged in much the same way as the retail industry (e.g., Amazon.com and E-bay) has. Increased numbers of people may also be reached in a more convenient setting if they are using a computer without having to travel to a location or having researchers enter their environment (e.g., home). The phrase, "in the comfort and privacy of your own home" comes to mind.

As with any approach to design research, there are certain drawbacks to using CoDeViS methods as well. Issues such as the separation between physical reality and virtual reality, scale, and tactile feedback are limited or impossible, but the use of CoDeViS can be seen as a natural "next step" in the evolution of design research tools. The ongoing search for more effective and efficient methods of design research for industrial designers has been an evolutionary struggle for much of the last century.

An Evolution

Design research in industrial design has evolved over the past 50 years. This evolution has included a shift to a research based practice of industrial design. Many industrial designers have come to terms with formalized research in the design process. They have reconciled the need for creativity with the need to do valid and credible research that justifies, helps direct, and inspires design activity. Although this journey has been littered with obstacles and barriers, companies have actually witnessed increased innovation and market success as design creativity and research rigor have been reconciled.

Research constituted a "straight-jacket" according to some industrial designers as described in a major article in *Industrial Design* magazine in 1958 (Fleishman, 1958). Subsequently, in the 60's and 70's this kind of reaction to research persisted; some industrial designers felt rigorous "scientific" methods limited the creative and intuitive aspect of an industrial designer's activity and that research was, "a fancy way of telling him (the designer) something he already knows through long experience." (Fleishman, 1958). Fleishman (1958) also confirms how some industrial designers were conducting research: "…it is their need to develop an exploratory, informal, and even free wheeling approach to research – while remaining creative designers – that has conditioned them to maintain their amateur standing as researchers… .The manner in which designers have fitted research to design is a reflection of their awareness of the limitations and dangers of overformalized M/R (market research)." This "free wheeling" approach to design research, as Fleishman describes, has advantages that include direct designer contact with: context, activities, attitudes, beliefs, and generally larger contextual issues not revealed through typical quantitative market research provided (or missed) by an outside researcher or report.

However, over the last 50 years, a few industrial designers did not resist research. They promoted the activity among peers and with clients. A few examples include: Observation and personal interviews conducted by Henry Dreyfuss Associates (Dreyfuss, 1955); designer participation and time motion studies conducted by designers for Montgomery Ward and the "pop tent" design (McCullough, 1957; Ferebee, 1959); and observation, interviews, and surveys by Byron Bloch for Stantham medical instruments (Kelly, 1966). The designers who conducted research remained a minority until a process of reconciliation began to occur in the late 1970s and 1980s when design firms began hiring social science research experts who shared their approach to research and helped formalize the design research process and methods. However, for the majority of industrial designers, indifference and even contempt toward research remained until about 15 years ago when the effects of social science expertise began to be felt in the industrial design community (Darrel Rhea, personal interview, 9 November 2004). So, industrial designers have, in a sense, "borrowed" traditional research methods used in the social sciences (e.g. observation and interviewing) and time compressed the typically long duration of an ethnographic field study to appropriately fit the demands of fast product development; these methods are also used in a more targeted way that reveal unmet user needs.

The inclusion of social science expertise helped formalize research in industrial design and has given credibility and added value to the research activities of industrial designers. Arnold Wasserman terms the result of this evolution of industrial design, and inclusion of formal research methods in the design process as, "research based design" (personal interview, 29 December 2004). Research based industrial design has become standard practice with many industrial designers and in product development. Research in industrial design has been evolving and one of the many natural "next steps" will be to use virtual space as a potential facilitator of more efficient qualitative and quantitative research and design.

Leveraging Virtual Space

A range of possibilities exist for CoDeViS in many stages of the design process including: generative, evaluation/refinement, and product customization. CoDeViS can be done at the "fuzzy front end" of the design process where ideas are generated for completely new product exploration or to redesign an existing product. It can be done as the design, or prototype, is evaluated and refined with and by participants during the development process. The idea of product customization, which has been available for some years now with such products as computers and eyeglasses, can also be expanded to include more products that have been designed and await a customer's final input for configuration, size, and feature options.

Product Customization

CoDeViS in Design	*Collaborating with CoDeViS*
Concept Generation	File Storage/Transfer Media
Prototype Refinement	Intranet/Network
Product Customization	**Internet/Website**

Successful product development relies greatly on the voice of customer (Chu, Cheng, & Wu, 2006). The Internet is an enabler of communication for voice of customer input; customers could potentially configure, if not design their own personalized products. An example of a company that integrates the voice of the customer directly to a customizable product offering via the Internet is Dell Computer. At Dell, the product customization lies in the internal components of the product, but there is currently no way for the customer to configure the aesthetic or form of the product.

The process of defining a product may not only include communication but may include cooperation and cocreation, where a product-producing company relies on individual customers to specify or even design a product that specifically meets the customer's needs and wants (a customized product). This new role of the customer, in the instance of mass production, moves into a space which has traditionally been the domain of product-producing companies (Piller, Moeslein, & Stotko, 2004). When the customer is an integral part of the development and production process, the customer can be considered a codesigner. There is value added to both parties (the customer and the producer) during the transaction, companies achieve differentiation and consumers receive a product that fits individual needs and wants. The Internet is an enabler for this complex interaction and information exchange, which is needed for product cocreation (Piller, Moeslein, & Stotko, 2004).

The means to manufacture a wide range of customizable goods has been available for some time. Recent developments in flexible manufacturing systems (FMS), computer aided design/manufacturing (CAD/CAM), and just in time (JIT) production are enabling large-scale customization of products without negatively impacting cost efficiency. Dewan, Jing, and Seidmann (2000) state: "Flexibility in manufacturing means being able to reconfigure manufacturing resources so as to produce different products efficiently." Product-producing companies are also making advancements in "production flexibility," which "is the ability quickly and economically to vary the part assortment for any product that an FMS can produce" (Dewan, Jing, and Seidmann, 2000).

Though, few product-producing companies are currently integrating direct customer input into the design processes via the internet, other industries with a presence on the Internet are involving their customers (e.g. Dell, Amazon, EBay). Internet consumers favor companies that value their involvement whether it be through individually expressed reviews of existing products (E bay), being able to control the community (Amazon), or specify/customize features of products (Dell).

Prototype Refinement

CoDeViS in Design	*Collaborating with CoDeViS*
Concept Generation	File Storage/Transfer Media
Prototype Refinement	**Intranet/Network**
Product Customization	**Internet/Website**

In the hands of designers and engineers, 3D CAD tools can be used to facilitate a more effective and streamlined design process through the following:

- Collaboration with others can be enhanced in two ways: visual based systems (e.g. visualizing, inspecting, and annotating design models in a 3D Web or CAD space) or codesign systems in a CAD space (e.g. interactive comodeling and comodification) (Li, Lu, Fuh, & Wong, 2005; Arnold, 2006).
- Better integration between design team members "…data can be transferred into engineering design (3D solid modeling) systems, allowing the entire development process to be more easily integrated." (Ulrich & Eppinger, 2004).

Recent collaborative computing software has advanced to help product designers and customers work together (e.g. Adobe Acrobat 3D). The few attempts to include the customer have been with "Web-based collaborative visualization (WCV), which enables the user to visualize, annotate, and control (a) 3D design model interactively over the Internet" (Chu, Cheng, & Wu 2006).

Another way to use CoDeViS in the prototype refinement phase is to combine codesign and mass customization methodologies together. Value could be added to a product, customer loyalty could be enhanced, and it may be a new way to look at the relationship between the designer and the manufacturer. Traditionally, the design process takes place in a controlled setting where design team members test their ideas on subjects for potential products, use traditional ergonomic models, and then the data is used to determine the size, scale, and direction of the design. Once the design is set, manufacturing gets involved and the mass production process begins. In this scenario, input and needs from the customer are presented at the front end of the design process and ergonomic features that individual consumers have requested may be left out of the final mass produced product because they are too costly to tool or manufacture for people not considered in the ergonomic norm. Consumers may quickly lose their voice once the manufacturing process begins.

We are working on a way to keep the voice of the everyday person in the design process during product/prototype refinement. In this case, the participant/customer specifies their physical dimensions and relies on mass customization methods to manufacture product that is ergonomically customized. The physical measurements that the customer specifies will be used as input data to scale the product to the individual's personal measurements. That data will be used to drive a products' final configuration, and then manufactured through mass customization. Companies using customer input in this way, producing goods through mass customization, may build a loyal relationship between themselves and the customer through involvement in the design process.

The industrial designer may potentially play an important role in this business model. Designers will be challenged to balance the design of the product so that common product platforms are used but not to the extent that they inhibit the consumer's creative input. Common product platforms are the basis for mass customized products. Figure 3 further describes this scenario:

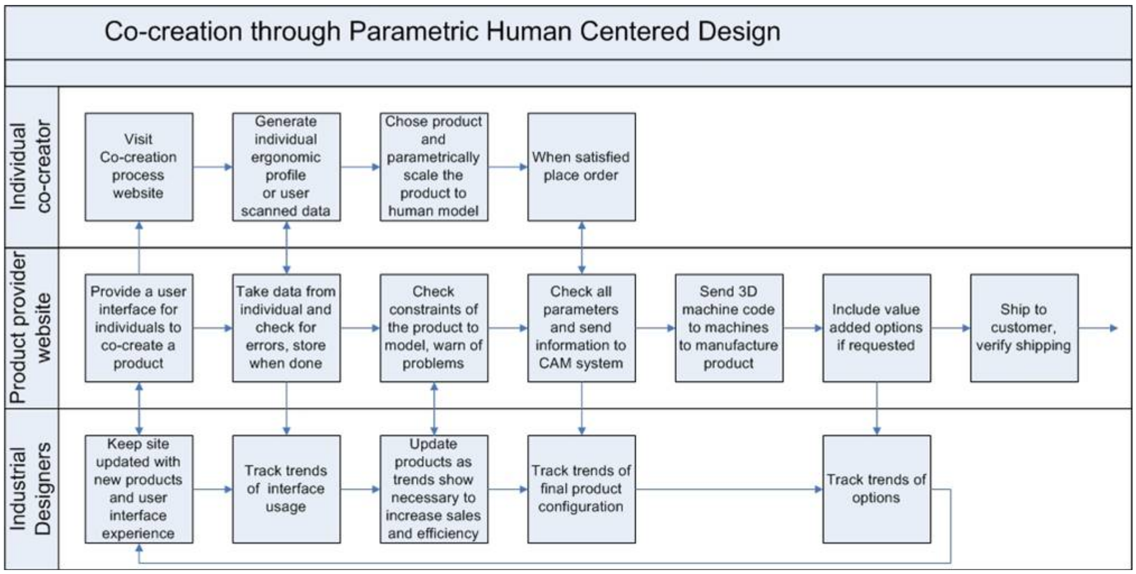

Figure 3

Concept Generation

CoDeViS is also appropriate at the "fuzzy front end" of design as well. During concept generation and before the design brief everyday people may take part in research and design in virtual space. There are several ways collaboration can occur:

CoDeViS in Design	*Collaborating with CoDeViS*
Concept Generation	**File Storage/Transfer Media**
Prototype Refinement	**Intranet/Network**
Product Customization	**Internet/Website**

Relying on the creativity of end-users during the design process is well founded. This has been done for years using physical methods and tools. Design firms such as Fitch, Sonic Rim, and Make Tools (recently founded by Elizabeth B.-N Sanders) have or are including everyday people in the research and design process as codesigners. One concept that helps us understand the potential value and basis of CoDeViS during concept generation is to understand the idea the above firms promote as "Make, Do, Say." This represents a spectrum of end-user participation methods in research and design:

Say	e.g., Interview, Questionnaire, Discussion Group
Do	e.g., Observation, Usability Test, Video Ethnography

Make	e.g., Collage, Workbook, Velcro Modeling

Figure 4

Using this model, the design team can get a more complete understanding of the customer through what they talk about, how they actually act, and how they express their dreams through making things (Dresselhaus, 2000; Sanders & William, 2001; Squires & Byrne, 2002).

Velcro Modeling in particular enables a participant to create actual forms that are abstract yet have physical dimensions that are concrete without being heavy laden with specific sensory detail such as color, surface texture, exact dimensions, or other realistic representations that are more appropriately left to later in the design process when concepts or prototypes are being refined. The abstract and iconic nature of Velcro models allows enough room for the participant and others to envision the potential of the ideas that the participant/codesigner is trying to express (McCloud, 1994; Sanders & Williams, 2001).

Before Velcro Modeling occurs there are usually immersive activities and tools that the participant codesigners engage in before making models. This usually entails journaling or workbook activities that help the participant to immerse themselves in their existing experience so they are prepared to deal with and express problems they are having or ideas they want to share when they create representations. Following this pattern, CoDeVis can also help codesign participants express their creativity and dreams with the added possible benefit of lower cost, time, and a greater number of participants. The following pilot study serves to illustrate how this can work.

Eight adults were recruited to express their ideas about the future of car interior design for a single occupant commuting vehicle concept. Each of the participants was familiar with commuting to work and/or school as it typically occurs today in existing cars. Without any specific training or instruction they were directed to a web site where three files could be downloaded to their personal computer. The files were the following:

- File #1 MS Word document that contained directions, a story, and a 2-part questionnaire
- File #2 Google SketchUp application (a 3D modeling application available at no cost)
- File #3 SketchUp 3D model file containing a one person commuting vehicle concept with abstract shapes to use as virtual “Velcro Modeling” parts (see Figures 5 and 6).

As the participants worked with the CoDeVIS tool they were asked to complete three steps:

- Step 1. Record current experience and pay attention to various aspects of the commute such as: controlling, sitting, storing, securing, entertaining, communicating, eating, and drinking.
- Step 2. Read a scenario that describes the participant getting into the car and what the vehicle is capable of in terms of technology, speed, and safety. The scenario concludes by stating: “Your commuting experience is restful, productive, and safe. You arrive at work feeling good about how you just spent your time and pleased with how your day has begun.”
- Step 3. Familiarize with Google SketchUp and open the SketchUp 3D model file so that the interior can be designed by moving and placing abstract shapes that are assigned meaning and notated by the participant using a text tool. Figure 5 shows the SketchUp model as it was first opened. Figure 6 shows a model file that has been manipulated and notated by one of the participants.

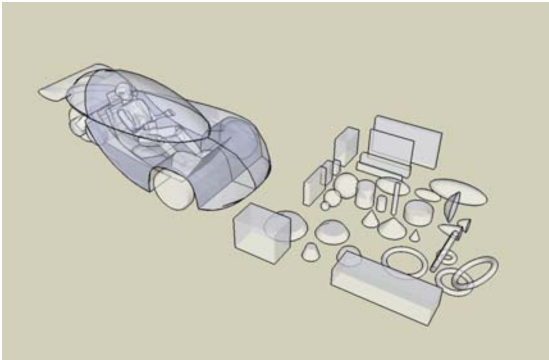

Figure 5.

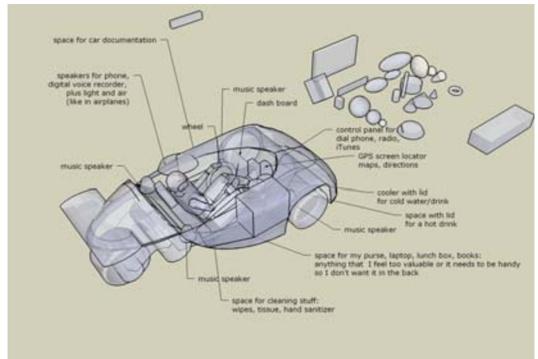

Figure 6.

Finally, after using SketchUp, the participant was directed to record their ideal experience in the MS Word document. Again they were asked to address issues they considered in step 1 and any additional ideas that came to mind. The SketchUp and MS Word files were then saved and uploaded to the web site for analysis.

A content analysis of the files submitted by the participants revealed a variety ideas expressed and a broad range of features/capabilities that were designed into the car. A majority of participants, however, wanted to have some level of automation in the car enabled by imbedded computer technology and connected to the outside world through wireless technology; a kind of robotic car that allowed the passenger to focus attention on activities such as: work, relaxation, breakfast, entertainment and communication. After the participants completed their work, they were asked open ended questions such as likes, dislikes, and time to complete. A majority of the participants appreciated most aspects of the study but were somewhat irritated with learning how to use an otherwise “simple” 3D modeling tool. The participants used approximately one hour of their time to learn the basic functions required to complete the 3D work.

In an actual project using this method of CoDeViS, the ideas of the participants would be further analyzed for common traits, combined, or expanded into concepts with the aid of a designer or design team. Concepts could then be shared with the original participants or another group of participants for further evaluation and refinement.

Conclusion

The strengths of CoDeViS methods include reducing cost and time to gather the thoughts and creativity of large numbers of everyday people. There is also the potential, because of the digital nature of the data, that the participant responses could also be analyzed using fast and efficient computer analysis tools. These strengths could be compelling to the many companies that desire to conduct user-centered design research but struggle with the money and time investment required by traditional methods. Weaknesses of CoDeViS may include lack of direct physical interaction with full sized objects and actual face-to-face meetings with people in the design team. Interestingly, for everyday design team members, the car project described above did not require a high degree of technical computing skill to conduct the study; this method is highly accessible and adaptable without the need to purchase specialized expertise, software, or equipment.

Considering today’s ubiquitous computing technology and familiarity among everyday people CoDeViS methods are a natural growth area in design research. CoDeViS methods can contribute to user-centered innovative product design and deserves our attention.

References

Arnold, J. (2006) “Virtual product design studio.” Paper presented at the Engineering and Product Design Education Conference, Salzburg Austria.

Arnold, J. (2006) “Reconciliation of research and creativity in industrial design.” Paper presented at the Industrial Designers Society of America National Education Symposium, Austin, TX.

Chu, C., Cheng, C., & Wu, C. (2006) “Applications of the web-based collaborative visualization in distributed product development.” *Computers in Industry, 57*(3), 272-282.

Dewan, R. M., Jing, B., & Seidmann, A. (2000) “Achieving First-Mover Advantage Through Product Customization on the Internet.” Paper presented at the Proceedings of the Twenty-First International Conference on Information Systems, Brisbane, Queensland, Australia.

Dresselhaus, B. (2000) *ROI: Return on innovation*. Portland: Dresselhaus Design Group, Inc.

Li, W. D., Lu, W. F., Fuh, J. Y. H., & Wong, Y. S. (2005) “Collaborative computer-aided design research and development.” *Computer-Aided Design, 37*(9), 932.

McCloud, S. (1994) *Understanding comics: The invisible art*. New York: HarperCollins.

Piller, F. (2001) *Mass Customization*. Wiesbaden: Gabler.

Piller, F., Moeslein, K., & Stotko, C. (2004) “Does mass customization pay? An economic approach to evaluate customer integration.” *Production Planning & Control,* 15(4), 435-444.

Sanders, E. B.-N., & Williams, C. T. (2001) “Harnessing people's creativity: ideation and expression through visual communication.” In J. Langford & D. McDonagh-Philip (Eds.), *Focus Groups: Supporting Effective Product Development*. Taylor and Francis.

Squires, S., & Byrne, B. (Eds.). (2002) *Creating breakthrough ideas*. Westport, CT: Bergin & Garvey.

Ulrich, K. T., & Eppinger, S. D. (2004) *Product Design and Development*. New York: Tara McGraw-Hill.