Co-Design in Virtual 3D Space for Bicycle Accessory Design

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Abstract: The case study described in this paper helps validate and explain how co-design research with end-users can be conducted in 3D virtual space. Co-design in 3D virtual space is compared with Co-design in physical space during an industrial design studio course; centered on creating innovative bicycle accessories for particular bicycles and the cyclists who use them. The course, conducted with preliminary consultations with Trek, a major bicycle manufacturer, involved cyclists that the students solicited for information, observed, and co-designed with. The physical and virtual 3D co-design activities not only helped the students design products but were also compared; helping form the author's conclusions and recommendations about the value of co-design in 3D virtual space.

Key words: Co-Design, Design Research, Virtual Product Design, Design Education

1. Introduction

It has been said that if design is problem solving, then design research is problem finding (Marty Gage, personal interview, March 2008). The case study in this paper and with co-design in general, we think of the research participant as one who can both supply information about real design problems and help solve those problems collaboratively with the designer. This view of the participant is fairly new in the historical development of design research. Traditionally, and for over 50 years, industrial designers have employed various methods, such as observation and interviews, to obtain information from the potential end-users of their products. Recently (within the last 2 decades) with the inclusion of design team members with social science training there has been an explosive growth in the development of new methods of design research; a whole category being participatory design research, or simply co-design [1]. In co-design the user becomes an equal shareholder in the design process and the designer/researcher becomes responsible for facilitating the participant's creative expressions.

Relying on the creativity of end-users during the design process is well founded. Using physical methods and tools, design firms such as Fitch, Sonic Rim, Make Tools, and Lextant have included everyday people in the research and design process as co-designers. One concept that helps us understand the potential value and basis of Co-design 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 (see table 1):

Say	e.g. Interview, Questionnaire, Discussion Group
Do	e.g. Observation, Usability Test, Video Ethnography
Make	e.g. Collage, Workbook, Velcro Modeling

Table 1, Say Do Make

Using this model, the design team can get a more complete understanding of the customer through what they talk about, how they act, and how they express their dreams through making things [4,6,7].

Velcro Modeling in particular (see table 1) enables a participant to create actual forms that are abstract yet have physical dimensions that are concrete without being heavy laden with specific sensory details 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 modeling allows enough room for the participant and others to envision the potential of the ideas that the participant/co-designer is trying to express [5,6]. To a certain extent, modeling material is purposefully simple and abstract in order to encourage creative expression without being led toward preconceived solutions and to allow freedom of expression; in much the same way a child constructs an imagined toy from Legos and envisions a realistic thing or character in the mind without need for realism in the actual constructed object.

Co-Design in Virtual Space (CoDeViS) is a natural “next step” for Co-design and Velcro modeling; leveraging virtual space as a potential facilitator of fast paced, global, low cost, efficient, qualitative, and quantitative design research. Virtual 3D co-design methods are an outgrowth of physical co-design methods such as 2D collages and 3D Velcro modeling, These physical methods have been widely accepted as effective ways to involve people outside the design team in the research and design process.

CoDeViS is appropriate at the “fuzzy front end” of design or later in the design process. There are several ways collaboration can occur: file storage/transfer media (e.g. CD, USB drive), Intranet/Network, or internet/website. Basic tools include: a computer, 3D modeling software, and a word processing program. Before Velcro Modeling or CoDeViS occurs there are usually immersive activities and tools that the participant co-designers 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.

Virtual methods offer promise to those seeking to make the principles of co-design available to larger groups of people in discrete locations around the world at lower cost. Additionally, virtual 3D co-design methods facilitate insights in ways that are different from physical methods [2]. The main purpose in conducting this study was to compare the difference between physical co-design modeling and CoDeViS. Previous studies have affirmatively answered questions about CoDeViS regarding issues such as potential research cost reduction and potential for increasing numbers of participants compared with physi cal co-design [2,3]. The table below describes some of these comparisons:

Aspect of Co-Design	*Physical Velcro Modeling*	*Co-Design in Virtual Space*
Participant Kit Creation	Anyone can make	Must possess moderate 3D computer modeling and possibly website skills
Kit Cost	Depends on level of detail and volume, high	If kit is created on existing hardware/software, low
Kit Distribution	Travel time and/or postal fee	Instantaneous, free if using email or existing web site tools
Facilities	May need additional space or can be expensive	Participant access to a computer anywhere
Travel Time and Cost	May be significant	Not significant
Participant Scheduling	Timing and coordination is rigid, can be difficult	Within a time frame, flexible for participant
Analysis	Usual data input and transcription time	Reduced data input and transcription time
Participant Training	Low	Moderate
Interaction Level	High	Low
Amount of Participants	Limited	Unlimited

Table 2, Aspects of Physical Velcro Modeling and Co-Design in 3D Virtual Space (Arnold, 2008).

The following case study attempts to reveal, through comparison between physical 3D and virtual 3D methods, advantages and disadvantages these methods offer in terms of quality and quantity of ideas that participants were able to express.

2. Context of the Study

Fifteen senior level industrial design students, during a 10 week design studio assignment to design bicycle accessories, were asked by their instructor/author of this paper) to engage potential end-users in co-design during the beginning research phase. Each student was assigned to a team of three members. Each team chose a particular user group of cyclist and an existing bike design as a beginning point in the research and design process. Their directive was to discover innovative bike accessories dealing with issues such as cargo, lighting, and weather protection. The research methodology included direct user observation and interviews with existing products and mock-ups the students created as testable prototypes. The students also engaged users in physical and virtual 3D co-design activities to create potential design solutions based on user input. The observation, interview, and co-design results were then compared and triangulated to justify actionable product concepts. All members of each team were required to create their own accessory concept based on what their team discovered through the various research methods employed; i.e. ethnographic, physical 3D co-design, and virtual 3D co-design/CoDeViS. These students had received formal instruction and applied co-design methods in a previous course; the end result being design recommendations. This course described in this paper was the first time this group of students created actual product designs based on the results of their own co-design activity.

Each of the 3 student team members focused on conducting a particular design research method: ethnographic, physical 3D co-design, and CoDeViS. The students recruited their own participants, interacted with them inside and outside of class, and analyzed data their own participants offered in conjunction with other data received through other student team members. Each student was directed to interact with a minimum of 3 participants.

Premade co-design tool kits were fabricated by the authors for the students to use during the research phase of the project. The same 3D computer file was used to generate the models in laser-cut acrylic models (physical 3D co-design) and "Google Sketchup" (CoDeViS) (see figure 1 and 2 below):

Fig. 1. Physical 3D co-design tool kit

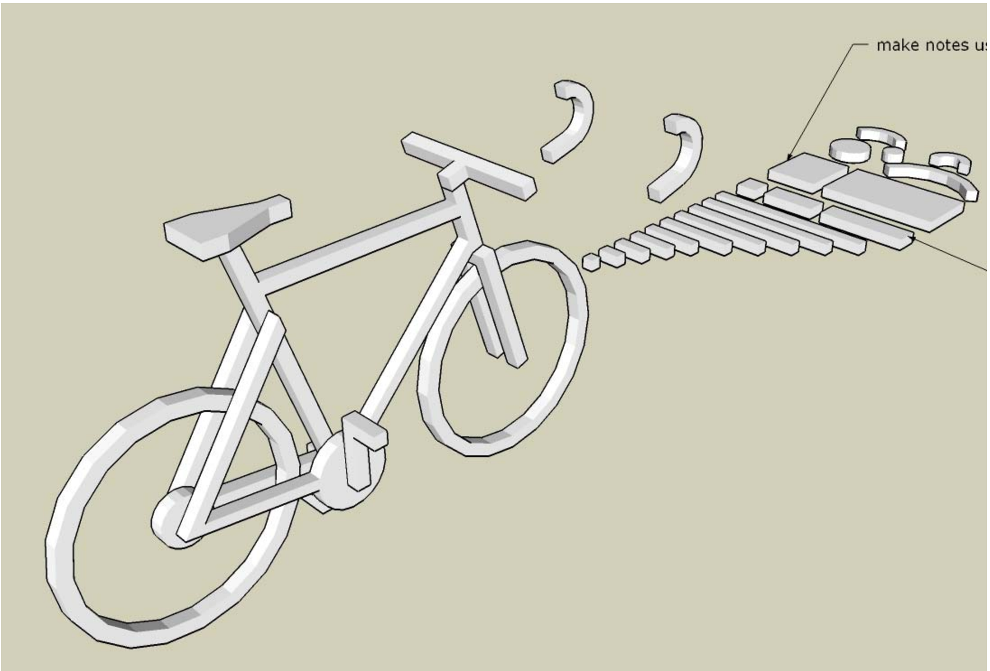

Fig. 2. CoDeViS tool kit

The physical 3D co -design tool kits were taken to participants and used as part of semi-structured interviews consisting of questions regarding current cycling experience and problems with accessories. Participants were then asked to express their concerns and ideas using the modeling material provided (see figure 1 above).

A set of three CoDeViS files were distributed to each participant identified by the student design team members:

- File #1 MS Word document that contained directions and a space to write in thoughts and answers to questions.
- File #2 Google SketchUp application (a 3D modeling application available at no cost, also downloadable from Google)
- File #3 SketchUp 3D model file containing a model of a bike and abstract shapes to use as virtual "Velcro modeling" bike accessory parts (see figure 2 above). The models were created with minimal effort using "Rhino" NURBS 3D CAD software and exported as a .3ds model file (SketchUp imports this and other file types).

The MS Word file had directions beginning with an exercise designed to help the participants immerse themselves in the design problem prior to creating virtual 3D concepts. Participants were asked to think and write about their current cycling experience and associated problems. This exercise was also intended to take the place of preliminary dialogue that would normally take place in a face-to-face interview with a researcher. After writing, the participants were then asked to install Google SketchUp on their own computer, familiarize themselves with it, and open the SketchUp 3D model file so that ideas could be expressed in 3D virtual space; much like physical 3D co-design modeling.

3. Findings

The primary purpose of this paper was to compare virtual 3D co-design with physical 3D co-design so that those interested in these topics can gain a better understanding of the benefits and drawbacks of using 3D co-design in the design process – in either an educational or professional practice context. The qualities or points of comparison between physical and virtual highlighted by the authors are as follows:

- Wants
- Designs
- Modeled Forms
- Notations

The above points were expressions of wants, ideas, and design opportunities during this project. Although identifying problems with current bike accessories was part of the co-design process in this project, the focus here is to compare the more creative aspects offered by physical and virtual methods. The authors counted and assessed instances of the above points recorded by the physical co-design interviews and the CoDeViS files that were gathered by the industrial design students in the course.

During and after the research phase of this project, 4 out of 5 groups reported difficulty in recruiting willing participants to engage in CoDeViS. Generally, the students preferred to interact with the participants face-to-face with physical 3D co-design kits because CoDeViS appeared to be a complex and time consuming process by the students and participants; and in terms of learning the technological aspects. The students also had prior experience with physical co-design methods before this project which could have biased their lower comfort level with CoDeViS. The student response was surprising because, being of the "millennial generation" their comfort level with virtual space was previously assumed to be at a high level. This may still be true because of the close comparative nature of the study and the students having easy access to informal comparisons between the two methods of co-design used in this project. It is assumed that willing participants would more easily be attracted if tangible incentives were offered (e.g. money, gifts) for participation. In this case, no tangible incentives were awarded for participation.

Table 3 below describes the analysis of these sessions and response files:

	Wants	Designs	Modeled Forms	Notations	Total
Commute – Physical	2	4	4	1	11
Commute - Virtual	10	6	11	16	43
Cops – Physical	4	3	6	12	25
Cops – Virtual	8	3	9	0	20
Urban – Physical	6	1	8	0	15
Urban – Virtual	11	2	11	13	37
Mountain – Physical	12	3	6	17	38
Mountain – Virtual	11	2	9	9	31
Fixie – Physical	8	1	7	9	25
Fixie – Virtual	2	2	7	2	13
Total Physical	32	12	31	39	114
Total Virtual	42	15	47	40	144

Table. 3. Comparison of physical 3D co-design and CoDeViS

Overall, CoDeViS appears to yield greater detail in terms of wants, designs, modeled form, and notations/recordings offered by the participants. However, if the scale of this study were increased greater reliability would obviously be achieved.

High marks for "Modeled Forms," using CoDeViS, may indicate that participants are actually encouraged or prompted to put more detail work into their model making. This is apparent because there were a greater number of actual forms placed on the bike model and configured to communicate design intent. Having a form that is recorded by the user could offer some additional value because it may leave less opportunity for incorrect interpretation by the researcher.. Compared to physical 3D co-design this might not be as significant because of the nature of these two modes of interaction; on one hand (CoDeViS), the design researcher is absent and therefore the participant may feel compelled to describe in greater detail using form in order to communicate ideas. On the other hand, in a physical 3D co-design interview the researcher is usually present and the participant can use gestures, additional words, and body language to describe ideas. A possible drawback to physical 3D co-design in this kind of situation may be that there would be an increased demand for the researcher to interpret and remember the participant's intentions. There may be an increased probability of inaccuracies and missed details.

Another possible reason for increased modeled forms produced using CoDeViS may be that manipulating 3D virtual form may be an interesting activity for participants. The promise of helping students conduct a design study, and in return learn an interesting new computer program through self teaching, may be perceived as a valuable activity by participants.

The specificity of descriptions recorded as notations appeared to be greater in CoDeViS. This is a finding less apparent in Table 3. Physical 3D co-design instances yielded more ambiguous modeling and notations. They lacked the more lengthy text notations and work seen in CoDeViS. Again, this may be due to the face-to-face nature of the physical co-design interview and the perception/assumption that because the researcher and co-designers are present, detailed descriptions will be captured. Google Sketchup also offers, if the participant cares to explore, additional tools to create custom forms. A small number of participants seemed inclined to explore these tools in Google Sketchup and created fairly elaborate models above and beyond the expectations of co-design activity where simple shapes are all that is required. Specificity would obviously be desirable especially where greater numbers of participants could be recruited and analysis time constraints became more of an issue. Specificity and the potential to broadly distribute the co-design activity are some of the benefits of CoDeViS.

Other details such as wants, designs, and notations/recordings appear to be close to equivalent between CoDeViS and physical 3D co-design.

4. Conclusion

This case study further demonstrates the potential value of CoDeViS as an effective tool for design research. The results of the studio course and analysis of the data collected by the students add further evidence that virtual 3D co-design can efficiently add meaningful content to user-centered design research endeavors. The process and results also demonstrate how students deal with and respond to this kind of design research. The quantity of wants, designs, modeled forms, and notations gathered through CoDeViS appear to be at least equivalent to physical 3D co-design, if not more so in CoDeViS. Qualitatively, the analysis appeared to indicate nearly equivalent value from the student researcher and participant perspectives.

Surprisingly, the logistics of recruiting for CoDeViS was perceived as more difficult from the student perspective; however there were no recruitment incentives offered, nor was there a requirement for students to recruit participants from locations far away from their classroom (i.e. other regions or countries). With incentives and the need to connect with remote locations this negative perception of CoDeViS may be diminished.

After the research and co-design phase of the project was conducted the students moved into a design mode where they created actual product designs. These designs were justified and inspired by a combination of all three design research methods (i.e. observation, physical, 3D co-design, and CoDeViS). Findings were triangulated and resultant designs were perceived as innovative by the participants who were recruited for the initial research phase and later consulted as prototypes were fabricated for evaluation. The product designs were inherently user-centered and a case could easily be made; justifying each design for further development. This is a worthy goal to achieve in product design education.

A larger scale study would obviously be beneficial to further validate, find problems with, and develop CoDeViS. However, combined with previous studies involving CoDeViS [2,3] the authors are confident this method of design research has sufficient potential to merit serious attention and implementation in professional practice.

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